STRUCTURAL ANALYSIS OF A REINFORCED
CONCRETE CANTILEVER STAIRCASE

by

KIN-TANG HO

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Approved by:

Vernon H. Rosebraugh
Major Professor

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SYNOPSIS

Methods of analyzing a concrete cantilever staircase comprising two straight flights and a landing and supported only on the upper and the lower floors are presented herein.

The method developed by A. Siev includes the determination of the primary moments considering the whole structure as a simple statically indeterminate system and the secondary moments resulting from the consistent deformation at the intersection between the flights and the landing.

A. R. Cusens and J. G. Kuang developed a method of analysis by assuming that the space structure, which is composed of plates or slabs, can be replaced by straight beams and that the method of least work can be used to solve this highly indeterminate structure.

W. Fuchsteiner's assumptions are similar to those of Cusens and Kuang with the exception that the landing slab is replaced by a curved bar element.

The results from previously reported tests are in good agreement with the above-mentioned methods which have already been employed in the practical design of staircases of this type.

INTRODUCTION

The use of cantilever straight multiflight staircases has become popular with architects in the past few years. The stress analysis of this type of structure is of considerable interest to structural engineers.

Theoretical analyses have been published by W. Fuchsteiner (1), G. Szabo (2), A. C. Liebenberg (3), A. Siev (4), P. L. Gould (5), A. R. Cusens and J. G. Kuang (6), and F. Sauter (7).

Liebenberg first introduced the concept of space interaction of plates. His method of analysis is based on the staircase treated as a statically indeterminate structure with the assumption that the torsional restraining moment in the landing may be neglected.

Siev has extended Liebenberg's theory to include the determination of the torsional restraining moment resulting from the compatibility of deformations between the flights and the landing. His method shows that this moment is usually small and may be considered as a secondary effect.

Cusens and Kuang's method is based on the application of the principle of least work with the assumptions that the flight plates can be reduced to bar elements which coincide with their longitudinal axes. The landing bar

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Numbers in parentheses refer to references listed in the Bibliography.

element will be a straight line to be located in a position near the line of intersection.

Fuchsteiner is the first person who suggested the space bar method which is similar to that of Cusens and Kuang with the only difference being that the landing is replaced by a curved bar instead of a straight one.

Siev, Cusens and Kuang, and Fuchsteiner's approaches have shown good correlation with test results and hence only these three methods will be described in detail in the following sections. A numerical example is also given to illustrate the procedure of calculation for each approach.

NOTATION

a,b,c,g,h,l = Dimensions of the staircase

A = Cross-sectional area of the flight

E = Modulus of elasticity

G = Modulus of elasticity in shear

H = Reaction in the X-direction

I = Moment of inertia

I_b = Moment of inertia of beam C-H about the X-axis

J = Polar moment of inertia (For a rectangular section, the value depends on the magnitude of the width-depth ratio of the section)

M_o = Redundant moment at point O about the X-axis

M_r = Bending moment about the horizontal axis of the section

M_s = Bending moment about the vertical axis of the section

M_t = Torsional moment of the section

M_x = Total torsional restraining moment in the landing or moment about the X-axis

M_y = Moment about the Y-axis

M_z = Moment about the Z-axis

$M_{\bar{x}}$ = Torsional moment in the flight

$M_{\bar{z}}$ = Bending moment in the flight about the axis perpendicular to the flight surface

r = Radius