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No 6

Traffic Calming: Its Evolution, Tools Used, Implementation Measures and Applicability to Sri Lankan Roads

by
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FOREWORD

It is a real pleasure to introduce a very timely publication “Traffic Calming: Its Evolution, Tools Used, Implementation Measures and Applicability to Sri Lankan Roads” which focuses on road safety and traffic management.

Many countries all over the world are paying more attention to methods for improving road safety because of the increasing number of road accidents and associated loses of lives and resources. Any attempt to minimize injuries due to road accidents should be encouraged. Unsafe road environments are the result of a lack of understanding of the safety implications in road design and traffic management. Prof. Weerasekera’s publication on Traffic Calming tools fulfills a timely need in road safety and traffic management education.

This monograph provides good reference material not only for undergraduate and postgraduate students in transportation but also for professionals involved in road design, traffic management and road safety.

This is an excellent document that supports the need to disseminate knowledge and understanding about road safety and traffic management. While congratulating Prof. Weerasekera for producing this useful publication, I hope this will encourage professionals involved in road design and traffic management to use effective traffic calming measures to improve road safety standards in the country.

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I would also like to place on record my gratitude to the following:

Professor Dayalatha Lekamge, Dean of the Faculty of Education, and Chairperson of the Editorial Board of OUSL Monograph Series for assisting in the publication of this monograph and Ms. Yasmin Raheem for her assistance in language editing.

Professor Upali Vidanapathirana, Vice Chancellor, OUSL for initiating the OUSL Monograph Series, which provided OUSL academics an opportunity to publish their research.

Finally I am grateful to my loving wife Darshi and son Tirath for their continuous support during the writing of this monograph and my dear parents who gave me all support and assistance throughout my education.

Prof. Kolita Sirinatha Weerasekera
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TRAFFIC CALMING: ITS EVOLUTION, TOOLS USED, IMPLEMENTATION MEASURES, AND APPLICABILITY TO SRI LANKAN ROADS

ABSTRACT

This study examines the concept of traffic calming, tools and methods available for traffic calming, and its effectiveness in countries where traffic calming strategies are adopted. This study also seeks to ascertain its applicability in Sri Lanka especially in Colombo and its suburbs. The study further observes the origin of traffic calming, its evolution over time, how different traffic calming policies are practiced in some countries, the development of tools and devices used for traffic calming, its application to suit different situations, and its adaptability in busy local townships mainly in Colombo.

This document is supported by a comprehensive literature survey which examines and summarises previous studies conducted on different aspects of the effectiveness of different tools used in traffic calming operations and studies the impact (both positive and negative) not only on road users but also on residents living in close proximity to the roads studied. Although traffic calming may be a novel experience to Sri Lankan road engineers, it has been practiced in some countries quite extensively over a considerable period of time.

In the post war scenario when the Sri Lankan government is spending large sums of money to improve Sri Lankan roads, it is of utmost importance that the authorities ensure that appropriate traffic management practices are put in place to enhance the safety of not only the passengers in the vehicles but also the pedestrians on the roads. Hence, the expected outcome of this study is to create awareness of traffic calming concepts and processes among traffic and highway engineers in the country and encourage them to practice traffic calming measures wherever applicable meaningfully in Colombo and its busy suburbs.

This study attempts to demonstrate successful applicability of traffic calming for a sample of residential and collector roads in Colombo by studying a network of roads around Havelock Town and Thimbirigasyaya in Colombo 5. The road network in the area selected was studied carefully and suitable traffic calming tools and measures were proposed for implementation.

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CHAPTER ONE

INTRODUCTION

Traffic calming

'*Traffic calming*' is a term which was frequently used in discussions in urban traffic policy and traffic management strategy discussions in some developed countries, over the past couple of decades. More recently, *traffic calming* is a term that has been used to describe a much wider context of traffic management and restrain in cities world wide, including cities and towns in some developing countries as well. In short, the term *traffic calming* includes any action or programme that reduces street traffic and slows down motor vehicles within residential and local areas to make the neighbourhoods safer and more people-friendly through a variety of measures which include the removal of extraneous traffic, vehicle speed reduction, measures aimed at improving the safety of pedestrians and drivers, enhancement of the street environment and encouraging to motorists to drive calmly (Russell and Pharaoh, 1990).

Although numerous definitions of traffic calming are found in literature on the topic, all these definitions basically mean the same. Traffic calming is "traffic control actions and measures that offer to minimise the undesirable impact of motor vehicles on local human activities". It is important to mention that by calming traffic accessibility and mobility should not be significantly reduced for the residents, the commercial community, the workers or the visitors to the area in question. Traffic calming should not be misunderstood to be a lessening of traffic in an area, but to be a control measure to calm down traffic by reducing the average speed of traffic, imposing road discipline, and improving the safety of all road users.

Traffic calming is conducted with the support of a large number of physical tools that have been evolved and developed over the years. Figure 1 shows some of the commonly used traffic calming tools used to slow down motor vehicles and improve overall safety of both vehicles and pedestrians within residential and local areas to make the neighbourhoods safer and more people-friendly.

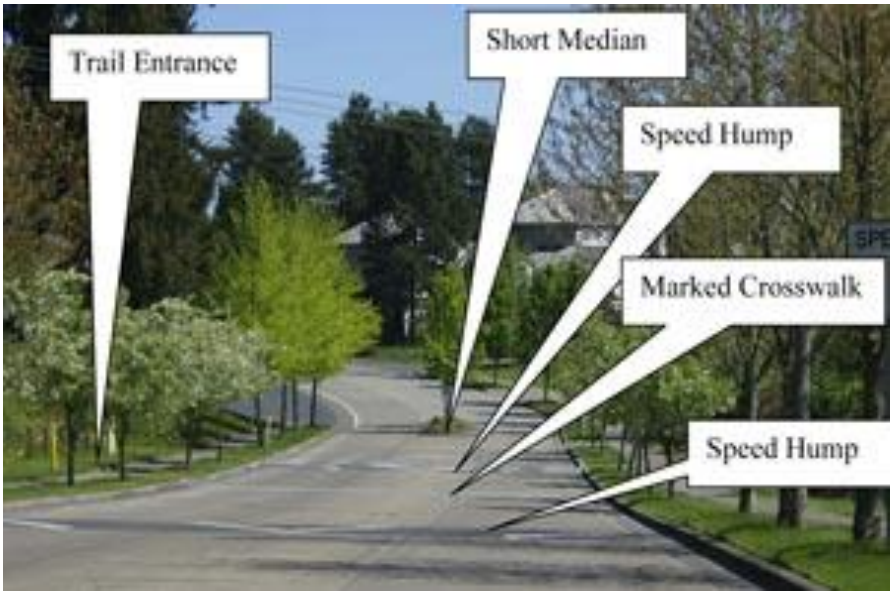

Figure 1 – Some Common Traffic Calming Tools

(*Source: www.americantrails.org/i/resourceimages/ptnyt.)*

Origin and history of traffic calming

Alker Tripp (1938) was the first person to develop an overall approach to traffic calming in residential, commercial, and working areas. His first book *'Road Traffic and its Control'* appeared in 1938, and a shorter and slightly amended version of this book followed in 1942 under the title *'Town Planning and Road Traffic'*. Tripp identified two major problems in road traffic that had to be tackled: (1) road safety and (2) increase in traffic volume. Tripp's views on road safety in urban areas were very pronounced. He stated that "under modern conditions, casualties could be reduced very rapidly if vehicle speeds were heavily reduced, and the nearer the speed of the vehicle could be brought to 3 or 4 miles per hour the better the results" (Tripp, 1938, pp. 117-118). However, he later admitted that "so drastic a reduction of speed is not possible, it would destroy the value of modern transport". He continued to express the view that high traffic speeds should only be maintained on roads which were specially designed for it. Nearly 60 years after Tripp's views on limiting vehicle speeds on roads, Plowden and Hillman (1996), traced the connection between speeds and its various harmful effects such as accidents, increased fuel consumption, emissions, and noise and altered travel patterns. They recommended a standard urban speed limit of 35 kmph and a rural speed limit of 90 kmph, in the United Kingdom.

Hass-Klau (1990) who studied the origin and history of the term "traffic calming" suggested that the term could be a translation of the German word *verkehrsberuhigung.* It is an amalgamation of the words *verkehr* (traffic) and *beruhigung* (comfort, calm or ease of mind). According to Brindle (1991) the word *verkehrsberuhigung* first appeared in German technical literature in the mid 1970's to describe speed control measures that were being applied in Germany in local streets. At time there was a growing concern in Europe about improving the liveability of urban streets by reducing the adverse impact of motor vehicles.

Traffic calming evolved in Europe from the early 1970s in different countries under different terminologies. In the Netherlands the *"woonerf"* or "*shared zone"* concept was practiced in old established residential areas well before the 1960s. The main objective of the Dutch *woonerf* principle was to design streets which made some kind of co-existence possible between pedestrian activities and vehicle usage on residential streets (Hass-Klau, 1990). One notable example is the Dutch *Woonerven*, a measure directed at calming traffic on residential streets. Residents of the Dutch city of Delft decided to transform their neighbourhood streets into *"woonerven,"* or *"living yards."* The streets were redesigned to integrate them with the yards of adjoining residences. This provided the motorist with the illusion that they were driving among the residential yards, not on a separate thoroughfare. The illusion was accomplished by placing parking spaces, sand boxes, gardens, and tables onto the streets. Woonerven brought motoring speeds below 15 kmph and successfully reduced intruder traffic and speeding vehicles in low-volume areas. Woonerven was not a suitable solution for streets that required a higher volume of cars or long distances of speed control where such low speeds were not permissible. The cost of creating a neighbourhood with woonerven was about 50 percent more than conventional street reconstruction. Woonerven works best on local access streets for short distances.

In Germany speed limiting practices such as *Tempo 30, 40, 50* (limiting speeds in residential and other sensitive areas) was practiced in the late 1970's (Schleicher-Jester, 1989). Sweden adopted *"TRAFIKPLAN 77"* in 1977. Later in 1977, SCAFT guidelines (i.e. Swedish national guidelines on urban planning with respect to road safety, Swedish version) were tried in some European countries.

In the mean time the Transport and Road Research Laboratory (TRRL) in the UK was involved in developing and experimenting with road humps for controlling speeds on residential roads and speed bumps for parking areas (Hodge 1992; Bulpitt 1995). These experiments led to the development of the famous Watt's profile in 1973 (Watts, 1973). Traffic calming schemes were first implemented in the UK at the end of the 1970s with the then Transport and Road Research Laboratory (now TRL) carrying out some of these methods as experimental schemes.

In Australia the concept of the Local Area Traffic Management (LATM) scheme was developed in calming or pacifying traffic in local and residential areas (Ashton 1981; Brindle 1991). The Australian use of traffic management devices to reduce speeds and improve safety in local streets has multiplied over the past two decades. As the literature shows, Local Area Traffic Management was extensively used in Australia in the early days to describe the use of physical measures and other restraints on vehicle operation to create more liveable and safer local streets (Mehta 1984; Gennaoui and Hawley 1985; and Taylor and Rutherford 1986).

Figure 2 – Traffic Calming

CHAPTER TWO

OBJECTIVES AND LEVELS OF TRAFFIC CALMING

Objectives of traffic calming

The objectives of traffic calming can be basically categorised into four areas: (1) to enhance safety, (2) to provide more space for movement, (3) to reduce pollution, and (4) to be aesthetic. These four objectives can be summarised as follows:

2.1 Enhance safety

Enhance safety through eliminating potential accident hazards. It is of utmost importance to control/guide vehicular movements in order to protect human life, prevent injuries to all road users, minimise the severity of accidents and avoid any property damage.

2.2 Share urban space with people

When vast expanses of road carriageways are established for vehicular movement, then space is lost for other human activities. This is so particularly when space is not adequately utilised by vehicles. Through the concept of co-existence (or shared paths) some road space could be given back to pedestrians and cyclists while also ensuring their safety.

2.3 Reduce pollution and noise (Minimise environmental impacts)

The impact on the environment through vehicular emissions, smoke, noise and, vibration has to be minimised. The importance of protecting the environment is well understood all over the world. Hence through traffic calming actions, the impact on the environment could be minimised.

2.4 Aesthetics and achieving harmony between pedestrians, vehicles and residents

It is generally accepted that motor vehicles are intrusive and dominating elements, particularly in residential environments. Hence it is important to have a safe co-existence and harmony between pedestrians, vehicles and residents.

Levels of traffic calming

There are three types of roads i.e., (i) arterial roads, (ii) collector roads, and (iii) local roads. See Figure 3.

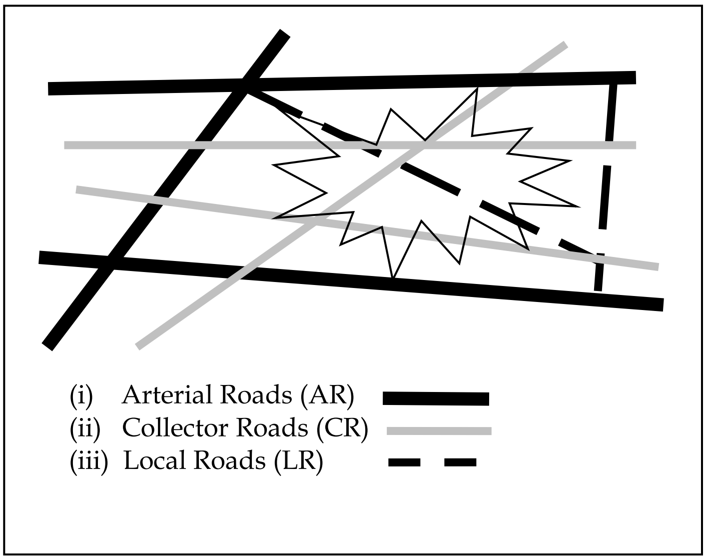

Figure 3 - Hierarchy in a Road Network

Arterial roads predominantly carry through traffic from one region to the other and constitute the principal avenues of communication for metropolitan traffic movements. They are part of the main road system in a country.

The principal function of a collector road is to distribute traffic between the arterial roads and the local roads. It ‘collects’ traffic from a catchment of local roads and branching off it and connects up to a local crossing road or arterial road.

Local roads are those roads which fulfil a need to directly cross a local traffic area because in one dimension at-least, the area is too large to be reasonably covered by intra-suburban traffic. Local roads are used solely as local access roads, but traffic volumes and types of vehicles will depend on the intensity and nature of surrounding developments. Figure 4 depicts (1) the accessibility, and (2) the mobility variation with the road hierarchy. It is seen that when road hierarchy increases the mobility function too increases, while he accessibility function decreases. Designated speeds would also increase with the increase of road hierarchy for higher mobility. Hence traffic calming should be conducted at different levels.

