

LB/DON/60/02

⑦

REHABILITATION OF STEEL BRIDGES THROUGH PRESTRESSING

A Thesis submitted for the partial fulfillment
Of the Degree of Master of Engineering in
Structural Engineering Design

Submitted by



University of Moratuwa, Sri Lanka.

Electronic Theses & Dissertations
www.theses.moratuwa.lk

B.V.D.N. CHANDRASIRI

FEBRUARY 2002

ප්‍රධාන කාර්යාලය
මොරටුව විශ්ව විද්‍යාලය, ශ්‍රී ලංකාව
මොරටුව

Supervised by

Dr. M.T.R. JAYASINGHE

Senior Lecturer

Department of Civil Engineering

University of Moratuwa

074549



University of Moratuwa

624 "02"
624.2/8

74549

TH

74549

ABSTRACT

Throughout the world, bridges are being newly built, repaired, strengthened, replaced to provide essential infrastructure facilities for the Development. Sri Lanka is no exception. The cost of bridging has become a heavy burden to the National Economy in Sri Lanka, due to the continuing demand for access and mobility to under developed or developed areas respectively.

The bridge stock in Sri Lanka mainly comprises of small to medium span bridges, built using steel and/or concrete. Almost all the Medium Span Bridges are steel truss bridges.

The Steel Bridges are generally more than 50 years old and are in need of repair/strengthening or replacement.

Sri Lanka has successfully repaired/strengthened some of the Steel Bridges in the past, though now they are replaced due to their insufficient width, more often than not. This is primarily due to the fact that the steel truss bridges are not easily amenable to widening, economically.

In this research, it is shown that the steel truss bridges could be widened to meet the current traffic demand, even without strengthening, due to the large factor of safety, used in the original designs, and the new knowledge gained in the material and structural behavior of these bridges.

In bridges where such a large factor of safety is not in-built, it is shown that prestressing could strengthen the bridge after the widening, economically.


Further, it is shown that the life span of the widened bridge could be prolonged after the widening due to the application of the prestressing force, which reduces the probability of fatigue failure.

ACKNOWLEDGEMENTS

Sincere thanks are due to the Project Supervisor Dr. M.T.R. Jayasinghe for his able guidance and the friendly encouragement extended to me, without which this thesis could not be a reality.

I wish to thank the Vice Chancellor, Dean Faculty of Engineering and Head, Department of Civil Engineering, of the University of Moratuwa for allowing me to carry on this project utilizing the facilities available at the University.

Thanks are especially due to the course/research coordinator Dr. Mrs. P. Hettiaarachchi and all the Lecturers of the Post Graduate Course on Structural Engineering Designs, who helped us to develop our knowledge on the subject.

Finally I wish to thank  the Management of the Road Development Authority for financing my participation on the post graduate course and providing all the facilities required for the preparation of this thesis.

B.V.D.N. CHANDRASIRI
Road Development Authority
Sethsiripaya
Battaramulla.

Contents

Abstract	i
Acknowledgements	ii
Contents	iii
List of Illustrations	v
Notations	vii
Chapter 1.0 Introduction	1
1.1 General	1
1.2 Local Scenario on Steel Bridges	2
1.3 Need for rehabilitation	3
1.4 Objectives of the study	4
1.5 Methodology	5
1.6 Main Findings	6
1.7 Arrangement of the report	6
Chapter 2.0 Literature Review	11
2.1 General	11
2.1.1 Need for Rehabilitation	11
2.1.2 Causes of Deterioration	12
2.1.3 The Meaning of Rehabilitation	13
2.1.4 Use of Prestressing for rehabilitation	14
2.2 Strengthening Methods for Steel Bridges	15
2.2.1 Increasing Member Cross Section	15
2.2.2 Adding/Replacing Members	16
2.2.3 Adding supports or moving supports	18
2.2.4 Providing Continuity	18
2.2.5 Providing Composite Action	19
2.2.6 Providing Lateral Support or Stiffness	20
2.2.7 Providing Post Tension	21
2.2.8 Modifying Load Paths	25
2.2.9 Reducing Dead Load	25
2.3 Summary	28

Chapter 3.0	Applicability to the Sri Lankan Scenario.....	38
3.1	General.....	38
3.2	Recent Case Studies.....	41
3.3	Determination of economic feasibility	43
3.4	Summary.....	46
Chapter 4.0	External Prestressing as a strategy for Bridge Strengthening.....	63
4.1	Case Study	63
4.2	The details of Case Study.....	65
4.2.1	Strength	65
4.2.2	Constructability	66
4.3	Summary.....	67
Chapter 5.0	Cost Study.....	79
5.1	General.....	79
5.2	Cost study.....	80
5.3	Summar.....	82
Chapter 6.0	Conclusions and Future Work.....	87
6.1	Conclusion.....	87
6.2	Future work.....	88
List of Reference	.....	89
Appendix	.....	94



List Of Illustrations

Charts

Chart I	8
Chart II	9
Chart III	10
Flow Chart 3.1	47
Flow Chart 3.2	48

Figures

Figure 2.1.....	30
Figure 2.2.....	30
Figure 2.3.....	32
Figure 2.4.....	32
Figure 2.5.....	33
Figure 2.6.....	34
Figure 2.7.....	34
Figure 2.8.....	34
Figure 2.9.....	35
Figure 2.10.....	36
Figure 2.11.....	37
Figure 4.1.....	69
Figure 4.2.....	70
Figure 5.1.....	85
Figure 5.2.....	86

Tables

Table 4.1	71
Table 5.1	83
Table 5.2	84

Plates

Plate 3.1	50
Plate 3.2.....	52
Plate 3.3.....	53
Plate 3.4.....	54
Plate 3.5.....	55
Plate 3.6.....	57
Plate 3.7.....	58
Plate 3.8.....	59
Plate 3.9.....	60
Plate 3.10.....	61
Plate 3.11.....	62
Plate 4.1.....	73
Plate 4.2.....	74
Plate 4.3.....	75
Plate 4.4.....	76
Plate 4.5.....	77
Plate 4.6.....	78



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

Notations

Z_{req}	.....	Is the required Section Modulus
l_e	.....	Is the Effective length of compression chord
δ	.....	Is the lateral deflection of the U frame at the level of the centroid of the chord due to a unit lateral force
d_1	.....	Is the distance from the centroid of compressive chord to the nearer face of the cross member of the U frame
d_2	.....	Is the distance from the centroid of compressive chord to the centroidal axis of the cross member of the U frame
E	.....	Is the Young's Modulus of the material
I_1	.....	Is the second moment of area of the web member forming an arm of the U frame
I_2	.....	Is the second moment of area of the cross member
u	.....	0.5 for outer beam and 0.33 for inner beam
s	.....	Is the distance between U-frames
f	.....	Is the flexibility of the joint
k_3	.....	Is taken as 1.0
I_c	.....	Is the second moment of area of the compression chord
A	.....	Is the cross sectional area
I	.....	Is the second moment of area
λ_{LT}	.....	Is the slenderness ratio
r	.....	Is the radius of gyration
I_{xx}	.....	Is the the second moment of area on major axis
I_{yy}	.....	Is the the second moment of area on minor axis
r_{yy}	.....	Is the radius of gyration on minor axis
σ_c	.....	Is the allowable compressive stress
σ_y	.....	Is the Yield stress of the material

