

**APPLICABILITY OF SUSPENSION BRIDGES
FOR TRANSPORTATION IN RURAL AREAS
IN SRI LANKA.**

R.S.K.Thrimavithana

Thesis submitted to the in partial fulfillment of the requirements for the Degree of Master of
Engineering in Structural Engineering Design.

Department of Civil Engineering

University of Moratuwa

Sri Lanka.

September 2009

93916

ABSTRACT

For the rapid economic development of rural villages in Sri Lanka the transportation facilities should be upgraded. In this context, one of the bottlenecks is the need of large number of bridges which is a costly item. Therefore the solution given at the moment is the provision of pedestrian suspension bridges, which can be used only for passengers. Almost all the suspension foot bridges available might not withstand dynamic forces such as wind induced dynamic forces and human induced dynamic forces. The biggest issue on these bridges is the safety. For these locations the development of a suspension bridge that can handle both human and cycles loads safely, will be a great advantage. These structures however are always lively with low stiffness, low mass, low damping and low natural frequencies.

A conceptual study has been carried out to investigate the dynamic characteristics of slender suspension foot bridges under human induced dynamic loads. As the first step, some places where suspension foot bridges are located were visited. While crossing the bridge, during the site visit it was felt that those existing bridges are not comfortable and identified as low safety. Different types of suspension bridges and different structural models were observed. Then existing suspension foot bridges were modeled using both software PROKON (V-2.1) and SAP 2000 (V9.3). Under the first step it was tried to introduce different modifications to existing bridges to satisfy comfort and more structural stability with safety. Since these bridges are having low structural factor of safeties, no modifications are allowed.

ACKNOWLEDGEMENT

I am extremely grateful and deeply indebted to my principal supervisor Prof. M.T.R.Jayasinghe for his enthusiastic and expertise guidance, constructive suggestions, encouragements throughout the course of study and valuable assistance in many ways. His immense patience and availability for comments whenever approached even amidst his heavy pressure of work throughout the entire period of study deserve grateful appreciation. I would like to express my sincere gratitude to all other lecturers who taught me during the period of study.

Also the guidance and the help given by the Principal Structural Engineer- Mott MacDonalds, UAE, Abdul Wahab shall be highly appreciated. I must thank to all of my friends who helped me in different ways and means to bring this study success.

Finally I wish to express my appreciation to my family for their support encouragement and patience.



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

Contents

Abstract

Acknowledgement

Table of contents

List of figures

List of tables

1.0	Introduction	1
1.1	Background	1
1.2	Objectives of the study	3
1.3	Methodology	3
1.4	Main findings of the study	4
2.0	Literature review	6
2.1	Historical development of suspension bridges	6
2.2	Theoretical background of suspension bridges	10
2.3	Types of suspension bridges	13
2.4	Measures against excessive vibration of slender foot bridges	14
2.5	BS 5400 recommendations on human induced vibrations	16
2.6	Aerodynamic effect and criteria for the design	16
2.7	Seismic analysis criteria on suspension bridge	19
3.0	Review on existing passenger foot bridges in Sri Lanka	21
4.0	Load on the foot bridge model considered	27
4.1	Dead load	27
4.2	Imposed load	27
4.3	Wind loads	27
4.4	Dynamic loads	29
5.0	Development of suspension bridge model for passenger and light vehicular traffic	30
5.1	General	30
5.2	The cable	31
5.3	The stiffening girder	32
5.4	The towers	34
5.5	The hangers	35
5.6	The anchor block	36
6.0	Computer modeling of suspension bridge models considered	38
6.1	Model 1 - Concept	38
6.2	Model 2 - Concept	40
6.3	Model 3 - Concept	42
6.4	Model 4 - Concept	44
6.5	Model 5 - Concept	45