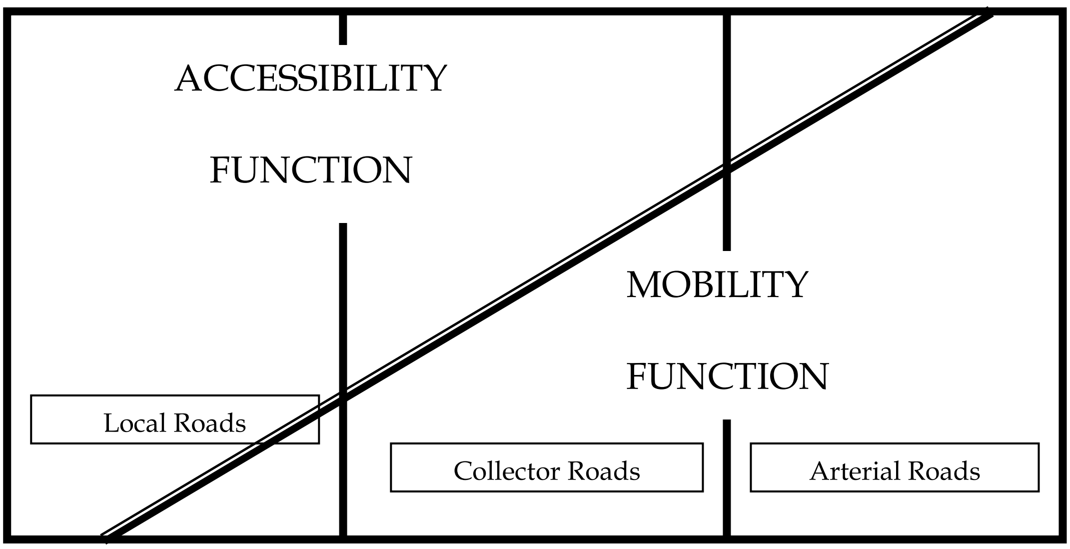

Figure 4 – Relationship between Road Type and Traffic Function

According to Brindle (1991) there are three levels of traffic calming that could be adopted:

Level 1 Traffic Calming – Actions taken to restrain traffic speed and lessen traffic impact at the local level, where traffic volumes, levels of service and network capacity are not an issue.

In Level 1 traffic calming (at local level), few local roads with problems are selected and treat them. 'Local Area Traffic Management' and 'Residential Street Management' are terms used in Australia to describe what traffic calming means are practiced at local level.

Level 2 Traffic Calming – Actions taken to restrain traffic speed and lessen traffic impact at the corridor (intermediate) level, where traffic volumes, levels of service and network capacity are an issue.

In Level 2 traffic calming (at intermediate level), a residential area is selected and treated as one unit. The term traffic calming is increasingly accepted as including speed restraints and street rearrangements on traffic routes through activity areas (shopping centres, country towns etc.), and slow-speed mixed traffic areas in town centres.

Level 3 Traffic Calming – Actions taken at the macro-level, to lessen traffic levels and to lessen the impact city-wide.

In Level 3 traffic calming (at macro level), a large area including arterial roads is selected and treated as one complete system. The more radical view extends the term traffic calming to include a much wider range of traffic reduction and suppression policies. This means that traffic calming also includes the area of urban transport policy, thus widening the scope from the original singular focus on traffic management.

CHAPTER THREE

FINDINGS OF PREVIOUS STUDIES

Literature survey

An extensive literature survey was conducted to study the different physical tools used for traffic calming purposes in various countries and their conclusions are summarised below. Previous studies have identified twelve different impacts resulting from traffic calming tools as indicated in sub-sections 3.1 to 3.12. The findings of these studies will be very helpful in developing appropriate traffic calming schemes for different situations.

3.1 Vehicle speeds

The next paragraph indicates the general conclusions arrived at by the different studies conducted and published by the following researchers regarding the impact on vehicle speeds due to traffic calming devices [Watts, 1973 (UK), Sumner and Baguley, 1978 (UK), Jarvis, 1978 (Aust), Ashton, 1981 (Aust), Kassem and Al-Nassari, 1982 (Saudi Arabia), Daff and Siggins, 1982 (Aust), Mehta, 1984 (Aus), Taylor and Rutherford, 1986 (Aus), Gennaoui and Smith, 1987 (Aus), Gorman et al., 1989 (USA), Broadbend and Salmon, 1991 (UK), Bicknell, 1993 (UK), Lines, 1993 (USA), Tan and Ward, 1994 (Aus), Macdonald, 1995 (UK), and Weerasekera, 2009 (SL)].

It could be concluded from the studies listed above, that speed reductions by physical speed control devices used in traffic calming are effective only in close proximity to these devices. These speed reductions can be controlled by varying parameters such as the type of device, the profile of the device, the spacing in between devices, the types of vehicles riding over the devices etc. All of these studies have contributed to the common conclusion that physical speed control devices are capable of effectively reducing the average speeds and percentile speeds of vehicles in close proximity to the devices. The spacing between the devices was seen as an important criterion. Increases in the spacing between devices resulted in higher average speeds and higher maximum inter-device speeds. The speed reduction at the device depended on the severity of the forced changes of the trajectory of the vehicles.

3.2 Safety of drivers and pedestrians

The next paragraph indicates the general conclusions arrived at by the studies conducted and published by the following researchers on the safety of drivers and pedestrians [Sumner et al., 1978 (UK), Sumner and Baguley, 1978 (UK), Jarvis, 1980 (Aus), Mehta, 1984 (Aus), Gorman et al., 1989 (USA), Parker, 1989 (UK), Hodge, 1992 (UK), Evans, 1994 (UK), Bulpitt, 1995 (UK), Weerasekera, 1998 (Aus), and Weerasekera, 1999 (SL)].

Supported by an extensive literature survey of 'before' and 'after' studies, it has clearly been shown that a greater percentage reduction in accidents, sometimes as high as 80% occurs in road stretches with road humps. Based on observations made on a large number of traffic calming schemes, it is now well accepted that speed control devices contribute greatly towards improving the safety of both pedestrians and drivers.

3.3 Traffic flow changes

The next paragraph indicates the general conclusions arrived at by the different studies conducted and published by the following researchers on traffic flow changes due to traffic calming schemes [Ashton, 1981 (Aus), McDonald and Jarvis, 1981 (Aus), Parker, 1989 (UK), Van den Dool and Fisher, 1989 (Aus), Chua and Fisher, 1991 (Aus), Lines, 1993 (USA), Macdonald, 1995 (UK)].

All of the above studies show that, from 'before' and 'after' traffic counts, traffic volumes were reduced once speed control devices were installed. These reductions in traffic volumes were often significant, and depended on the degree of speed control measures applied. It is evident that when speed control devices are used in traffic calming schemes, some traffic is diverted to adjacent routes since these routes become comparatively more attractive for travel. Hence, when traffic calming schemes are planned, it is important to ensure that the peripheral roads and adjacent major roads have the ability to accommodate this diverted traffic without congestion.

3.4 Geometry

The next paragraph indicates the general conclusions arrived at by the different studies conducted and published by the following researchers on the geometry of traffic calming tools [Watts, 1973 (UK), Walsh, 1975 (USA), Jarvis, 1978 (Aus), Kassem and Al-Nassari, 1982 (Saudi Arabia), Hagan, 1985 (Aus), Taylor and Rutherford, 1986 (Aus), Kjemtrup, 1988 (Denmark), Fwa and Tan, 1992 (Singapore), and Macdonald, 1995 (UK)].

The earliest studies of various geometrical designs of road humps were conducted by Watts (1973), and Walsh (1975). Watts observed that very small humps are not effective for altering the speed of all types of vehicles. It was found that the greater the height of the hump, the more severe the effect; the shorter humps of considerable heights, however were not acceptable on safety grounds. There has been a large number of experiments carried out in different countries relating to the use of speed control devices with varying profiles for achieving effective results at lower costs. Taylor and Rutherford (1986) studied the family of 'diagonal slow points' devices used by many municipalities for speed control on local streets. Vehicle speed profiles were measured

3.5 Noise

The next paragraph indicates the general conclusions arrived at by the different studies conducted and published by the following researchers on noise changes due to traffic calming tools [Sumner and Baguley, 1978 (UK), Sumner and Baguley, 1979 (UK), McDonald and Jarvis, 1981 (Aus), Taylor, 1983 (Aus), Dewar, 1984 (Aus), Mehta, 1984 (Aus), Smith, 1985 (Aus), Gennaoui and Smith, 1987 (Aus), Chua and Fisher, 1991 (Aus), and Van Every and Holmes, 1992 (Aus)].

