DEVELOPMENT OF A GEOMETRIC DESIGN INDEX FOR UPGRADING DECISION MAKING – CASE STUDY FOR A PROVINCIAL ROAD NETWORK IN A DEVELOPING COUNTRY

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DECLARATION

"I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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……………………………………… Date:…………………

Dr.H.R Pasindu

ABSTRACT

D.P Lalith Sirisumana

Provincial level and local roads comprise nearly 50% of the road network in mileage in Sri Lanka. They play a pivotal role in providing access to the local communities especially in rural areas and an essential component of the economic development of those areas. These roads are under the purview of Local Councils and Provincial Road Development Authorities. Most of these roads do not conform to the design guidelines as they were often developed from local footpaths or gravel roads. Therefore, the travel speeds are very low and safety issues have arisen with the increase in travel demand and the use of motorized vehicles. Therefore, there is need to upgrade these roads to the appropriate design standards to ensure safe and efficient mobility to the road users. However, the road agencies have limited funding to implement upgrading projects on the entire network. Thus, it is pertinent that there is a methodology to prioritize the roads based on the current operational performance so that the funding allocation can be done in the most effective manner. Road upgrading in the context of the study is focused on roadway improvements such as alignment, road width, shoulder etc. In addition to the limited funding, the agencies also lack the technical capacity to carry out detailed investigation and surveys on highway performance that are typically carried out in other road agencies at national level. Therefore, the study proposes a simplified methodology to evaluate the Geometric Design index of the roads based on their roadway and operational characteristics, to be used to assess road network conditions and identify upgrading needs for a highway agency of a low volume road network.

DEDICATION

This dissertation is dedicated to my beloved parents, my charming wife Shirani, and my kids Pubudu, and Ishsra, who have always been with me, through every hurdle I encountered.

ACKNOWLEDGMENT

I would like to initially extend my gratitude towards my supervisor Dr.H.R Pasindu, a Senior Lecturer at the University of Moratuwa for agreeing to be my supervisor and providing all the necessary guidance throughout the course of this dissertation.

My sincere thanks, in particular go to Prof J.M.S.J Bandara, Head of the Department of Civil Engineering at the University of Moratuwa, and Prof.W.K.Mampearachchi,and Dr. Dimantha, Senior Lecturers at the Department of Civil Engineering University of Moratuwa.

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My sincere thanks is also extended towards the Transportation Engineering Division of the Department of Civil Engineering for providing support for the research. Finally, I would like to convey my gratitude to my colleagues at the Transportation Engineering Division, my family Eng. Renuka Weerasri,Eng.Srilal Rathnayake, Eng. Udeni Wickramarathne and all others who helped me in various means to make this research a success.

D.P Lalith Sirisumana

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LIST OF ABBREVIATIONS

Wk.	- Weightage for factor k;
Rk	- rating for factor k;
n	- Total number of factors.
LOS	- Level of Service
GDI	- Geometric Design Index
PRDA	- Provincial Road Development Authority

1 INTRODUCTION

Low volume roads in Sri Lanka are generally under the purview of the Local Government or the Provincial Councils. These are categorized as ‘C’ Class and ‘D’ Class roads, which form more than 50% of the road network in the country in terms of road-kilometers *(1)*. The government has invested heavily on improving the condition of these roads, and has upgraded them to asphalt concrete or concrete paved roads in the recent years *(2)* under World Bank, Asian Development Bank and other monetary institution loans. However, due to various reasons, major improvements have not been made to the roadway characteristics such as lane width, shoulder width, radius of curvature of these roads. The improvements in the road surface condition, population growth and increased use in motorization has resulted in the increase in travel demand on these roads. Thus creating a need to upgrade these roads to conform to proper design requirements to ensure safe and efficient mobility for the road users.

In addition to limited funding, the agencies also lack the technical capacity to carry out detailed investigations and surveys on highway performance that are typically carried out in other road agencies on a national level. Therefore, any methodology used to evaluate the performance of provincial road networks should be based on the data that can be easily collected during the routine network survey. This ensures the continuity in the application of the method in relation to the decision-making process.

The study proposes a simplified methodology to calculate the performance index of roads to be used for highway upgrading prioritization. Road upgrading in the context of the study is focused on roadway improvements such as the alignment, the road width, the shoulder etc. not necessarily the surface or pavement type improvements. Therefore, the study focuses on the roadway and operating characteristics rather than the pavement condition, as the intention is to evaluate their performance with respect to planning level decision making where roads will be selected for upgrading. It is deemed that the maintenance management system would incorporate the pavement condition of the roads.

1.1 Objectives

The objective of this research is to find an interrelation among the road characters such as road width, shoulder width, right of way and passing bays etc. which affect the roadway functionally. It is intended to derive a formula by analyzing the selected criteria as a Geometric Design Index. By using the outcome of the formula, a level of service category can be prepared to define the existing condition of any road in the Western province. It will guide the way of future improvements of these roads up to the desired conditions.

1.2 Scope of work

The research mainly covers provincial roads in the Western province. These are low traffic volume roads used to access main roads or acts as a connection between main roads. There are ten executive engineering divisions covering all the provincial roads **in Colombo, Gampaha** and **Kaluthara** Districts in the Western province under the Provincial Road Development Authority (Western Province). An appropriate number of roads were selected from each engineering division to represent all the intended characters to suit the research. Table 1.1 gives the proposed plan of selected roads from each division for the research.