Contents

Abstract

Acknowledgement

Table of contents

List of figures

List of tables

1.0	Introduction	1
1.1	Background	1
1.2	Objectives of the study	3
1.3	Methodology	3
1.4	Main findings of the study	4
2.0	Literature review	6
2.1	Historical development of suspension bridges	6
2.2	Theoretical background of suspension bridges	10
2.3	Types of suspension bridges	13
2.4	Measures against excessive vibration of slender foot bridges	14
2.5	BS 5400 recommendations on human induced vibrations	16
2.6	Aerodynamic effect and criteria for the design	16
2.7	Seismic analysis criteria on suspension bridge	19
3.0	Review on existing passenger foot bridges in Sri Lanka	21
4.0	Load on the foot bridge model considered	27
4.1	Dead load	27
4.2	Imposed load	27
4.3	Wind loads	27
4.4	Dynamic loads	29
5.0	Development of suspension bridge model for passenger and light vehicular traffic	30
5.1	General	30
5.2	The cable	31
5.3	The stiffening girder	32
5.4	The towers	34
5.5	The hangers	35
5.6	The anchor block	36
6.0	Computer modeling of suspension bridge models considered	38
6.1	Model 1 - Concept	38
6.2	Model 2 - Concept	40
6.3	Model 3 - Concept	42
6.4	Model 4 - Concept	44
6.5	Model 5 - Concept	45

7.0	Results and summary	47
7.1	Analysis results	50
7.2	Conclusion	52
7.3	Suggestion for future works	52
8.0	References	54

Appendix

1. Output data for bridge span 45m - model-1
2. Output data for bridge span 45m - model-2
3. Output data for bridge span 45m - model-3
4. Output data for bridge span 45m - model-4
5. Output data for bridge span 45m - model-5
6. Output data for bridge span 60m - model-1
7. Output data for bridge span 60m - model-2
8. Output data for bridge span 60m - model-3
9. Output data for bridge span 60m - model-4
10. Output data for bridge span 60m - model-5
11. Output data for bridge span 75m - model-1
12. Output data for bridge span 75m - model-2
13. Output data for bridge span 75m - model-3
14. Output data for bridge span 75m - model-4
15. Output data for bridge span 75m - model-5 and the computer output results

LIST OF FIGURES

Fig. 2.1.1 : Niagara Falls Bridge	09
Fig. 2.1.1 : Old St. Clair Bridge	10
Fig. 2.2.1 : Elevation of typical suspension bridge	12
Fig. 2.2.2 : 3D view of typical suspension bridge	12
Fig 2.2.3 : Types of suspension bridges.	13
Fig-3.1 Suspension footbridge at Hiniduma across Gin ganga	23
Fig-3.2 Suspension footbridge at Kosgulana across Kukule ganga	24
Fig-3.3 Suspension footbridge at Peradeniya across Mahaweli ganga	25
Fig-3.4 Suspension footbridge at Nagoda across Gin ganga	26
Fig 6.1.1 : Model-1 of proposed foot bridge structure	39
Fig 6.1.2 : Model-1 (PROKON) of proposed foot bridge structure	40
Fig 6.2.1 : Model-2 of proposed foot bridge structure	41
Fig 6.2.2 : Model-2 (PROKON) of proposed foot bridge structure	42
Fig 6.3.1 : Model-3 of proposed foot bridge structure	43
Fig 6.3.2 : Model-3 (PROKON) of proposed foot bridge structure	43
Fig 6.4.1 : Model-4 of proposed foot bridge structure	44
Fig 6.4.2 : Model-4 (PROKON) of proposed foot bridge structure	45
Fig 6.5.1 : Model-5 of proposed foot bridge structure	46
Fig 6.5.2 : Model-5 of proposed foot bridge structure	46

LIST OF TABLES

Table 5.1.1 Details of suspension bridges already constructed in Sri Lanka	30
Table 7.1 : Dimensions of the deck depending on the span	47
Table 7.2 : Member sizes of the deck depending on the span and the depth	48
Table 7.3 : Deflections of the deck depending on the span and the model	49



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk