DEVELOPMENT OF GUIDELINES FOR ANALYSIS, DESIGN, CONSTRUCTION AND REPAIR OF MASONRY ARCHES

by

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This thesis was submitted to the Department of Civil Engineering of the University of Moratuwa in partial fulfillment of the requirements for the Degree of Master of Engineering in Structural Engineering Design

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August 2001

SUMMARY

Masonry arch has a long history of usage since it was first used by Egyptians 5000 years ago. The 12th & 13th centuries saw the greatest developments in stone masonry arch in U.K. and Europe. It possessed great advantage in structural applications, but its usage has been retarded with the advent of tension carrying material. Nowadays it is only viable for small span bridges where aesthetic considerations govern the choice. However in Sri Lanka too, a large number of old masonry arches, some of medium to long span, are still in use as road bridges or rail bridges. Therefore, Bridge Engineers still have to deal with them and their task is extremely difficult due to lack of design or other guidance through Codes of Practice. Hence, a comprehensive study of masonry arch bridges covering analysis, design, construction, maintenance and repair was considered opportune to provide the much needed guidance.

In the analytical study, previous theoretical studies available in literature were reviewed and fundamental theories, which have been derived, were used for the computation of influence lines for moving loads on masonry arch bridges. Elastic method was found to be the most satisfactory method and guidance was developed for the conduct of vertical and lateral load analysis. For the engineers who favour the use of the finite element technique, studies were conducted to determine a suitable element and mesh capable of providing an economical solution, which does not deviate by no more than 5% from the exact solution. The MEXE method was found to be the best approach for routine strength checking of existing masonry arch bridges, and its details were presented for local usage. Study of secondary effects led to the development of methods to consider secondary effects in masonry circular arch analysis from basic principles and also using finite element techniques.

Bridges in use where structural construction drawings are available were studied in detail. The available type drawings were checked for viability for suitable modifications if necessary, and all available empirical rules for proportioning arches and various design approaches were reviewed. The study led to the recommendation of an empirical formula for proportioning the arch, as well as a detailed design procedure for the maximum utilization of the BS 5628, which gives little specific guidance on design of masonry arch bridges.

Previous construction methods available in literature for arch construction now long forgotten were studied. This review led to the recommendation of methods suitable for Sri Lankan conditions.

Finally, various defects and repair methods recommended in the available literature were studied in detail, and repair methods suitable for Sri Lankan conditions were recommended.

ACKNOWLEDGEMENTS

The Author expresses her sincere gratitude to the following.

Prof. N.A.D.R. de Alwis, Head, Department of Civil Engineering University of Moratuwa for giving an opportunity to follow the M.Eng. Degreee Course,

Supervisor of this project Professor S.R. de S. Chandrakeerthi for his excellent guidance, inspiration and advice throughout the project, and for the critical assessment and refinement of the dissertation,

Dr. (Mrs.) M.T.P. Hettiarachchi, the Course Coordinator for her encouragement and guidance throughout the study; Mrs. D. Nasnayakkara of the staff for her valuable assistance in computing the project work; Computer Staff of University of Moratuwa Civil Engineering Department for their assistance provided from the Computer laboratory,

Road Development Authority for sponsoring this work and providing relevant technical information,

Road Development Authority officials who helped in numerous ways in the preparation of my thesis.

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TERMINOLOGY

Some of the more commonly used technical terms used in relation to masonry arches are as follows:

Skewback - This is the surface (generally inclined) upon which the arch ring or rib rests. This surface is the assumed dividing line between arch and abutment and is a purely imaginary plane.

Crown - The highest point on the centre line of the arch ring.

Spring line - The intersection of skewback and soffit.

Soffit - The under surface of arch ring.

Intrados - The curve of intersection of the soffit plane and a vertical plane parallel to the centre line of the roadway.

Extrados - The intersection of the curved back or upper surface of the arch with a vertical plane parallel to the centerline of the roadway.

Span - The clear distance between spring lines measured horizontally and parallel to the centre line of the roadway.

Rise - The vertical distance between the spring line and the intrados at the crown.

Spandrel - That portion of the structure lying above the arch ring.

NOTATIONS

R	-	Radius of the arch
U	-	Strain energy
E	-	Modulus of elasticity
I	-	Moment of Inertia
M	-	Bending moment
H	-	Horizontal thrust
V	-	Vertical reaction
L	-	Span of the arch
T	-	Torsional moment
h	-	Rise of the arch
a	-	Horizontal distance from end of arch to load point