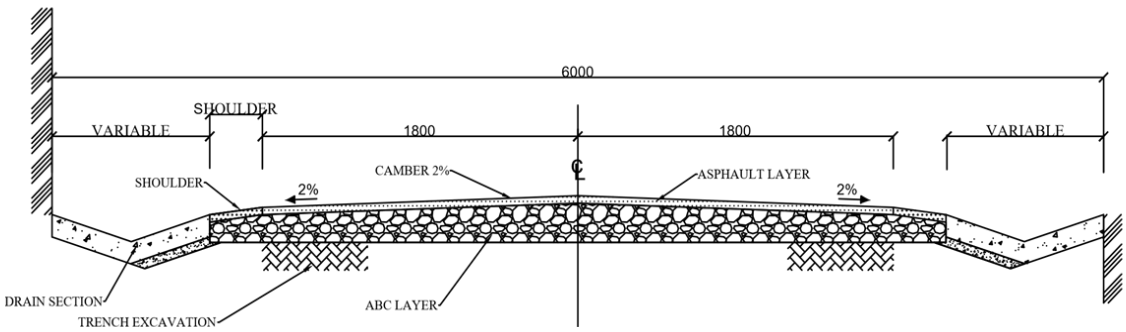

Figure 1.1 Typical cross section of a road

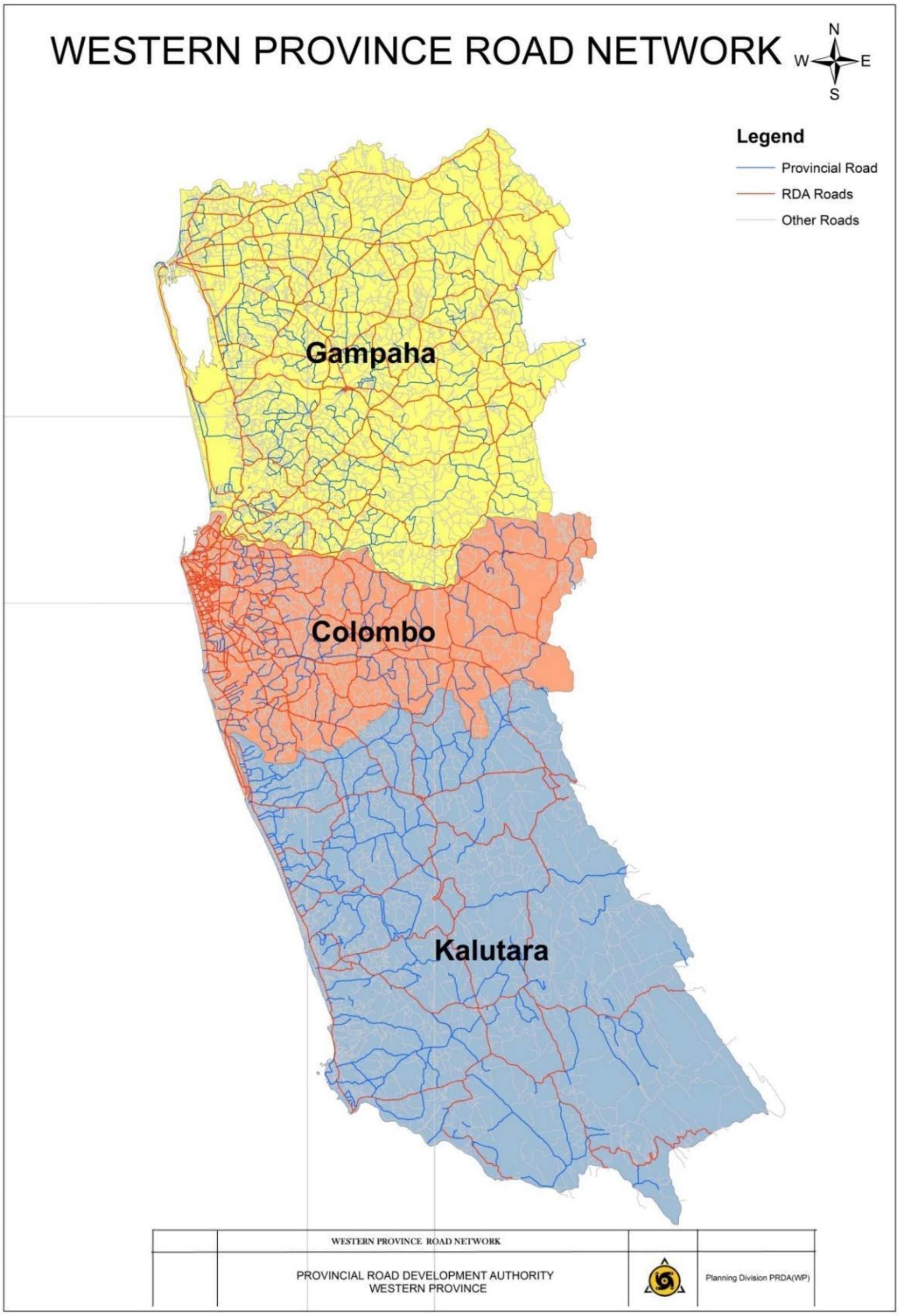

Figure 1.2 The map of the Western Province

Table 1.1 Selection of Roads from each Division in Western Province

DISTRICT	EXECUTIVE ENGINEERS DIVISION	SECRETARIAT DIVISION	SELECTED NUMBER OF ROADS
COLOMBO DISTRICT	1. Colombo	Kotte	3
		Kaduwela	3
		Kolonnawa	3
	2. Avissawella	Avissawella	3
		Homagama	3
	3. Moratuwa	Moratuwa	2
		Ratmalana	2
		Dehiwala	2
		Maharagama	2
		Kasbawa	2
GAMPAHA DISTRICT	4. Udugampala	Gampaha	3
		Minuwangoda	3
		Diulapitiya	3
	5. Negambo	Negambo	3
		J-Ela	3
		Wattala	3
		Katana	3
	6. Nittambuwa	Athanagalla	3
		Meerigama	3
	7. Kiridiwala	Dompe	3
		Mahara	3
		Biyagama	3
		Kelaniya	3
KALUTARA DISTRICT	8. Kaluthara	Kaluthara	3
		Beruwala	3
		Panadura	3
		Bandaragama	3
	9. Horana	Horana	3
		Bulathsinhala	3
	10. Agalawatta	Agalawatta	3
		Mathugama	3

2 LITERATURE REVIEW

Some information was gathered from the literature review. They were helpful to enhance the research idea. Some of them are;

2.1 Level of Service for Heavy Vehicles on Rural Road survey

Level of Service for Heavy Vehicles on Rural Road survey has been done by H.V LOSSR (9). The purpose of this survey was to develop a practical approach to the management of rural arterials, attempting to provide a fit-for-purpose level of service (LOS) for each of the major rural arterial categories of the rural arterial road network. LOS is expected to be determined from the information and data derived from this survey. The survey was directed at three main groups of stakeholders: heavy vehicle drivers, heavy vehicle fleet managers and road infrastructure managers. The outcome of this survey was used to inspire change in maintenance strategies aimed at meeting a fit-for-purpose LOS for each rural arterial category. In some cases, this could mean the incremental road upgrade practice.

2.2 Development of Geometric Design Standards for Low- Volume Roads in Canada

Preparation of standards had been done by D. Bews,et al(10).(1987), Department of Indian Affairs and Northern Development, Transportation Division, Technical Services and Contracts Branch, Ottawa, Ontario, Canada KIA OH4.

Approximately 76 percent of the road system in Canada had been classified as rural local roads that carry low traffic volumes. In the past, geometric design standards for roads were not available in Canada. The lack of national standards for low-volume roads resulted in agencies developing their own. These standards were not compatible with the required functions of the road, and also had the effect of non-uniform treatment of roads between road jurisdictions. National standards were originally developed for a higher classification of roads, to meet economic constraints. It became evident that there was a need to construct these roads more economically, and to maintain their safety and effectiveness. As a result, the Roads and Transportation

Association of Canada (RTMC) initiated a project to develop a national set of geometric design standards for low-volume roads. A separate chapter for low-volume roads is now included in the Manual of Geometric Design Standards for Canadian Roads.

In 1983, RTAC approved the establishment of a project steering committee to research and develop a set of geometric design standards for low-volume rural roads that would be the product of a consensus of the majority of users in Canada.

The objectives of the project were defined as follows:

- To establish uniform national standards for the classification of low-volume roads to meet the special services requirements of road agencies across Canada,
- To provide standards compatible with the present economic requirements without jeopardizing the safety or effectiveness of the road, and
- To provide standards for road agencies that relate to the type of road function which will ensure standardization

The project steering committee, which consisted of representatives from federal, provincial, territorial, county road authorities, and the private sector, established terms of reference, and selected a consultant to perform the work. Funding for the project was provided by the Council on Highway and transportation Research and Development (CH-l-RD) of the Roads and Transportation Association of Canada, and the Federal Department of Indian Affairs and Northern Development.

2.3 Roadway Widths for Low-Traffic-Volume Roads

This research was based on determining the road width for low volume roads, was done by C.V. ZEGEER, et al (11). (1994), University of North Carolina Highway Safety Research Center Chapel hill, NC and T.R. NEUMAN CH2M HILL Evanston, IL, national Academy Press, Washington, D.C. 1994 held a significant importance in my research. Maintaining and reconstructing the two-lane highway system has emerged as a serious problem. The problem primarily results from the extensive size of the system, and the fact that significant mileage of two-lane highways was designed and built considering outdated standards not being reflective of the current design policy. Also, a large portion of low-volume roads is unpaved, that presents maintenance problems in addition to safety concerns. Thus, in terms of their extensive mileage, low-volume roads are clearly an important component of the highway transportation system. A great proportion of the two-lane rural road system is thirty years old or more, necessitating investment to replace pavements, repair shoulders, and address other problems. As per the details, over one-quarter of the mileage of such roads have lane widths of 9 ft. or less, two-thirds have shoulder widths of 4 ft. or less, and 11.5 percent of two-lane highway mileage has no shoulders. These statistics contrast with current design values shown in the '1990 American Association of State Highway and Transportation Officials a Policy on the Geometric Design of Highways and Streets'. For extremely low volume and low-speed highways, the 1990 AASHTO Policy calls for 22ft to 24ft roadways (11ft to 12ft lane widths) regardless of terrain or other conditions. Over the last 50 years, design criteria for all highways have evolved to reflect changes in vehicle width and performance, greater understanding of driver behavior, and advances in material and construction techniques. Cross-section values in the AASHTO policies from 1940 to the present have gradually changed to the point where, except for extremely low-volume and low-speed highways, AASHTO policy criteria specifies a 22ft. to 24ft traveled way (i.e., 11 -ft. to 12-ft lanes) for all terrain and other conditions. Much of the existing rural mileage was designed according to a criteria that prevailed more than 30 years ago. There is undoubtedly a significant mileage of low-volume roads that have not been "designed" in the conventional sense. Such roads evolved over the years, starting out as horse paths and eventually being upgraded over time to a paved surface. There are insufficient funds to reconstruct the entire two-lane system to design values specified in the 1990 AASTHO policy. Similarly, abandoning roads or allowing continued long term deterioration is not a viable option. State and local highway agencies find their engineers confronted with difficult choices. Should a highway merely be repaved within its existing cross section, or should reconstruction be considered according to values shown by AASHTO Furthermore, in many cases, accident problems that do exist may not be necessarily attributable to the variables that describe the cross section in the AASHTO Policy (i.e., the width of traveled way and shoulder), but to other factors such as the roadside or horizontal or vertical alignment. However, once a decision is reached to reconstruct rather than resurface or maintain a highway, the current AASHTO Policy applies, which calls for certain minimum cross-sectional dimensions. There is no current evidence that denotes such dimensions produce significant safety benefits; generally, they do have major cost implications. Recent research concerning resurfacing, restoration, and rehabilitation (3R) practices [TRB Special Report 214, (3)] have suggested that acceptable safety and operational experience could be expected on low-volume roadways with lane widths that are somewhat narrower than those proposed in the AASHTO Policy. If this result could be demonstrated through carefully conducted research, the implications would be noteworthy and will be a revision to the values shown in the policy, reflecting greater sensitivity.

2.4 Estimating levels of service (LOS) for freight on rural roads

This paper was presented by Tim Martin (12) (2016) using the analysis and outcomes of a large interview survey for three groups of transport stakeholders (road freight drivers, operators and road infrastructure managers); and (ii) analysis and outcomes of a rural arterial road driver test based circuit survey using both drivers of heavy vehicles and cars, to rate the variations in the three major factors that impact LOS, in order to define the comparative requirements for rural freight. The top three major factors, or road attributes, impacting on LOS for heavy vehicle drivers and freight operators subsequently ranked in the descending order of importance by the interview survey were: (i) ride comfort (road roughness); (ii) road shoulder width and condition; and (iii) road and bridge geometry and general access. The follow-up driver test survey investigated the responses of truck and car drivers to the variations of the above identified three key road inventory attributes. Analysis of sample rating data indicated that LOS ratings provided by car and truck drivers closely followed changes in LOS for roughness, shoulder width and lane width, but truck drivers on average rated LOS lower than it was rated by car drivers. Results also indicated that the use of road surface measures linked to truck ride characteristics, as opposed to the currently used roughness measures such as IRI, which heavily reflects car ride response that would improve the capability of asset managers to deliver LOS better tailored to the needs of freight vehicles.

In order to ensure that the full range of road users are appropriately serviced, road asset managers need to improve their understanding about the requirements of the freight and logistics industry. This can be addressed in part by asking the customers what they want. Customers' requirements can then be translated into quantifiable measures, such as technical levels of service (LOS) relevant to asset management. However, it might be expected that different components of the freight industry may have markedly different needs, leading to conflicts both within the industry and with other road users. In Australia the importance of roads for transporting freight, as assessed by the road freight task (ton-km per head of population), is high relative to other OECD countries, ranking third behind USA and Finland (Martin et al 2016). Similarly, in terms of the road freight task per unit of gross domestic product (GDP), Australia has the highest value of this statistic, relative to all the other OECD countries, indicating the major importance of road freight to the Australian economy. The above statistics show how important it is for Australia to meet road freight transport needs on a largely rural road network. There are nearly 2.5 million licensed heavy vehicle (HV) drivers (10% of Australia's population) available to drive 560 000 registered heavy vehicles (ABS 2012). These numbers also show the significance of the Australian road freight industry in terms of employment.

3 METHODOLOGY

The prepared questionnaire was forwarded to Executive Engineers in the Provencal Road Development Authority of the Western province. Research covers 80 roads spread in all ten divisions in the Western province.

3.1 Questionnaire

The questionnaire mainly consisted of three sections: Part "A", Part 'B" and Part "C" .All the details were collected by directly interviewing the respective engineers, and data were fed to the computer soft copy of the prepared questionnaire during the interviews. Part "A" of the questionnaire was mainly for collecting raw details. It was useful for the identification of the road location, length and width. Part "B" was used for the collection of analytical data. Part "C" was used for the further evaluation of the reasonability of the provided data in part "B" with the actual existing parameters of the roads. Evaluation of the provided information using part "C" simultaneously with the interview going on was effective in the readjustment of the said information more accurately. Specifically during the ranking and weighting of criteria, and also in rating the roads in the provided gradation table. In addition, part "C" had given simple guidelines to the interviewer for easy assessment. A separate questionnaire sheet was issued for each road.(Table 301, 3.2, 3.3 and 3.4)

Table 3.1 Proposed Questionnaire Part A and b

CRITERIA FOR PERFORMANCE EVALUATION OF LOW VOLUME ROADS

PART 'A'

Province	Western Province	District	Colombo
EE Division	Moratuwa	Electorate	Maharagama
		Length	3.6
Road Name	Kottawa - Athrugiriya	carriage way Width	6

PART 'B'

		BASIC DETAILS			SUGGESTION	
A	Vehicle composition	Heavy Vehicle	0.203		Heavy vehicle or	Light vehicle
		Light Vehicle	0.797			
B	RDA classification	C			Class C	Class D
C	Vehicle Speed	Existing	Expected	average time (min)		
	(km/hr.)	24		9		
D	Connectivity	Road Start	Main road		Main road or minor road	
		Road End	Main road		Main road , minor road or dead end	
E	Traffic volume		per day			

Table 3.2 Proposed Questionnaire Part B continue

F	Rating for this road				
		% score			
	Class A	75 -100			In good and acceptable condition
	Class B	50 -75	65		Satisfactory and Regular maintenance is enough
	Class C	25 - 50			poor condition and need improvement
	Class D	0 - 25			Very poor condition and need more attention

G	Ranking of criteria				
	Criteria	Ranking according to effect	% weight for each criteria	Actual parameters	
1	Road width	8	7	6	ranking should be most important criteria as no 1 and others in ascending order
2	Shoulder width	1	22	0.5	
3	Narrow Bends	6	7	2	
4	Right of Way	2	15	5	Weightage should be as a percentage of impotency among the most important 5 criteria
5	Structures	7	9	medium	
6	Passing Bays	5	10	6	
7	Road Furniture	3	15	Low	
8	Access to civic centers	9	2	1	
9	Railway crossing	4	13	1	
			100		