A number of 'before' and 'after' studies indicated that there was an overall reduction in noise levels where traffic calming measures had been implemented, mainly due to the reductions in traffic volumes and speeds (Sumner and Baguley, 1978, 1979). In these studies it was found that, in close proximity to mid-block humps and raised platforms, there was an increase in noise levels due to the rattling of goods in heavy vehicles, sudden braking of vehicles, and the constant acceleration and deceleration of vehicles. It was noticed that traffic noise is a very location-specific impact and that the results can sometimes be confusing due to factors such as short survey durations, sudden fluctuations in traffic flow, occasional loud vehicles, and noises generated locally. The duration of noise recordings should be increased to obtain more definite conclusions.

Chua and Fisher (1991) stated that a 3 dB(A) change in the noise level is acceptable as being necessary for the population as a whole to notice a difference in the noise. However, the available data on traffic speed and volume reduction suggests that a noticeable difference of 3 dB(A) occurred in situations which had reductions of volume by 50%, or somewhat lesser reductions coupled with greater speed changes (Sumner and Baguley 1978, 1979; Mehta, 1984). More studies of noise changes around speed control devices with longer survey durations have been proposed.

3.6 Community attitudes

The next few paragraphs in section 6.6 indicate the general conclusions arrived at by the different studies conducted and published by the following researchers regarding community attitudes towards traffic calming schemes and tools used for traffic calming [Daff and Siggins, 1982 (Aus), Gennaoui and Smith, 1987 (Aus), Van den Dool and Fisher, 1989 (Aus), Gorman et al., 1989 (USA), and Chua and Fisher, 1991 (Aus)].

Community attitudes towards speed-reducing devices have been reviewed in the studies listed above. There seemed to be strong agreement with the assumption that residential streets are primarily for the residents and secondarily for traffic. The studies quoted above, most of which were based on public opinion surveys, interviews and household questionnaire surveys, show that the majority of the residents are in favour of speed-reducing schemes in residential areas. These surveys also showed that although a majority of residents and drivers were in favour of physical speed control devices such as road humps, raised platforms and slow points there was always a group which opposed such devices. The issue of physical speed control devices as a speed control measure has proved to be a very polarising issue; either people liked them or disliked them.

These studies show that a majority of the public accepted the notion that physical speed control devices helped to reduce overall speeds and traffic volumes on the roads however, there were somewhat different opinions on the following issues:

- safety near these devices
- minor damage and increased wear and tear to vehicles
- appearance of these devices and changes to streetscapes
- pedestrian crossing difficulties
- travel time differences
- road-side parking
- effects on nearby property values
- access from driveways
- shapes and sizes of the devices

The common public complaint about humps and raised platforms were related to noise generation in close proximity to these devices and passenger/driver discomfort. All of these studies showed a general acceptance by a majority of the community if these devices were properly utilised.

3.7 Driver and passenger comfort

The next two paragraphs in section 3.7 indicate the general conclusions arrived at by the different studies conducted and published by the following researchers regarding driver and passenger comfort [Watts, 1973 (UK), Sumner and Baguley, 1978 (UK), Jarvis, 1980 (Aus), Kassem and Al-Nassari, 1982 (Saudi Arabia), Kjemtrup, 1988 (Denmark), and Jarvis and Giummarra, 1992 (Aus)].

Kjemtrup (1988) commented that the vertical acceleration to which a person is subjected in passing over a hump depends on (i) the geometric design of the hump, (ii) the vertical speed, (iii) the vehicle suspension system, (iv) the vehicle tyre pressure, and (v) the softness of the seat, etc.

Jarvis (1980) produced a series of plots indicating driver/passenger discomfort versus vehicle crossing speed for different types of vehicles, and for different profiles of speed control devices, which suited Australian conditions. Many discomfort level (of driver/passenger) studies have been conducted in other countries as well.

3.8 Effects on different types of vehicles

The next two paragraphs in section 3.8 indicate the general conclusions arrived at by the different studies conducted and published by the following researchers on the effects on different types of vehicles [Watts, 1973 (UK), Jarvis, 1980 (Aus), Kjemtrup, 1988 (Denmark), and Jarvis and Giummarra, 1992 (Aus)].

Watts (1973) studied the effect of road humps on different types of vehicles at varying crossing speeds, by giving different discomfort ratings for vehicles. It concluded that with respect to speeds, larger goods vehicles were the most affected for the majority of the different hump profiles that were investigated. Later, the on-site tests carried by the TRRL (Sumner and Baguley, 1978 and 1979) showed large reductions of heavy vehicles and also a significant reduction in the number of motor cycles on roads with hump installations. Similar results were observed from a Danish study (Kjemtrup, 1988) which measured the effect of humps (C-humps and T-humps with varying dimensions) on 3 different types of vehicles (normal cars, buses and long, articulated vehicles). This study proved that cars pass over these devices with much more ease than longer vehicles.

From the Australian Road Research Board (ARRB) research on different profiles of raised platforms it was found that raised platforms with ramp lengths of 2 meters and heights of 100 mm produced acceptable crossing characteristics for buses at speeds up to 24 km/h (Jarvis and Giummarra, 1992). It was concluded that raised platforms with this profile had a good balance between the requirements for the control of passenger car speeds, and the need for bus occupant comfort (both driver and passengers).

3.9 Travel time

The next two paragraphs in section 3.9 indicate the general conclusions arrived at by different studies conducted and published by the following researchers on travel time [Sumner and Baguley, 1978 (UK), Sumner and Baguley, 1979 (UK), McDonald and Jarvis, 1981 (Aus), Daff and Siggins, 1982 (Aus), and Metha, 1984 (Aus)].

All of the above studies indicated that there was a definite increase in travel time depending on the length of the road for which traffic calming was done and the degree of measures applied. The TRRL studies (Sumner and Baguley, 1978 and 1979) showed considerable increase in average travel times, in some cases as high as 90% (at a location with nine Watts profile humps within a stretch of 750 metres) where the speed control devices were strictly applied. Daff and Siggins (1982) observed a smaller percentage in average travel times 30% on a 1.7 km road stretch with seven horizontal displacement slow points.

Mehta (1984) noted that in the evaluation of some residential area traffic calming schemes in Australia there was an average travel time increase of between 20 and 40 seconds when compared to travel time without the use of traffic calming tools. This was due to traffic diversions to peripherals that resulted from the control measures applied to residential area.

3.10 Emergency response times

The next three paragraphs in section 3.10 indicate the general conclusions arrived at by the different studies conducted and published by the following researchers on movement of emergency vehicles and their effect on response times due to traffic calming schemes [Daff and Siggins, 1982 (Aus), Gorman et al., 1989 (USA), Evans, 1994 (UK), and Bulpitt, 1995 (UK)].

Evans (1994) observed in a study done in UK that the most worrying criticism had come from ambulance and fire services, which had obvious concerns about the cumulative effect on their response times.

In contrast Gorman et al. (1989) in their evaluation study of road humps in Omaha in the United States of America pointed out that for emergency vehicles the road humps were not an issue as long as they were placed on collector and major roads. They suggested that if a road hump is to be installed on such a road, police and fire departments should be consulted before such devices were installed. However, they commented that the actual increase in response time because of a typical road hump is in the order of a few seconds and argued that it is not life-threatening in most cases.

All the above studies concluded that the installation of physical speed control devices increase the response time of emergency vehicles, although there are conflicting views on the significance of this increase.

3.11 Fuel consumption

The next two paragraphs in section 3.11 indicate the general conclusions arrived at by the different studies conducted and published by the following researchers on the effect on fuel consumption due to traffic calming schemes [Taylor and Anderson, 1982 (Aus), Moses, 1989 (UK/USA), Zito and Taylor, 1996 (Aus)].

From a series of field experiments using an instrumented car equipped with the ARRB's fuel travel time data acquisition system with a GPS positioning system and a speed and travel-time monitoring system, Zito and Taylor (1996) observed that a road stretch with a series of humps increased vehicle fuel consumption, whereas the introduction of mini-roundabouts decreased the overall fuel consumption. These results confirmed the earlier claim by Moses (1989) that road humps and undulations of road surfaces increase the overall fuel consumption of vehicles, sometimes by up to 20%.

