ANALYSIS AND DESIGN OF INTERCONNECTED SKEW GIRDER BRIDGES

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THESIS SUBMITTED

FOR THE AWARD OF THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN

CIVIL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY, DELHI
NEW DELHI- 110029
INDIA

1975

C E R T I F I C A T E

This is to certify that the thesis entitled, 'Analysis and Design of Interconnected Skew Girder Bridges' being submitted by Sri Ramji Agrawal to the Indian Institute of Technology, Delhi for the award of Degree of Doctor of Philosophy in Civil Engineering, is a record of bonafide research work carried out by him. Sri Ramji Agrawal has worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis, which, to my knowledge, has reached the requisite standard.

The results contained in this thesis have not been submitted, in part or in full, to any other University or Institute for the award of any degree or diploma.

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ACKNOWLEDGEMENTS

This thesis owes its materialization to the untiring efforts of Dr.C.S.Surana, who sacrificed so much of his valuable time and leisure in explaining the many intriguing facets of this problem. The author can record only his utmost gratitude for the kind help, guidance and constant encouragement throughout this investigation.

The author is deeply grateful to Prof.B.M.Ahuja for providing his inspiring guidance and valuable suggestions during the experimental stage of the work. The author is also thankful to Prof. Saranjit Singh, Prof.K.Seetharamulu, Prof.A.K.Basu and Dr.S.Krishnamoorthy of the Department of Civil Engineering for providing necessary laboratory and departmental facilities.

The author thankfully acknowledges the financial support given by the Council of Scientific and Industrial Research for this project.

The author is highly indebted to Prof.N.Roy, Prof.R.B.Singh Prof.Ashok Kumar and Prof.V.B.Mishra of Civil Engineering Department, I.T.,B.H.U.,Varanasi, for taking interest in the work and providing him with an opportunity to work at I.I.T., Delhi.

For my dear friends Sarvsri R.N.Munshi, A.M.Antani, B.B.Bansal, S.K.Mishra, J.N.Dube, A.K.Nagpal, Anil Kumar,

SYNOPSIS

Numerous analytical and experimental studies have been reported in the field of skew slabs but very limited literature is available in the area of skew girder bridges. Further, the researchers in this field have been giving more emphasis on the analysis part and very little effort has been made to develop a generalised and simple design procedure for such bridges suitable for design offices. In this thesis, an attempt has been made to present a design method for skew girder bridges, after taking into account its actual structural behaviour with reasonable practical accuracy to suit the designers. The present investigation includes the following aspects:

1. An elastic analysis of interconnected skew girder bridges is presented using the method of Harmonic analysis. The analysis is initially made for a three girder, simply supported bridge and then extended to the case of bridges having several longitudinals and to continuous and right bridges. The actual transverse medium has been replaced by an equivalent uniform continuous medium(54)*. The torsional rigidities of the longitudinal girders and the transverse medium have been taken into account. The loading consists of the first three harmonics in the form of Sine series and each girder has been loaded at a time with only one harmonic loading. For each longitudinal, the deflection and the rotation have been assumed to be made up of the first three harmonics of the Sine and Cosine Fourier series respectively. This introduces six deformation coefficients per girder.

* The number in parenthesis indicates the reference number in the List of References.

The moments and shears per unit length at a transverse section considered, have been written down from the slope deflection equations and the necessary simultaneous linear equations have been formulated. These equations are in terms of dimensionless parameters and are solvable by computer for any given case. Their solution gives the deflection and the rotation coefficients for each girder. From these coefficients, other influences are obtained by successive differentiation.

The above proposed method is an improvement over the method suggested by Surana (55) in the sense that it takes into account the first three harmonic terms of the general Sine form of loading instead of concentrated loads. This procedure considerably facilitated the preparation of design graphs and charts for moment coefficients. Also, by taking three harmonic terms in the rotation expression, there is significant improvement in the rotational form of the structure as substantiated by the experimental results. This has also improved the load distribution in the system.

2. The bending and torsional coefficients have been obtained for various dimensionless bridge parameters for one harmonic loading at a time and a family of curves have been drawn for each coefficient. Using these curves, the moment coefficients for a particular set of bridge parameters are evaluated from which the design bending and torsional moments, deflection, shear etc. can be found out. Thus the method is versatile in

nature as the design of skew girder bridges of any dimension and skewness is possible without using the computer facility. A bridge is analysed to illustrate the use of the design graphs for moment coefficients.

3. To show the accuracy and the validity of the proposed method in comparison to other methods of analysis, a grid has been analysed. A reinforced concrete three girder skew bridge representing an actual design problem, is analysed to show the accuracy of the proposed method for such bridges. The analysis of a five girder composite skew bridge is also presented for the purpose.

4. The laboratory tests on five steel grid models have been conducted. The experimentation has been undertaken with two main objectives - firstly to verify the accuracy of the theoretical rotational form assumed in the analysis and secondly to find out the efficient orientation of the transversals in skew girder bridges. A right steel grid with three longitudinals has also been tested to verify the applicability of the proposed method to the case of right bridges.

5. The experimentation also consisted of tests on three scale models of reinforced concrete bridges. The objects of the testing have been to establish the accuracy and the applicability of the proposed method of analysis to concrete bridges and to study the elastic behaviour of the structure under design loads

and the mode of failure at ultimate. The models have been tested extensively first in the elastic range and then upto failure. The experimental results have been compared with the theoretical results.

C O N T E N T S