Table 3.3 Proposed Questionnaire Part C

PART 'C'	CRITERIA EVALUATION				SUGGESTION		
							actual Value
1 Road width	Current condition	Low	Medium	High	up to 3.5m	low	
				×	Between 3.5 - 4.0m	medium	6
					above 4.0m	High	
2 Shoulder width	Current condition	Low	Medium	High	up to 0.6m	low	
		×			Between 0.6-1.0m	medium	0.5
					above 1.0m	High	
	●. Shoulder Width required for sudden parking For the safety of pedestrian and drivers ●.Shoulder Width is depend on the type of vehicle. ●. When considering expected width, it should be consider the expected speed and type of vehicle Category						
3 Narrow Bends	Current condition	Low	Medium	High	above 6 No /km	low	
				×	Between 3-6No/km	medium	2
					up to 3 No/km	High	
	If There is more Bends are in the road, Its effecting to the ●. Driving comfortability ●. Reduce the speed ●. Cause for accident						
4 Right of Way						line	
	Current condition	Low	Medium	High	up to 3.0m	low	
				×	Between 3.0 - 5.0m	medium	5
					above 5.0m	High	
	If There is not enough space to improve Road Then need Road side Acquisition and cause high expenditure						
5 Structures	Current condition	Low	Medium	High	Existing structures are steamily not enough	Low	
			×		There some structures but not enough for proper maintain	medium	medium
	●.Extension of culvert ●. Required new Culvert ●. Required new Retaining Walls and toe wal ●. Required concrete drains ●. Required more Earth drains				Existing structures are e but no full fill requireme	High	

Table 3.4 Proposed Questionnaire Part C continue

6 Passing Bays

Current condition	Low	Medium	High
			×

up to 3 No/km	Low	
Between 3-6No/km	medium	6
above 6 No /km	High	

- . Since the Road is narrow, it is required to provide passing bays to pass vehicle and overtake.
- . Even though widen the road, it is required -to provide passing Bays and Bus bays .

7 Road Furniture

Current condition	Low	Medium	High
	×		

Edge line and pedestrian only	Low	
Edge line, pedestrian and sign boards	medium	Low
Edge line, pedestrian and sign boards, street lighting	High	

Road furniture
- . Edge Line and Pedestrian
- . Sign Boards
- . Street lights

8 Access to civic centers

Current condition	Low	Medium	High
	×		

up to 1 No	High	
Between 2-3No	medium	1
above 3 No	Low	

Intended civic centers are
- . School
- . Hospital
- . Main temples
- . Government organizations

9 Railway crossing

Current condition	Low	Medium	High
	×		

up to 1 No	High
Between 2-3No	medium
above 3 No	Low

Table 3.5 Summary of the collected data

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
		COLOMBO DISTRICT																		
		Moratuwa							Colombo						Awissawella					
		Maharagama		Dehiwala		Kesbawa		Morat	Colonnawa		Kotte		Kaduwela		Paduk	Avissawella		Homagama		
	Description	Kottawa - Athrugiriya	Kalalgoda Road	Sri Saranankera Road	Kadawatha Road	Palanwatta - Kosgahahena	Dewananda rd - Piliyandala	Jhon Rodrigo road	Angoda = Walpola - akgona	Galwana - Mulleriyawa - Walpola	Rajagiriya - Madinnagoda	Gangodavila - Udahamulla	Kalapaluwawa - Thalangama	Nawagamuwa - Korathota	Padukka - Gurugoda	Akarawita - Giramulla - Kaluaggala	Kosgama - Pugoda	Habarakada - Ranala	Homagama - Wakanda	Wewalpanawa - Waga
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	**Vehicle composition**	0.2	0.2	0.23	0.19	0.19	0.17	0.17	0.1	0.14	0.11	0.13	0.17	0.15	0.18	0.2	0.27	0.12	0.21	0.17
2	**RDA classification**	C	D	C	C	D	D	D	C	C	C	C	C	C	C	D	C	D	C	D
3	**Vehicle Speed**	24	10	20	10	13	10	7	15	20	20	16	12	22	25	20	12	10	8	13
4	**Traffic volume**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	**Length**	3.6	2	1.65	1.6	3.2	1.3	0.9	2.55	3.35	2.7	1.3	3	3.62	7.6	3.3	4.07	2	1.25	5.6
6	**carriage way Width**	6	4.5	6	5	5	4	4.5	4.2	6	4.5	4.5	5	4	4.5	4	5.5	3.6	4	3.9
Rating for the road																				
Class 1	75 -100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	75	0	0	0
Class 2	50 -75	65	0	65	0	60	0	0	0	60	55	55	50	50	55	50	0	0	50	52
Class 3	25 - 50	0	45	0	50	0	40	45	45	0	0	0	0	0	0	0	0	45	0	0
Class 4	0 - 25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Rated Value	65	45	65	50	60	40	45	45	60	55	55	50	50	55	50	75	45	50	52
Ranking of criteria																				
1	Road width	8	1	6	3	1	1	1	1	5	2	2	1	1	1	1	5	1	2	1
2	Shoulder width	1	2	2	1	4	3	3	2	1	1	1	2	4	2	3	2	4	3	2
3	Narrow Bends	6	5	1	7	3	7	4	6	3	6	6	6	3	7	7	6	3	5	5
4	Right of Way	2	4	8	2	5	4	5	3	2	4	3	3	5	3	2	3	5	1	4
5	Structures	7	7	5	5	7	6	7	7	7	3	7	4	2	4	5	1	2	6	4
6	Passing Bays	5	3	7	4	2	2	2	4	4	5	4	5	6	5	4	7	6	4	3
7	Road Furniture	3	6	3	6	6	5	6	8	6	7	5	7	7	6	6	4	7	7	6
8	Access to civic centers	9	8	4	8	8	8	8	5	8	8	8	8	8	8	8	8	8	8	8
9	Railway crossing	4	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Weighting for criteria																				
1	Road width	7	25	10	17	20	23	23	25	14	25	25	25	25	24	20	13	25	17	22
2	Shoulder width	22	17	16	25	12	18	20	22	20	28	30	17	12	22	15	16	12	15	19
3	Narrow Bends	7	10	18	2	15	4	12	5	16	3	5	10	14	3	8	12	14	11	9
4	Right of Way	15	12	8	20	10	15	10	20	15	10	20	16	10	17	18	15	10	23	15
5	Structures	9	10	11	12	10	8	5	3	6	23	2	15	19	13	12	17	19	9	8
6	Passing Bays	10	13	9	15	18	20	20	15	14	8	10	11	8	10	14	11	8	14	16
7	Road Furniture	15	10	14	8	10	10	8	5	12	2	4	4	7	9	10	9	7	8	5
8	Access to civic centers	2	3	12	1	5	2	2	5	3	1	3	2	5	2	3	7	5	3	3
9	Railway crossing	13	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3
		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Actual existing parameters																				
1	Road width	6	4.5	6	5	5	4	4.5	4.2	6	4.5	4.5	5	4	4.5	4	5.5	3.6	4	3.9
2	Shoulder width	0.5	0.6	0.5	0.3	0.75	0.3	0.3	0.3	0.3	0.3	0.3	0.6	1	0.8	0.9	1	0.6	0.6	0.6
3	Narrow Bends	2	3	3	1	3	3	4	4	4	2	2	3	6	3	2	2	2	3	4
4	Right of Way	5	4	5	4	4.25	4.25	4	3.3	4	3	3.2	3.1	4	4	3.5	5	2.7	3.5	3.5
5	Structures	mediu	mediu	mediu	medi	medi	medi	medi	mediu	mediu	mediur	High	mediur	Low	mediu	mediu	mediu	mediu	mediu	mediur
6	Passing Bays	6	3	6	6	4	4	2	3	3	5	4	3	3	3	3	6	3	3	3
7	Road Furniture	Low	Low	medium	Low	Low	Low	Low	Low	mediu	mediu	mediu	mediu	mediur	Low	Low	mediur	Low	Low	Low
8	Access to civic centers	1	1	4	2	1	1	1	5	1	2	1	2	1	1	1	2	1	1	1
9	Railway crossing	1	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1

3.2 Identification of the Main factors affecting Highway Functional Performance

A sample of 60 roads which were two lane roads with moderate traffic levels, were selected for the study. General characteristics of the roads are given in Table 3.6.

Table 3.6 Summary of the roadway and operating characteristics of the sample roads

Characteristic	Average	Minimum	Maximum
Vehicle Speed (km/h)	17.2	4.8	38.4
Carriageway width (m)	7.5	4.0	12.0
Road width(m)	4.0	3.0	8.0
Shoulder width(m)	0.6	0.3	1.2
Road length (km)	3.6	0.45	11.3
Heavy vehicle %	10%	0.2%	30%

Field inspections were carried out on the sample road sections to identify the main issues prevalent on the roads, and the roadway and operational characteristics such as width, shoulder, average travel speed, road furniture etc. were recorded. The common issues noted during the surveys are as follows,

1. Vertical alignment, horizontal alignment, and curvature transition does not conform to the design requirements
2. Variability in road width
3. Lack of shoulder, or shoulder in poor conditions
4. There is no specified right of way
5. Inadequate provision of structures
6. Lack of or deteriorated pavement markings, road signs and road furniture
7. Lack of passing bays and bus bays where public transport services are in operation

3.3 Selection of Key Factors Affecting Highway Performance

Based on the issues observed, key factors identified were given to the senior engineers in the respective highway agency to rank and assign a weightage out of 100. The weightage and ranking was to be decided to represent their relative importance with respect to making a decision regarding upgrading the particular road. The average weightages were given with respect to the ranking order received from the expert engineers, and is presented in Table 3.7.

The selected engineers are having a thorough knowledge about their divisional roads having observed and maintained them for over a decade. They have a sound knowledge on average parameters of the overall road.

Table 3.7 Ranking and average weightage of the identified factors

Factor	Average weightage	Rank
Road width	20.6	1
Shoulder width	19.0	2
Right of Way	14.4	3
Passing Bays	12.5	4
Highway Structures	10.3	5
Narrow Bends	9.6	6
Road Furniture	9.2	7
Average Speed	4.4	8

Road width refers to the paved or unpaved area that is used by road users. Shoulder width is the paved or unpaved shoulder area on either side of the road. Right of way is the available area for future widening of the road etc. Passing bays refer to the availability of passing bays on narrow roads, especially when there is a bus route etc. Highway structures refer to the bridges, culverts etc. Narrow Bends are defined as those that require motorists to substantially slow down their travel speed in order to take the curve; these are often non-standard horizontal curves. Road furniture refers to the road signs, pavement markings, lighting etc. Average speed is the travel speed measured along the road section during low traffic flow conditions, uncongested flow. Since railway crossings and civic centers are less common in most of the roads, weightages for those were replaced by the speeds. Railway crossings and civic centers were identified to be indirectly related to speed.

The ranking and the relative weightages clearly depict the relevant issues in the provincial level road network. Low weightage is assigned to the factors such as vehicle speed, compared to road width. The shoulder width has also acquired a high level of importance due to its impact on pedestrians and non-motorized traffic as well as the longevity of the pavement sections. The main function of these roads is ‘accessibility’ hence, roadway parameters that affect accessibility, such as road width, shoulder takes precedence over factors that affect mobility, such as narrow bends. Another key factor is the highway structures, such as bridges, culvert, road side slopes which are often neglected or under maintained during routine maintenance operations.

3.4 Assigning Ratings for Each Variable Factor’s Based on their Measured Parameters

The objective of the study was to calculate a performance index. Therefore, the observed parameters of each of the variables that can be either measurable or qualitative must be transferred into a numerical value for the purpose of analysis. The study inspected the variation of each parameter considering values specified by the engineers, and assigned an appropriate rating normalized to give a value less than or equal to 1 for the pre-defined categories for each factor considering their relative impact on the performance of the road. For example, road width exceeding 6m was deemed adequate for the level of mobility expected from the road, therefore a score of 1 was assigned. Relative to that, a road section with less than 3.5m width was given 0.3. The relative score or rating between the categories did not always vary uniformly. When considering the speed, a speed range of 30-50 km/h was given a score of 0.9 relative to the maximum score of 1 given for speeds exceeding 60 km/h. Again, consideration was given to the expected function of the road.

Table 3.8 gives the assigned rating for each factor and their subcategories.

Table 3.8 Assigned rating for each factor and their subcategories

Criteria	Observed parameter categories	Assigned rating
Road width	< 3.5m	0.3
	3.5 - 4.5m	0.5
	4.5 - 6.0m	0.8
	> 6m	1
Shoulder width	< 0.6m	0.3
	0.6-1.0m	0.5
	1.0-1.5m	0.8
	> 1.5m	1
Narrow Bends	> 6 Nos./km	0.1
	3-6 Nos./km	0.3
	< 3 Nos. /km	0.7
	None	1
Right of Way	< 3.0m	0.3
	3.0 - 5.0 m	0.5
	5.0 - 7.0 m	0.8
	7 m	1
Structures	Require minor improvements	1
	Major repair to culverts, bridges etc.	0.6
	Reconstruction / Widening of bridges, reconstruction of culverts etc. required	0.1
Passing Bays	< 3 Nos. /km	0.5
	3-6 Nos./km	0.7
	> 6 Nos. /km	1
Road Furniture	All required road signs and markings are available	1
	Minor improvements/repairs to existing and less than 20% are missing	0.7
	More than 50% are missing and/or require major repair	0.3
	Less than 10% of the required road signs and markings are existing	0
Vehicle Speed	< 10 km/h	0.1
	10-20 km/h	0.3
	20-30 km/h	0.6
	30-50 km/h	0.9
	>50 km/h	1

4 CALCULATION OF GEOMETRIC DESIGN INDEX (GDI)

The weighted rating for each road section was calculated to represent its Geometric Design index (GDI_i) for road *i* as,

$$PI_i = \sum_{k=1}^{n} w_k r_k \quad \text{.......} (4.1)$$

Where,

w_k. - weightage for factor k;

r_k - rating for factor k;

n - Total number of factors.

Table 4.1 Assigned values for Wk

k	w_k
Road width	*20.6*
Shoulder width	*19.0*
Right of Way	*14.4*
Passing Bays	*12.5*
Highway Structures	*10.3*
Narrow Bends	*9.6*
Road Furniture	*9.2*
Average Speed	*4.4*

The ratings for each factor will be assigned based on the data collected during the inventory surveys.

4.1 Case Study

The derived formula is applied to evaluate the Geometric Design index for the selected 60 road sections in the same network. The same road sections are given to the senior engineer in the respective road agency to assign a subjective performance rating (out of

100), giving consideration to the need for upgrades in that road section based on their observation and experiences of the roads concerned. The scale of the rating is defined as follows:

- 75-100: Requires no upgrading: roadway characteristics conform to the design guideline standards, and operating speeds are satisfactory. Regular maintenance is needed for general up keeping.
- 50-75: Sections of the roads need improvements: such as improvements in alignment at curves, introduction of a passing bay, improvement of shoulders etc.
- 25-50: Upgrade required: road widening for a significant proportion, improvements to the road alignment, introducing structures for better widening of roads etc.
- 0-25:Prioritized roads having a need to undergo full improvement.

The ratings assigned by the engineers were compared with the calculated values from the Geometric Design index function given in Equation 4.1. The rating for each factor was assigned, based on the observed roadway characteristics.

The results are shown in Figure 4.1, which indicates a satisfactory fit between the calculated values and the engineers' ratings. The correlation coefficient was 0.931 and RMSE value was 5.72. This shows the proposed model satisfactorily represents the engineers' evaluation.

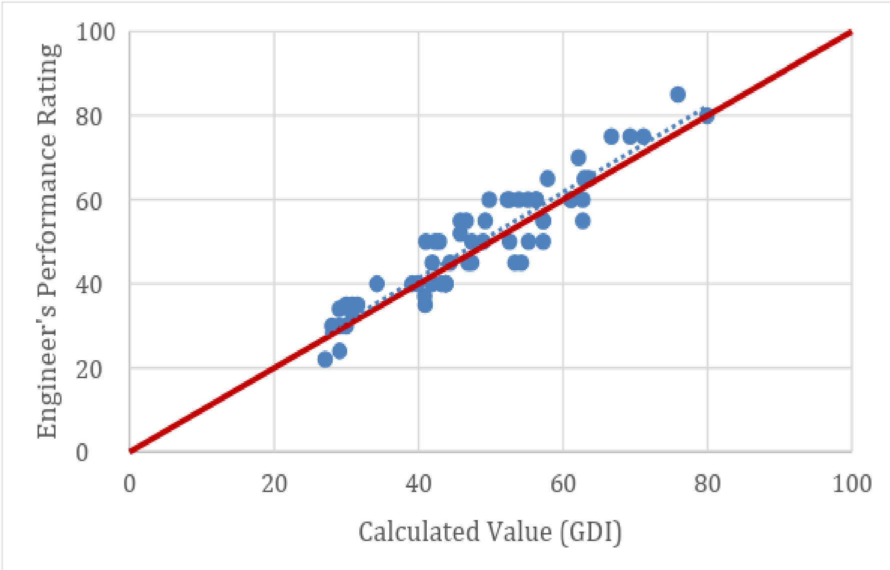

Figure 4.1 Scatter plot of Engineer's performance rating and calculated Geometric Design index (GDI)

4.2 Model Calibration Method

A regression analysis was carried out on the data set using a statistical software to identify the impact of each coefficient on the predicted output of the model at a 95% confidence interval with the null hypothesis (H_0) defined such that a given coefficient is equal to zero.

H_0: Given coefficient is equal to zero

H_1: Given coefficient is not equal to zero

From the analysis the p-values for 'Right of way' and 'Passing bays' were observed to be greater than 0.05. Hence the null hypothesis cannot be rejected. Therefore, the model was reconfigured by eliminating the two coefficients.

To improve the accuracy of the reconfigured model an optimization approach as given in equation 4.2, was applied,

$$\text{Min} \sum (y_i - GDI_i)^2 \quad \text{...} (4.2)$$

Where,

$$GDI_i = \sum_{k=1}^{n} w_k r_k$$

y_i is the Engineers subjective rating of the road section

s.t

$$\sum_{k=1}^{n} w_k$$

$$w_k \geq 0$$

The model coefficients of each factor were optimized to minimize the SSE value between the calculated value and the engineers rating, subjected to the constraints that the summation of coefficients should be equal to 100 (to ensure compatibility with the engineers rating scale) and non-negativity constraints. The model coefficients derived from the optimization approach is compared with the weightages assigned by the engineers in Table 4.2.

Table 4.2 Comparison of Model Coefficients

Factor k	Assigned weightages	Results from the Optimization analysis
Road width	20.6	28.7
Shoulder width	19.0	24.7
Right of Way	14.4	NA
Passing Bays	12.5	NA
Highway Structures	10.3	33.4
Narrow Bends	9.6	4.7
Road Furniture	9.2	3.3
Average Speed	4.4	5.2

The use of new coefficients made slight improvements to the model, with increased the correlation coefficient of 0.939 and a RMSE value of 5.28. This suggests that the model can predict the Geometric Design index of the road section at an acceptable accuracy level with consistency.

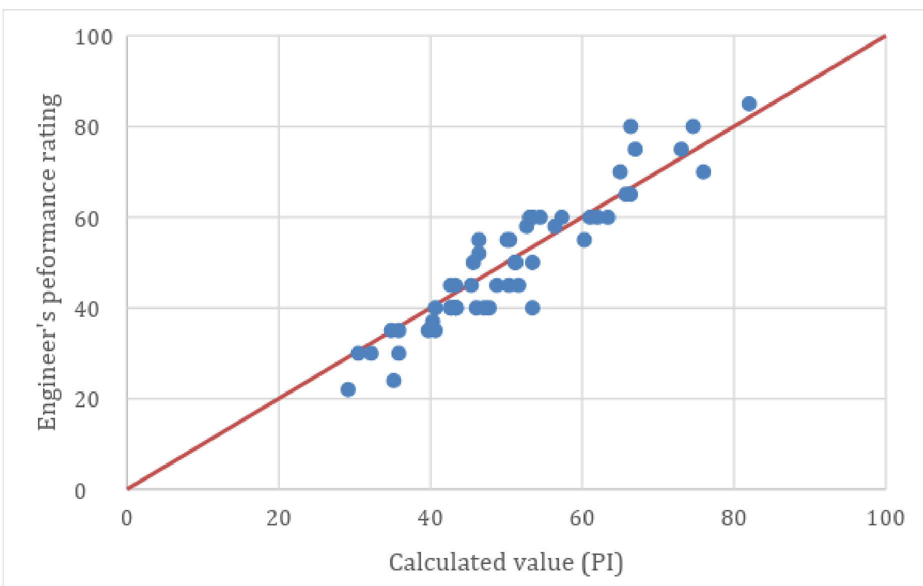

Figure 4.2 Scatter plot of Engineer's performance rating and calculated Geometric Design index using coefficient from the optimization analysis

The final Geometric Design index function is given as shown in Equation 4.3.

$PI = 28.7\, w_R + 24.7\, w_S + 33.4\, w_H + 3.3 w_N + 5.2\, w_F + 5.2\, V$…………………… (4.3)

Where, w_R, w_S, w_H, w_N, w_F, V are the adjustment factor for road width, shoulder condition, highway structures, narrow bends, road furniture and average travel speed respectively.

Further the remaining data were analyzed, and it shows the correlation coefficient of 0.861 and a RMSE value of 7.88 (Figure 4.3). This also implies that the collected data proves the reasonability of the subjected Geometric Design Index for the proposed classifications of low volume roads in the provincial areas.

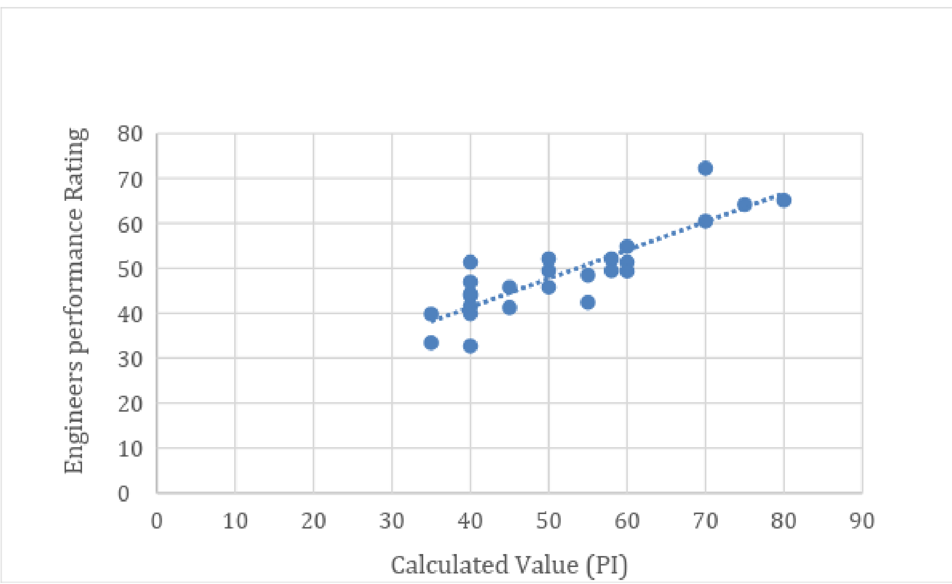

Figure 4.3 Scatter plot of Engineers' performance rating and calculated Geometric Design index using coefficient from the optimization analysis for remaining data

5 CONCLUSION

The study proposes a simple methodology to evaluate the Geometric Design index of roads. It addresses a unique problem encountered by road agencies when selecting roads for upgrading. Conventional level of service analysis methods which focus on traffic operations, and pavement management related methods which focus on the road condition or life cycle costs does not sufficiently address the requirements relevant to this issue, where the focus should be on the need to improve roadway conditions. This is especially relevant to provincial level roads with low to moderate traffic flows. This can be used in the prioritization of the roads in the network for upgrading projects.

This incorporates the roadway and operational parameters that has the most significant impact on the overall performance of the road. The required data can be easily collected using the limited resources available in the provincial level road agencies. The addition of other relevant parameters can be done using the same methodology. The model as shown in the case study can be calibrated to represent the considerations of the respective agency.

The results of the model can be incorporated into the prioritization criterion to make decisions with respect to network upgrade planning. This will eliminate the need to use subjective judgments in the planning process, and will eliminate undue influences that arise when making prioritization decisions, and will evaluate the overall network performance. Therefore, the proposed method, offers an objective method which requires minimal resources to be implemented in the planning process, that can be used as a tool to prioritize road upgrading projects.

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APPENDIX 01

SAMPLE OF QUESTIONNAIRE REPRESENTING THREE DISTRICT

1. Gangodavila – Udahamulla Road in *Colombo* district

CRITERIA FOR PERFORMANCE EVALUATION OF LOW VOLUME ROADS

PART 'A'

Province	Western Province	District	Colombo
EE Division	Colombo	Electrate	Kotte
		Length	1.3
Road Name	Gangodavila - Udahamulla	carriage way Width	4.5

PART 'B'

	BASIC DETAILS				SUGGESTION	
A Vehicle category	Heavy Vehic	0.128			Heavy vehicle or	Light vehicle
B RDA classification	C				Class C	Class D
B Vehicle Speed	Existing	Expected		averagetime (min)		
(km/hr.)	16			5		
C Connectivity	Road Start	Main road			Main rd or minor road	
	Road End	Main road			Main rd , minor road or dead end	
d Traffic volume		per day				

e *Rating for this road*

	% score		
Class A	75 - 100		In good and acceptable condition
Class B	50 - 75	55	Satisfactory and Regular maintenance is enough
Class C	25 - 50		poor condition and need improvement
Class D	0 - 25		Very poor condition and need more attention

f Ranking of criteria

	Criteria	Ranking according to effect	% weight for each criteria	Actual parametrs
1	Road width	2	25	4.5
2	Shoulder width	1	30	0.3
3	Narrow Bends	6	5	2
4	Right of Way	3	20	3.2
5	Structures	7	2	High
6	Passing Bays	4	10	4
7	Road Furniture	5	4	medium
8	Access to civic centers	8	3	1
9	Railway crossing	9	1	1
			100	

ranking should be most important criteria as no 1 and others in ascending order

Weightage should be as a percentage of importancy among the most important 5 criterias

PART 'C' CRITERIA EVALUATION | **SUGGESTION**

1 Road width

Current condition	Low	Medium	High
		×	

up to 3.5m	low	
Between 3.5 - 4.0m	medium	4.5
above 4.0m	High	

2 Shoulder width

Current condition	Low	Medium	High
	×		

up to 0.6m	low	
Between 0.6-1.0m	mediam	0.3
above 1.0m	High	

- . Shoulder Width required for sudden parking. For the safety of pedestrian and drivers
- .Shoulder Width is depend on the type of vehicle.
- . When considering expected width, it should be consider the expected speed and type of vehicle Category

3 Narrow Bends (Visibility)

Current condition	Low	Medium	High
			×

above 6 No /km	low	
Between 3-6No/km	medium	2
up to 3 No/km	High	

If There is more Bends are in the road, Its effecting to the

- . Driving comfortability
- . Reduce the speed
- . Cause for accident

4 Right of Way

Current condition	Low	Medium	High
		×	

from center line		
up to 3.0m	low	
Between 3.0 - 5.0m	medium	3.2
above 5.0m	High	

If There is not enough space to improve Road Then need Road side Acquisition and caurse high expenditure

5 Structures

Current condition	Low	Medium	High
			×

Existing structures are streamly not enough	Low	
There some structures but not enough for proper maintain	medium	High
Existing structures are enou but no full fill requirement	High	

- .Extension of culvert
- . Required new Culvert
- . Required new Retaining Walls and toe walls
- . Required concrete drains
- . Required more Earth drains

6 Passing Bays

Current condition	Low	Medium	High
		X	

up to 3 No/km	Low	
Between 3-6No/km	medium	4
above 6 No /km	High	

- . Since the Road is narrow, it is required to provide passing bays to pass vehicle and overtake.
- . Even though widen the road, it is required -to provide passing Bays and Bus bays .

7 Road Furniture

Current condition	Low	Medium	High
		X	

Edge line and pedestrian only	Low	
Edge line, pedestrian and sign boards	medium	medium
Edge line, pedestrian and sign boards, street lighting	High	

Road furniture

- . Edge Line and Pedestrian
- . Sign Boards
- . Street lights

8 Access to civic centers

Current condition	Low	Medium	High
	X		

up to 1 No	Low	
Between 2-3No	medium	1
above 3 No	High	

Intended civic centers are

- . School
- . Hospital
- . Main temples
- . Government organizations

2.0 Kothalwala – Alothiyawa Road in *Kaluthara* District

CRITERIA FOR PERFORMANCE EVALUATION OF LOW VOLUME ROADS

PART 'A'

Province	Western Province	**District**	Kaluthara
EE Division	Kaluthara	**Electrate**	Bandaragama
		Length	2.4
Road Name	Kothalawal - Alothiyawa	**carriage way Width**	3.8

PART 'B'