The increases in fuel consumption when driving over vertical displacement devices and slow points are attributed to the constant changing of gears and travel in low gear in close proximity to and on the devices.

3.12 Air pollution from vehicle exhausts

The next two paragraphs in section 3.12 indicate the general conclusions arrived at by the different studies conducted and published by the following researchers on air pollution from vehicle exhausts due to traffic calming schemes [Taylor and Anderson, 1982 (Aus), Van Every and Holmes, 1992 (Aus), and Bulpitt, 1995 (UK)].

Van Every and Holmes (1992), from a review of literature on the environmental and energy benefits of LATM, found substantial evidence of a deterioration of environmental conditions due to increases in air pollution as a result of increased acceleration and braking by drivers near physical speed control devices. They shared the view that the impact on air quality as a result of an LATM scheme is related to changes in fuel consumption. In LATM schemes with mid-block speed control devices this is normally considered a positive change and the percentage increase in fuel consumption was found to depend on the degree of traffic calming measures applied.

Taylor and Anderson (1982), by applying the MULATM model to some South Australian LATM schemes, came up with similar views. Bulpitt (1995), by analyzing some traffic calming schemes in the UK which involved road humps and raised platforms, made observations similar to those made by Van Every and Holmes (1992), and stated that vehicle exhausts increase air pollution as vehicles speed up or slow down over the obstacle course. All these studies concluded that although there is an impact on the surrounding environment by way of air pollution due to vehicle exhausts, the comparative increase in air pollution is minimal due to speed reducing devices that are used for traffic calming purposes.

Chapter layout

Chapter 1 of this monograph investigates the concept of traffic calming and its origin and history. Chapter 2 presents the objectives of traffic calming and how it can be implemented at different levels and the different actions that have to be taken for different levels of traffic calming.

Chapter 3 of this monograph is a comprehensive literature review of the studies conducted in different parts of the world as listed in section 3.1 to 3.12. This chapter contains the historical background, the effects and impacts of tools used for traffic calming, and the methods used in different parts of the world regarding speed management and traffic calming on residential, collector, and sub-arterial routes with or without high pedestrian involvement.

Chapter 4 discusses the issues involved in the implementation of traffic calming schemes and the importance of community involvement for the successful implementation of new traffic calming schemes.

Chapter 5 looks at the need for traffic calming on Sri Lankan roads.

Chapter 6 describes the application of a proposed traffic calming scheme for a network of roads in Colombo. This chapter also describes the conditions necessary for the introduction of traffic calming practices on arterial roads and all other types of minor roads.

CHAPTER FOUR

IMPLIMENTATION

Implementation of traffic calming schemes

After studying the importance of vehicle/pedestrian interaction and the measures adopted to improve this relationship in different countries it was observed that the implementation of strict speed control measures such as road humps and raised platforms is now becoming familiar to many municipalities that are trying to reduce the speeds in residential streets as well as sub-arterial roads with high traffic flows. As indicated by Hopper and Cannon (1994), and Creed and Menzies (1996), some authorities are currently not hesitating to use these devices on busy arterial roads running through town centres. Traffic calming tools such as: raised thresholds; raised platforms; curvilinear alignments; and traffic circles are suitable devices for busy arterial roads and are becoming popular in some countries.

It should be noted that when conventional speed reducing measures with slight modifications are used in roads with high volumes of traffic with a high degree of vehicle/pedestrian interaction, it is important to have a thorough understanding of the behaviour of these devices and their impact on the fundamental characteristics of traffic. The literature search in Chapter 3 has been directed towards achieving a complete understanding of the existing knowledge of the performance of commonly-used physical speed control devices. The current knowledge regarding the performance of these tools has been assessed in that chapter.

From the literature study it was noted that there are some commonly used traffic calming tools which are extensively used all over the world for traffic calming operations. They are listed with the expected objectives in Table 1.

Table 1 – Traffic Control Devices and Objectives

Traffic Control Device	Objectives
Entry Thresholds	Signifies entrance to residential environment. Reduce non-local traffic. Warn the drivers of expected lower speeds.
Speed Humps	Reduces speed near device. Reduces non-local traffic. Mid-block application. Used on streets with excessive speeds, non-local traffic, or high accident rate. Not suitable for volumes exceeding 5000 vpd. To be used only if other devices ineffective. Must be complemented by series of devices. Space 80 – 130 metres.
Offset Carriageway	Reduces speed near device. Reduces non-local traffic. Mid-block application. Can apply for low volume roads where speed is a problem. Appropriate for short streets with high volume.
Roundabout/Traffic Circle	Reduces speeds at device and reduces vehicle to vehicle hazards at intersection. Requires larger space at the intersection.
Raised Threshold	Signifies entrance to residential environment. Reduces non-local traffic. Can be coupled with safe pedestrian crossings.
Raised Platforms	Reduces speed near device. Reduces non-local traffic. Mid-block application. Can be coupled with safe pedestrian crossings. Pedestrians are more visible to the drivers and drivers are forced to slow down.
Curvilinear Alignment	Reduces non-local traffic. Mid-block application. Can apply for low volume roads where speed is a problem
One/Two Lane Slow Points	Reduces speed near device by changing visual environment. Reduces non-local traffic. Mid-block application on streets with wider carriageway attracting through traffic and excessive speed. Not suitable for narrow streets.
Diamond Slow Points	Reduces non-local traffic. Mid-block application. Can apply for low volume roads where speed is a problem
Intersection Treatments	Intersections can be treated in such a way that it discourages non-local traffic and also reduce speeds at these intersections.
Curb Extensions	Effective carriageway width is narrowed to reduce non-local traffic and vehicular speeds.
Diagonal Closure	Reduces non-local traffic and reduces conflict at 4-way intersection. May not be suitable for narrow streets. Reduces connectivity.
Chicane	Reduces speed near device. Reduces non-local traffic. Mid-block application. Can apply for low volume roads where speed is a problem. Appropriate for short streets with high speeds.
Angled Slow Points	Reduces non-local traffic. Mid-block application. Can apply for low volume roads where speed is a problem.
Necking	Reduces non-local traffic and vehicular speeds by reducing the width of carriageway for vehicles to give the appearance of a lower speed situation.
T-Diversion	4-way intersections could be converted to T- intersections by closure of one leg to eliminate non-local traffic and reduces hazards at intersection. Reduces connectivity.
Rumble Strip	These are corrugated surfaces producing noise and a physical sensation on the steering where drivers gets alerted due to these

	sensations. These can be effectively used for speed controlling and prevent drivers from deviating from the expected course.
Median Island	These are placed on the street to reduce the width of carriageway for vehicles to give the appearance of a lower speed situation to channelise traffic and to provide shelter for pedestrians.
Zebra Crossing	Ideal for arterial roads and other less important roads where the interruptions they cause to vehicles can be tolerated.
Shared Zones	In these zones pedestrians have equal rights with motor vehicles in the specified zone. Used in public parking areas, places around large shopping malls, university campuses, and in areas where children use the street space for play etc.
Appropriate Road Signs	This is a soft treatment through sign boards and appropriate carriageway markings.
Electronic Information	Initial installation cost is high. Suitable for high mobility roads such as expressways and freeways.
Close Circuit Cameras/Enforcement	Easy enforcement. 24 hour surveillance is possible for enforcement purposes, but a costly treatment.
Appropriate Landscaping	By appropriate landscaping speed is reduced to desired levels. The landscaping should create a user (driver) environment conducive to safety, and each element of the system should individually contribute to the goal of maximizing safety.
Different Surface Treatments	By different surface treatments and colour combinations, priority areas and desired speed zones are distinguished.
Road Closures and Diversions	Eliminate non-local traffic and reduces hazards at intersection. Can be applied at 3-way or 4-way intersections. Additional distance to be covered should not be greater than 200 metres.
Channelling	Separate conflicting traffic movements and direct traffic to specific paths for safe and orderly turning/crossing/merging. Appropriate for wide or uncontrolled pavement expanses. Reduces driver decision-making.
Pedestrian Refuge	Pedestrian refuges are often used where zebra crossings or traffic signal crossing are not justified. The location of a refuge should be the safest point to cross a road that is close to the pedestrians intended route, whilst not obstructing access to private drives and entrances. Pedestrian refuges, which have lowered kerbs and tactile paving, are normally positioned centrally in the carriageway. This has the effect of narrowing the road and reducing the distance pedestrians have to cross and it also has the effect of reducing the speed of passing traffic.
Traffic Islands	Traffic islands have the effect of narrowing the road and reducing the speed of passing traffic. Traffic islands should be located so as not to obstruct access to private drives and entrances and they are not intended for pedestrians as they have no dropped kerbs and tactile paving, although they do tend to offer pedestrians some protection when crossing a road.
Optical Speed Bars	These are used in low volume rural roads where speeding is a problem. Optical speed bars are drawn along the carriageway to give an optical illusion to the speeding drivers to force to reduce their speeds. This is a low cost solution for rural low volume roads where speeding is a problem.

