Ain Shams University
Faculty of Engineering

NON-LINEAR TORSIONAL BEHAVIOUR OF REINFORCED CONCRETE GIRDER TYPE BRIDGES

By

Saleh Mohamed Ibrahim El-Mekawy
B.Sc (Honors) 1984, M.Sc (1990) Structural Division
Civil Engineering Department
Ain Shams University

A Thesis
submitted in Partial Fulfillment
For the Requirement of the Degree of Doctor of
Philosophy in Civil Engineering (Structural)

Supervised By

Prof. Dr.
Mohamed I. Soliman
Minister of Housing and
New Urban Communities
Prof. of R.C. Structures
Ain Shams University

Prof. Dr.
Shaker A. El-Behairy
Prof. of R.C. Structures
Ain Shams University

Dr.
Ali S. Abdel Faiad
Lecturer of R.C. Structures
Ain Shams University

Cairo - 1997

بسم الله الرحمن الرحيم

بسم الله الرحمن الرحيم

Examiners Committee

Name, Title and Affiliation

Signature

1. **Prof. Dr. Mohamed I. Soliman**
   Minister of Housing and New
   Urban Communities.
   Professor of R.C. Structures,
   Ain Shams University
   (Supervisor)

2. **Prof. Dr. Hassan M. Hosny**
   Vice President of Helwan University
   Professor of R.C. Structures,
   Helwan University

3. **Prof. Dr. Abdel Wahab Abo El-Ainein**
   Professor of R.C. Structures,
   Ain Shams University.

4. **Prof. Dr. Shaker A. El-Behairy**
   Professor of R.C. Structures,
   Ain Shams University.
   (Supervisor)

Date
.... / .... / 1997

STATEMENT

This dissertation is submitted to Ain Shams University for the degree of Philosophy of Doctoral in Civil Engineering (Structural).

The work included in this thesis was carried out by the author in the department of Civil Engineering (Structural Division), Ain Shams University, from July 1993 to January 1997.

No part of this thesis has been submitted for a degree or a qualification at any other University or Institution.

Date : ..... / ...../ 1997

Name : Saleh Mohamed I. El-Mekawy

Signature : ....

To The Soul of My Father

To My Mother

To My Wife and My Daughter

Name : **Saleh Mohamed Ibrahim El-Mekawy**

Title : **Non linear Torsional Behaviour of Reinforced Concrete Girder Type Bridges.**

Doctor of Philosophy Dissertation, Faculty of Engineering, Ain Shams University.

ABSTRACT

Many attempts have been made to improve the aspects of design of R.C. bridges. The major aspects of design for such structures are : function, safety, economy and aesthetics.

In medium and long span continuous R.C. bridges, the girder type is now widely used as it is considered to be the most economic and aesthetic solution. In the analysis of such structures, the designer may need to provide a concrete slab at the lower side of the bridge, specially at the intermediate support regions, to satisfy the required strength at the critical sections. For simplicity of the solution, the effect of the box regions on the torsional and distortional analysis of such structures is normally neglected.

Therefore, the main purpose of the present research is to define and explain the general deformational behaviour of R.C. girder bridges with bottom slabs at the intermediate supports under the combined action of bending, torsion, and shear stresses. Also, the present work investigates the effect of the length of the bottom slab and its thickness as well as the amount of transverse reinforcement at the box regions on the torsional and distortional behaviour of this type of bridges.

A theoretical study has been conducted on R.C. girder type bridges to investigate the previously mentioned phenomena. The theoretical study has been performed using the finite element method, taking into account the non linear stress strain relationships for concrete and steel, as well as the probable bond slippage between steel and concrete. The results of this investigation, including deflections, strains, cracking and failure loads are presented and discussed.

The results of this study are combined with other available information to form some recommendations concerning the design, analysis and the economy of this type of bridges.

Key Words: Torsion, Distortion, Girder Type Bridges, Finite Element, Warping, Material Non-Linearity.

ACKNOWLEDGMENTS

It is great honor to complete my research work with sincere thanks to **Prof. Dr. Mohamed Ibrahim Soliman**, Minister of Housing and New Urban Communities, Professor of Reinforced Concrete Structures, Ain Sham University. My acknowledgment represents inadequate expression of appreciation for his guidance, continuous encouragement, valuable suggestions, constructive criticism, precise advice and kind supervision during all phases of this research work.

The writer wishes to express his special thanks and gratitude to **Prof. Dr. Shaker Ahmed El-Behairy**, Professor of Reinforced Concrete Structures, Ain Shams University, for his helpful suggestions, constant assistant, encouragement and generous support during the course of this research work.

The writer is extremely indebted to **Dr. Ali Sherif Abdel Faiad**, Lecturer of Reinforced Concrete Structures, Ain Shams University whose instructive supervision, continuous advice, permanent encouragement and experienced guidance made this work possible.

TABLE OF CONTENTS

CHAPTER 3: FINITE ELEMENT MODEL

CHAPTER 4: EXPERIMENTAL VERIFICATION OF THE FINITE ELEMENT PROGRAM.

CHAPTER 7: SUMMARY AND CONCLUSIONS

CHAPTER (1)