		BASIC DETAILS				SUGGESTION	
A	Vehicle composition	Heavy Vehic	0.044			Heavy vehicle or	Light vehicle
		Light Vehicle					
B	RDA classification	D				Class C	Class D
B	Vehicle Speed (km/hr.)	Existing	Expected		average time (min)		
		14			10		
					12		
C	Connectivity	Road Start	Main road			Main rd or minor road	
		Road End	Main Road			Main rd , minor road or dead end	
d	Traffic volume		per day				
e	***Rating for this road***						
		% score					
	Class A	75 -100				In good and acceptable condition	
	Class B	50-75				Satisfactory and Regular maintenance is enough	
	Class C	25 - 50	50			poor condition and need improvement	
	Class D	0 - 25				Very poor condition and need more attention	

f Ranking of criteria

	Criteria	Ranking according to effect	% weight for each criteria	Actual parametrs	Suggestion
1	Road width	1	23	3.8	ranking should be most important criteria as no 1and others in ascending order
2	Shoulder width	2	20	1	
3	Narrow Bends	5	10	3	
4	Right of Way	3	16	3.5	Weightage should be as a percentage of importancy among the most important 5 criterias
5	Structures	6	9	medium	
6	Passing Bays	4	14	3	
7	Road Furniture	7	5	medium	
8	Access to civic centers	8	3	1	
9	Railway crossing	9	0		
			100		

PART 'C'	CRITERIA EVALUATION				SUGGESTION		
1 Road width							
	Current condition	Low	Medium	High	up to 3.5m	low	
		×			Between 3.5 - 4.0m	medium	3.8
					above 4.0m	High	
2 Shoulder width	Current condition	Low	Medium	High	up to 0.6m	low	
			×		Between 0.6-1.0m	mediam	1
					above 1.0m	High	
	•. Shoulder Width required for sudden parking. For the safety of pedestrian and drivers •.Shoulder Width is depend on the type of vehicle. •. When considering expected width, it should be consider the expected speed and type of vehicle Category						
3 Narrow Bends (Visibility)	Current condition	Low	Medium	High	above 6 No /km	low	
			×		Between 3-6No/km	medium	3
					up to 3 No/km	High	
	If There is more Bends are in the road, Its effecting to the •. Driving comfortability •. Reduce the speed •. Cause for accident						
4 Right of Way						from center line	
	Current condition	Low	Medium	High	up to 3.0m	low	
			×		Between 3.0 - 5.0m	medium	3.5
					above 5.0m	High	
	If There is not enough space to improve Road Then need Road side Acquisition and caurse high expenditure						
5 Structures	Current condition	Low	Medium	High	Existing structures are streamly not enough	Low	
			×		There some structures but not enough for proper maintain	medium	medium
	•.Extension of culvert •. Required new Culvert •. Required new Retaining Walls and toe walls •. Required concrete drains •. Required more Earth drains				Existing structures are enou[g] but no full fill requirement	High	

6 Passing Bays

Current condition	Low	Medium	High
	X		

up to 3 No/km	Low	
Between 3-6No/km	medium	3
above 6 No /km	High	

- . Since the Road is narrow, it is required to provide passing bays to pass vehicle and overtake.
- . Even though widen the road, it is required -to provide passing Bays and Bus bays .

7 Road Furniture

Current condition	Low	Medium	High
		X	

Edge line and pedestrian only	Low	
Edge line, pedestrian and sign boards	medium	medium
Edge line, pedestrian and sign boards, street lighting	High	

Road furniture

- . Edge Line and Pedestrian
- . Sign Boards
- . Street lights

8 Access to civic centers

Current condition	Low	Medium	High
	X		

up to 1 No	Low	
Between 2-3No	medium	1
above 3 No	High	

Intended civic centers are

- . School
- . Hospital
- . Main temples
- . Government organizations

3.0 Kongasdeniya – Mallahawa Road in *Gampaha* District

CRITERIA FOR PERFORMANCE EVALUATION OF LOW VOLUME ROADS

PART 'A'

Province	Western Province	**District**	Gampaha
EE Division	Nittambuwa	**Electrate**	Meerigama
		Length	4.7
Road Name	Kongasdeniya - Mallahawa	**carriage way Width**	4

PART 'B'

		BASIC DETAILS			SUGGESTION	
A	Vehicle composition	Heavy Vehic	0.02		Heavy vehicle or	Light vehicle
		Light Vehicl	90			
B	RDA classification	D			Class C	Class D
B	Vehicle Speed (km/hr.)	Existing	Expected	average time (min)		
		24		12		
C	Connectivity	Road Start	Main road		Main rd or minor road	
		Road End	Main road		Main rd, minor road or dead end	
d	Traffic volume		per day			

e ***Rating for this road***

	% score		
Class A	75 - 100		In good and acceptable condition
Class B	50 - 75		Satisfactory and Regular maintenance is enough
Class C	25 - 50	45	poor condition and need improvement
Class D	0 - 25		Very poor condition and need more attention

f **Ranking of criteria**

	Criteria	Ranking according to effect	% weight for each criteria	Actual parame trs
1	Road width	2	19	4
2	Shoulder width	1	26	0.6
3	Narrow Bends	4	15	3
4	Right of Way	5	10	4
5	Structures	6	7	medium
6	Passing Bays	3	17	2
7	Road Furniture	7	5	Low
8	Access to civic centers	8	1	1
9	Railway crossing	9	0	
			100	

ranking should be most important criteria as no 1 and others in ascending order

Weightage should be as a percentage of importancy among the most important 5 criterias

PART 'C'	CRITERIA EVALUATION	SUGGESTION

1 Road width

Current condition	Low	Medium	High
		×	

up to 3.5m	low	
Between 3.5 - 4.0m	medium	4
above 4.0m	High	

2 Shoulder width

Current condition	Low	Medium	High
	×		

up to 0.6m	low	
Between 0.6-1.0m	mediam	0.6
above 1.0m	High	

- . Shoulder Width required for sudden parking. For the safety of pedestrian and drivers
- .Shoulder Width is depend on the type of vehicle.
- . When considering expected width, it should be consider the expected speed and type of vehicle Category

3 Narrow Bends

Current condition	Low	Medium	High
		×	

above 6 No /km	low	
Between 3-6No/km	medium	3
up to 3 No/km	High	

If There is more Bends are in the road, Its effecting to the

- . Driving comfortability
- . Reduce the speed
- . Cause for accident

4 Right of Way

Current condition	Low	Medium	High
		×	

	from center line	
up to 3.0m	low	
Between 3.0 - 5.0m	medium	4
above 5.0m	High	

If There is not enough space to improve Road Then need Road side Acquisition and caurse high expenditure

5 Structures

Current condition	Low	Medium	High
		×	

Existing structures are streamly not enough	Low	
There some structures but not enough for proper maintain	medium	mediu m
Existing structures are enou but no full fill requirement	High	

- .Extension of culvert
- . Required new Culvert
- . Required new Retaining Walls and toe walls
- . Required concrete drains
- . Required more Earth drains

6 Passing Bays

Current condition	Low	Medium	High
	X		

up to 3 No/km	Low	
Between 3-6No/km	medium	2
above 6 No /km	High	

- . Since the Road is narrow, it is required to provide passing bays to pass vehicle and overtake.
- . Even though widen the road, it is required -to provide passing Bays and Bus bays .

7 Road Furniture

Current condition	Low	Medium	High
	X		

Edge line and pedestrian only	Low	
Edge line, pedestrian and sign boards	medium	Low
Edge line, pedestrian and sign boards, street lighting	High	

Road furniture

- . Edge Line and Pedestrian
- . Sign Boards
- . Street lights

8 Access to civic centers

Current condition	Low	Medium	High
	X		

up to 1 No	Low	
Between 2-3No	medium	1
above 3 No	High	

Intended civic centers are

- . School
- . Hospital
- . Main temples
- . Government organizations

APPENDIX 02

PHOTOS INDICATING NATURE OF PROVINCIAL ROADS

Lack of passing bays on narrow roads

Narrow Bends

Poor shoulder conditions

Limited road width

Inadequate highway structures

Right of way limitations

Inadequate road furniture

Figure 1. Common issues prevalent in provincial road network.