Some of the references indicated in Chapter 3 of this monograph offer comprehensive details of the traffic calming tools that are shown in Table 1. The dimensions of these different traffic calming tools, and suggestions for suitable locations for their effective installations are also included in the references indicated in Chapter 3.

Figure 5 indicates an example of a simple typical traffic calming scheme that could be adopted in a residential area by using some of the previously discussed traffic calming tools. Similar types of traffic calming schemes (local/site specific) could be designed by traffic engineers with the agreement of all relevant stake holders.

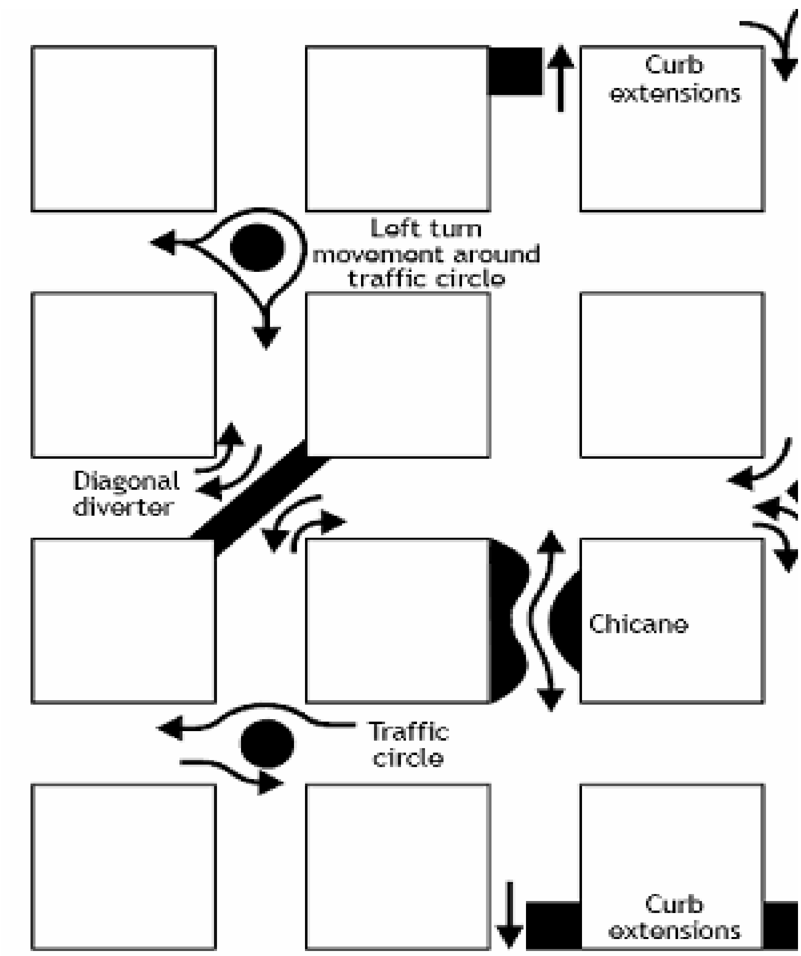

Figure 5 – Typical Traffic Calming Scheme

Community involvement

When traffic calming schemes are to be implemented in residential areas, the community's involvement is important. The strategy should be to involve the community not only in the identification of problems but also in the process of devising and assisting with the implementation of some solutions. The community involvement approach has as its central focus the idea that the community must both accept the problem and perceive the benefits of the solution for success to be achieved. Community involvement could be carried-out through leaflets, newsletters, questionnaire surveys, displays, public meetings, local newspapers, and written submissions. It is important that irrespective of the form of consultation used, the community should be advised of the nature and timing of the proposed schemes, because it is likely that there will be disruption to vehicular and pedestrian traffic patterns and possibly business activities. In today's context this is an action that is given low priority in Sri Lanka. This action is important because the aim is to keep the disruption due to the implementation of a scheme to a minimum; the public and the business community must have an opportunity to adjust their schedules, if possible. If the above detailed measures are considered before the implementation of any new traffic management scheme, there will be fewer criticisms from the public.

The most important initial step in minimising problems and gaining acceptance from the local community is to properly identify and clearly define the objectives of the scheme. This will lead to visualise the final outcome. It is important to prioritise these objectives and reach some kind of agreement with the community on this. Eventually it will provide the basis for comparing and evaluating later alternatives. It should be stressed that without such a clear understanding, assessment of schemes will always be subjective and may be faced with much criticism.

CHAPTER FIVE

NEED OF TRAFFIC CALMING IN SRI LANKA

General information

In the post-war scenario it seems that the Sri Lankan Traffic Police is making a desperate attempt to discipline local traffic, and to improve road practices of local road users (both motorists and pedestrians). It is encouraging to see that, the Sri Lankan Traffic Police is working hard through various awareness schemes such as educational campaigns, intensive roadside offender detection exercises, and monitoring programmes in order to bring law and order into highway usage. While enforcement is conducted it is also important to take steps to educate both motorists, and pedestrians on correct highway usage.

Although various foreign concepts of traffic calming are covered in this study, it is important that if Sri Lanka is to adopt traffic calming practices, those have to confirm to national standards depending on the demands and expectations of local conditions.

Basically from a traffic engineering point of view traffic calming schemes endeavour to:

- Manage vehicular speeds to desirable levels
- Improve safety of both pedestrians and drivers
- Change traffic flows
- Control noise levels
- Control environmental pollution (smoke, dust, harmful emissions)
- Change travel times (increase / decrease)
- Maintain local resident’s privacy
- Change road geometry

– Influence community attitudes (residents and drivers)
– Increase passenger comfort

Need for traffic calming in Sri Lanka

It can be seen that in spite of all the safety awareness campaigns spear-headed by the Sri Lanka Traffic Police with other relevant road agencies, the road fatalities and grievous injuries on Sri Lankan roads are on the rise (Table 2). By looking at the total accident numbers indicated at the bottom row of Table 2, one may get the impression that accidents are being reduced over the years; but according to the Traffic Police, these numbers indicated in Table 2, reflect much lower figures than the actual numbers. The low values are due to roadside settlements arrived at by the affected parties with the help of insurance companies and without informing the Traffic Police. Hence, many of these minor category accidents are not recorded by the police. But the ground reality is that, Sri Lankan road accidents are on the rise. It is laudable that the Sri Lanka Traffic Police with approval from the Defence Ministry has taken steps to install 100 roadside closed circuit TV cameras (CCTV) at crucial locations in Colombo for traffic monitoring purposes. Implementation island-wide will be too costly.

It has been observed that there is a high level of driver indiscipline on the local roads. Police detection records indicate that most driving offences are related to speeding, violation of road rules, and unruly behaviour by three-wheeler drivers etc. (Table 3). These high figures justify the importance of and the urgency to calm our traffic on roads, in order to ensure safety and more discipline on Sri Lanka's roads.

Table 2 - The Annual Accident Statistics

Type of Accident	2004	2005	2006	2007	2008	2009
Fatal	2,116	2,141	2,065	2,176	2,157	2,515
Grievous	4,560	4,968	4,710	5,036	4,963	5,529
Non-grievous	13,918	14,376	11,866	12,042	11,437	12,138
Damage only	32,864	21,686	14,698	13,204	11,863	13,870
Total	53,458	43,171	33,339	32,458	30,420	34,052

(Source: Sri Lanka Traffic Police, 2010)

Table 3 - Police Detections from 2004 to 2008

Type of Offence	2004	2005	2006	2007	2008
High speeding	113,543	136,846	125,261	153,388	151,702
Un-roadworthy vehicles	1,729	1,591	2,319	1,735	1,417
Driving under the influence of alcohol/drugs	10,526	12,826	11,418	163,083	189,133
Loading passengers away from bus halts	27,029	25,296	25,199	27,181	21,413
Offences committed by Three-wheeler drivers	300,470	322,383	266,238	279,320	255,710
Offences related to violation of road rules	315,959	338,108	324,727	372,224	354,399
Failing to stop at pedestrian crossings	38,242	30,629	19,819	19,762	7,933
Violation of other road rules	884,169	678,083	715,682	803,745	720,726
Total	**1,691,667**	**1,545,762**	**1,490,663**	**1,820,438**	**1,702,433**

(Source: Sri Lanka Traffic Police, 2009)

CHAPTER SIX

APPLICABILITY OF TRAFFIC CALMING IN SRI LANKA

Applicability in Colombo

Through this study it was attempted to demonstrate the successful applicability of traffic calming schemes for a sample of Colombo's residential roads by studying a network of roads around Havelock Town and Thimbirigasyaya in Colombo 5. The study area indicated in Figure 6 was selected as a suitable area for a proposed traffic calming scheme due to several reasons.

- The selected area is a prime residential area consisting of a selection of public places such as schools, playgrounds and places of religious importance etc.
- This area lies between a couple of arterial roads and consists of few collector roads and a residential road network.

  Arterial roads are (1) Havelock Road, and (2) Baseline Road.

  Collector roads are (1) Thimbirigasyaya Road, (2) Isipathna Mawatha, and (3) Park Road.

By implementing the proposed traffic calming scheme it is expected to reduce speeds in the local residential roads and to reduce intruder traffic on the local road network and ultimately to enhance safety by reducing speeds on local roads.

Figure 6 indicates the location of traffic calming tools that are proposed. Paragraphs A to O indicates the list of tools that could be installed to implement the proposed Colombo 5 Residential Area Traffic Calming Scheme.

A – Roundabout/Traffic Circle

By introducing a small roundabout or a traffic circle at the intersection at the Thimbirigasyaya Road and Fife Road intersection, the speeds of the vehicles on Thimbirigasyaya Road could be lowered to safer levels. This location is ideal for a small roundabout due to a fair balance of traffic along the three legs, and the availability of space at the intersection.

B - Chicane

Due to wider carriageway and low level of traffic, Fife Road is experiencing higher speeds not only during the day time but also during the night. Hence a chicane could be introduced at mid-block to reduce excessive speeds and thus discourage intruder traffic. This mid-block application is ideal for low volume roads where speed is a problem as is the case on Fife Road.

C - Roundabout/Traffic Circle

A small roundabout is proposed at the intersection at Isipathana Mawatha and Fife Road due to a fair balance of traffic along the four legs, and the availability of space at the intersection. The introduction of a roundabout will improve the throughput at the intersection while reducing speeds and improving safety at the intersection.

D/E – Raised Platforms

Raised platforms at mid-blocks along Isipathana Mawatha will encourage decreasing speeds along the road while improving safety.

F – Entry Threshold

An entry threshold at the entrance to Fife Road from Park Lane will reduce both speeds and through traffic along Fife Road which is a residential street. Introduction of an entry threshold at this intersection will improve the amenity level at Fife Road, Manthri Road, Manthri Place and Boise Place as indicated in Figure 5, which are all highly residential roads.

G - Roundabout/Traffic Circle

A small roundabout is proposed at the intersection of Park Road and Park Lane. The introduction of a roundabout will improve the throughput at the intersection while reducing speeds along Park Road. It will also improve safety at the intersection.

H/I – Raised Platforms

A couple of raised platforms at mid-blocks along Park Lane will lower speeds along the road while improving safety along the road. Since Park Lane is the main access to Isipathana Maha Vidyalaya, Colts Park, and Havelock Grounds, lower speeds and safety is a major concern along this road. Hence controlling vehicular speeds along this road is very important.

J – Raised Threshold

A raised threshold will minimise intruder traffic on Greenlands Avenue which is a premier residential street. This will also signify entrance to the residential environment while reducing non-local traffic. A raised threshold can be coupled with a safe pedestrian crossing across Greenlands Avenue.

K - Roundabout/Traffic Circle

By introducing a traffic circle at the intersection of Thimbirigasyaya Road and Siripa Road / Siripa Lane, the speeds of vehicles on Thimbirigasyaya Road could be decreased to safer levels. This location is ideal for a small roundabout due to the availability of a wider space at the intersection. Safety too could be improved with a traffic circle.

L – Traffic Signals

The intersection at Havelock Road and Thimbirigasyaya Road is already supported with traffic signals that operate satisfactorily. This is an intersection where a collector road meets an arterial road, and therefore experiences heavy traffic flows along the Havelock Road during the morning and evening peak hours. Signal timing should be flow responsive.

M - Roundabout/Traffic Circle

By introducing a small roundabout or a traffic circle at the intersection of Thimbirigasyaya Road and Kirula Road the speeds of vehicles on Thimbirigasyaya Road could be decreased to safer levels. This location is ideal for a small roundabout due to a fair balance of traffic along the three legs, and sufficiently available space at the intersection.

N - Traffic Signals

The intersection at Havelock Road and Isipathana Mawatha is already supported with traffic signals that operate satisfactorily. The traffic signals at this intersection are one of the first traffic signals that were installed in Colombo 5. This is an intersection where an arterial road crosses a collector road, and experiences heavy traffic flows along the Havelock Road during the morning and evening peak hours.

O – Speed Humps

Siripa Road is mainly a residential road where the width of the carriageway is not sufficient to accommodate through traffic along it. Hence, by introducing mid-block humps along Siripa Road it may reduce average speeds and non-local traffic along the road. These mid-block applications are suitable on streets which experience excessive speeds, non-local traffic, or high accident rates. A series of devices with space between 80 – 130 metres may be constructed along the road.

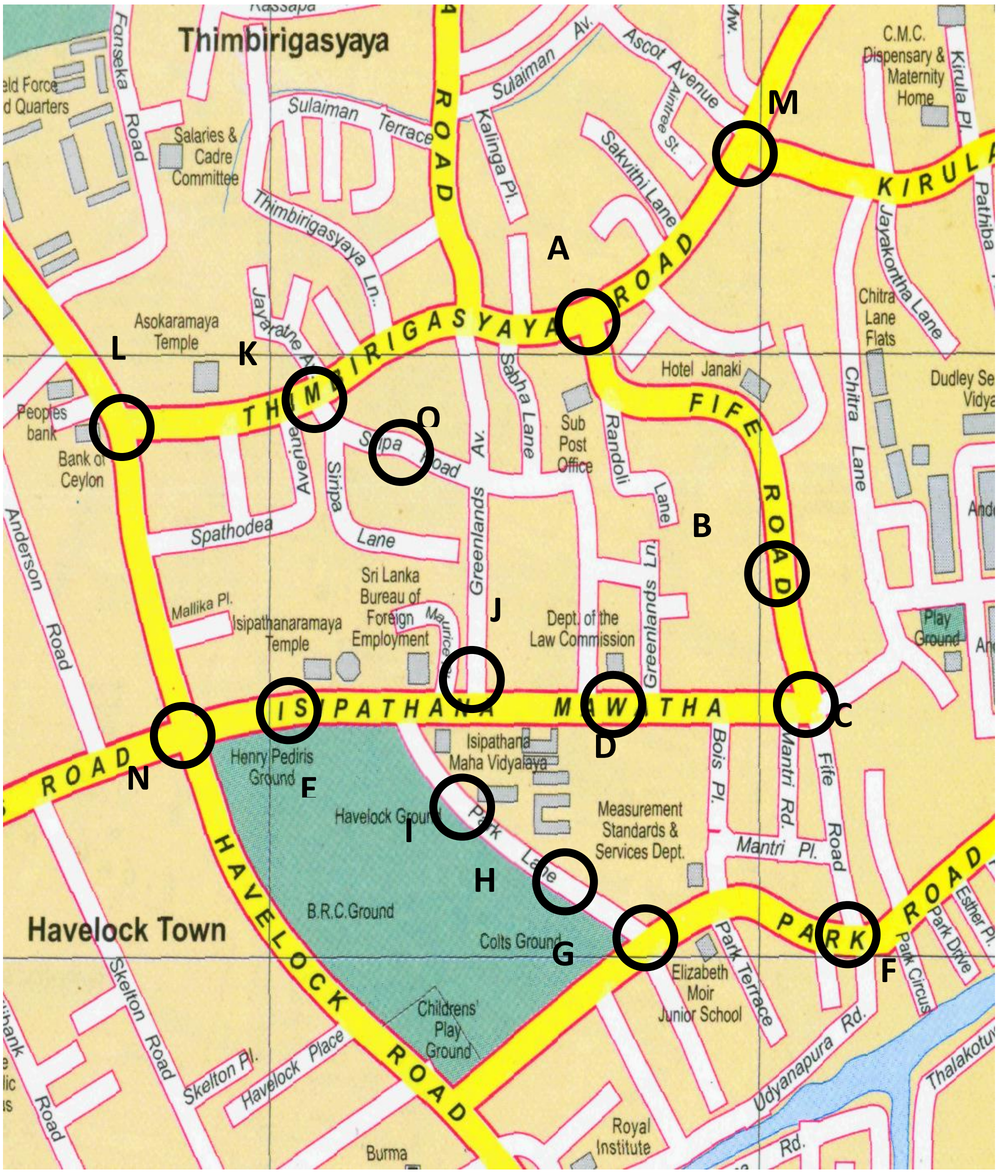

Figure 6 – Proposed Traffic Calming Scheme

Considerations for traffic calming on all roads

Although traffic calming is typically used on residential streets, there are certain tools that are appropriate for use on collector roads and some arterial roadways. When a traffic calming approach is considered for any road, thee following guiding factors should be taken into account:

1. Vehicular speeds are more critical than vehicular volumes in terms of safety. Hence vehicular speed should be addressed first and then vehicular volume restraints should be considered.
2. Community participation is important for successful implementation. The reasons for traffic-calming and management in the area should be clearly explained to residents and support for installation of these treatment tools should be to the satisfaction to the residents and the public.
3. Traffic-calming designs should be cost effective, predictable, and easily understood by drivers and other road users.
4. Traffic-calming and management measures should fit into, and preferably blend into the street environment.
5. Treatments carried-out have to be well designed and proportionately based on available information, design practices and any guidelines.
6. Traffic-calming areas or applications should be adequately and properly signed, marked, and lit at night to be visible to all motorists and pedestrians.
7. Traffic calming tools that meet multiple goals are usually more acceptable. For example, a raised platform with a road crossing facility will be more meaningful and useful to motorists and pedestrians than a speed hump. Raise platforms have several

clear goals, whereas the road hump may be perceived as a nuisance and an inconvenience.

8. Traffic calming tools need to be spaced appropriately to have the desired effect on speed and other expectations. When tools are placed too far apart they have a limited effect. Similarly, when tools are placed too close to each other they might be a nuisance to road users and a costly exercise. Devices usually need to be spaced about 100 to 150 meters apart. If they are spaced too far apart, motorists may speed up between them.
9. If properly designed, it should be able to create an environment that supports slower speeds for the entire length.
10. If the traffic calming tools used are under-designed then the expected results may not be achieved. Examples such as having too mild slopes in entry/exit ramps in raised platforms or having too gentle curves in chicanes will not bring effective expected results, and will appear as a waste of funds and may also reduce opportunities for future projects as well.
11. If a particular traffic calming measure is likely to divert traffic onto another local road, the overall area-wide road network should be considered so as not to transfer the problem from one place to another.
12. Traffic-calming measures should accommodate cyclists, pedestrians and people with disabilities**.**
13. All traffic calming tools should be able to accommodate emergency vehicles. Emergency response times shall be considered and should always be at a minimum.
14. Traffic calming layouts should be aesthetically pleasing to the road users and should blend with the surrounding environment.

Additional considerations for traffic calming on arterial roads

Suitable road grids will have streets within the arterial network that are primarily residential and are optimally used as routes to “collect” local traffic to move it to higher capacity arterial streets. When the street grid is largely built and the congestion continues to increase, collector arterials are being used as cut-through routes by motorists trying to avoid congestion. Communities are concerned about higher traffic speeds and volumes on the collector arterials in their residential neighborhoods and are requesting traffic calming solutions. In order to balance the demands placed on the arterial network, including use by large vehicles such as buses, trucks and emergency responders, with neighborhood concerns, the city needs clear policy directions about traffic calming practices that would be appropriate on arterial roadways.

1. Traffic calming on arterial roads become successful when adopted on arterial roads where neighbouring land uses are primarily residential.
2. Through traffic should be encouraged to use higher-classification arterial roads and avoid collector and residential roads as far as possible.
3. 1) education; 2) enforcement, and 3) correct engineering practices are important. If traffic calming devices are an appropriate solution, they shall be planned and designed in keeping with sound engineering and planning practices appropriate to the particular functions of the arterial road.
4. Arterial traffic calming projects should not significantly impact transit service access, safety, and scheduling.
5. Pedestrian and cycle movements should be given equal consideration with vehicle movement in the design and implementation of arterial traffic calming projects.

6. In arterial traffic calming projects parking issues should be considered on a project-by-project basis. Parking needs of residents should be balanced with the equally important functions of traffic, such as commercial parking, emergency vehicle access, transit, bicycle, and safe pedestrian movement.
7. Traffic calming on arterials should not divert traffic to non-arterial roadways through the use of traffic diversion devices.
8. Emergency vehicle access shall be maintained at the highest level and traffic calming tools should not unreasonably reduce emergency vehicle response times.

It is important to remember that there is no ideal solution or type plan for any traffic calming scheme, but every scheme is different from the other. Each scheme is site specific and should be acceptable to all stake holders who are the final beneficiaries.

Conclusions

It was observed from site investigations that the proposed traffic calming scheme at Havelock Town and Thimbirigasyaya in Colombo 5 could be implemented with ease, since road widths are adequate for the proposed traffic calming tools. But this may not be the situation elsewhere.

When traffic calming schemes are to be implemented in Sri Lanka, the following are some of the difficulties that could be anticipated.

1. Since the local road users are not accustomed to traffic calming schemes a process of education may be necessary.

2. Available carriageway widths of the Sri Lankan roads may not be sufficient for some of the traffic calming tool to be installed at some locations. Therefore some accepted tools used elsewhere may not be suitable for local conditions.

3. Research and further studies may be required in such cases. Research on space utilised, cost of structures, and road user responses could be conducted to ascertain which traffic calming tools would suit local conditions.

4. Unlike in some situations where local area traffic calming schemes have been successfully implemented in some developed countries, in Sri Lanka since the available road widths are narrow, solutions such as introducing curvilinear alignments or carriageway narrowing will not be an appropriate solution.

5. The high costs involved in some installations may create difficulties to the relevant local road agencies.

6. If heavy traffic diversions occur on local or residential roads residents may agitate.

7. Road authorities may have to face demands brought by politically motivated pressure groups with vested interests.

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