



Ain Shams University
Faculty of Engineering

**NON-LINEAR TORSIONAL BEHAVIOUR OF REINFORCED
CONCRETE GIRDER TYPE BRIDGES**

By

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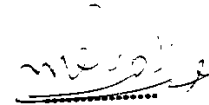
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STATEMENT

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.

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To The Soul of My Father
To My Mother
To My Wife and My Daughter

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

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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.

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CHAPTER (1)

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the 1990s, the number of people in the world who are undernourished has declined from 760 million to 600 million. The number of people who are malnourished has declined from 1.1 billion to 800 million. The number of people who are obese has increased from 100 million to 300 million. The number of people who are overweight has increased from 100 million to 300 million. The number of people who are obese and overweight has increased from 100 million to 300 million. The number of people who are obese and overweight has increased from 100 million to 300 million.

[illegible]

1. The first step in the process is to identify the problem or issue that needs to be addressed. This involves gathering information and understanding the context of the problem.

the 1990s, the number of people in the world who are under 15 years of age is expected to increase from 1.1 billion to 1.5 billion. The number of people aged 65 and over is expected to increase from 200 million to 400 million. The number of people aged 15 and over is expected to increase from 3.5 billion to 4.5 billion. The number of people aged 15 and over is expected to increase from 3.5 billion to 4.5 billion. The number of people aged 15 and over is expected to increase from 3.5 billion to 4.5 billion.

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Figure 1. The proposed model of the relationship between the perceived social support and the perceived stress. The perceived social support is measured by the perceived social support scale (PSSS) and the perceived stress is measured by the perceived stress scale (PSS).

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