International Journal of Engineering, Management, Humanities and Social Sciences Paradigms (IJEMHS)
Volume 30, Issue 02, Quarter 02 (April to June 2018)
An Indexed and Referred Journal with Impact Factor: 2.75
ISSN (online): 2347-601x
www.ijemhs.com

Design of Indeterminate Structures

Munish[1] and Jaswant Singh[2]

**[1]M. Tech. Scholar, Department of Civil Engineering,
CBS Group of Institutions, Jhajjar, Haryana (India)**

**[2]Assistant Professor, Department of Civil Engineering,
CBS Group of Institutions, Jhajjar, Haryana (India)**

Publishing Date: June 02, 2018

Abstract

This paper proposes a method for analysis of statically indeterminate structures, considering the shear deformations, which is an extension to the slope-deflection method, which is used to analyze all kinds of structures in the plane. This methodology considers the shear deformation and flexure. The traditional method takes into account only the flexure deformation and without taking into account the shear deformation, this is how it usually develops structural analysis of statically indeterminate rigid frames. It also makes a comparison between the proposed method and the traditional method as can be seen in the results tables of the problems considered, in the traditional method not all values are on the side of safety. Therefore, the usual practice, without to consider the shear deformations will not be a recommended solution. Then is proposed the use of considering shear deformations and also is more attached to real conditions. This document also gives guidance on designing of statically indeterminate structures. Here theory and practices are discussed in detail to understand the current scenario of designing. Analysis of multi storey building frames involves lot of complications and tedious calculations by conventional methods. To carry out such analysis is a time consuming task. Approximate analysis method and force method for analysis of statically indeterminate structure can be handy in quick analysis so as to get the estimates ready and participate in the bidding process. In this work, the applicability and effectiveness of this method has been checked under various loading conditions. Here loads has been apply on various types of frames, trusses, beams and cables etc. to check the results by deriving equations and solving matrix. It also provides guidance on simple checks to ensure the analysis is correct and an overview of member design for the less experienced designer. This document is limited to the modeling of general building and plant structures of normal proportions under static loading.

Keywords: *Indeterminate Structures, Force Method, Approximate Analysis.*

1. Introduction

Support reactions and internal Support reactions and internal forces of statically determinate structures can be determined using only the equations of equilibrium. However, the analysis of statically indeterminate structures requires additional equations based on additional equations based on the geometry of deformation of the structure.

Additional equations come from compatibility relationships, which ensure continuity of displacements throughout the structure. The remaining equations are constructed from member constitutive equations, i.e., relationships between stresses and strains and the integration of these equations integration of these equations over the cross section.

Design of an indeterminate structure is carried out in an iterative manner, whereby the (relative) sizes of the structural (relative) sizes of the structural members are initially assumed and used to analyze the structure. Based on the computed results (displacements and internal member forces), the member sizes are adjusted to meet governing design criteria. This iteration process continues until the member sizes based on the results of an analysis are close to those assumed for that analysis.

Another consequence of statically indeterminate structures is that the relative variation of member sizes influences the magnitudes of the forces that the member will experience. Stated in another way, stiffness (large member size and/or high modulus materials) attracts force. Despite these difficulties with statically indeterminate structures, an overwhelming majority of structures being built today are statically indeterminate.

2. Results

Approximate Analysis Method

An approximate structural analysis is used to reduce a statically indeterminate structure to one

that is statically determinate. By doing so a preliminary design of the members can be made, and once complete, the more exact indeterminate analysis can then be performed and the design refined. Trusses having cross-diagonal bracing within their panels can be analyzed by assuming the tension diagonal supports the panel shear and the compressive diagonal is a zero-force member. This is reasonable if the members are long and slender. For larger cross sections, it is reasonable to assume each diagonal carries one-half the panel.

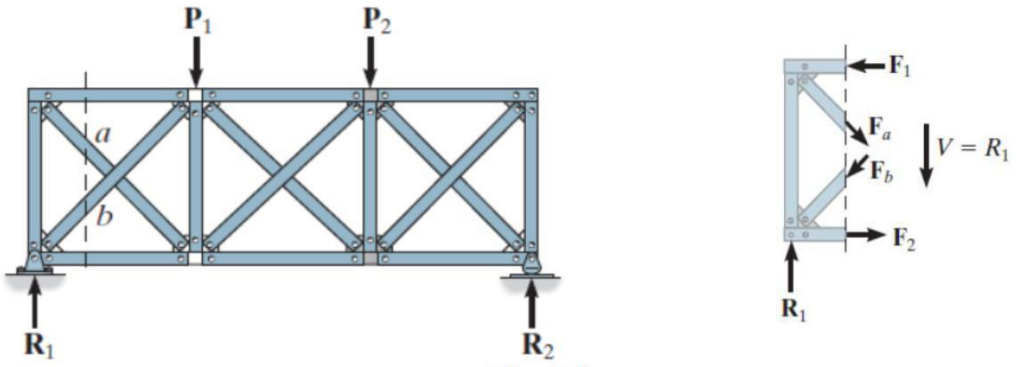

Fig. 7-1

The approximate analysis of a vertical uniform load acting on a girder of length L of a fixed-connected building frame can be approximated by assuming that the girder does not support an axial load, and there are inflection points (hinges) located $0.1L$ from the supports.

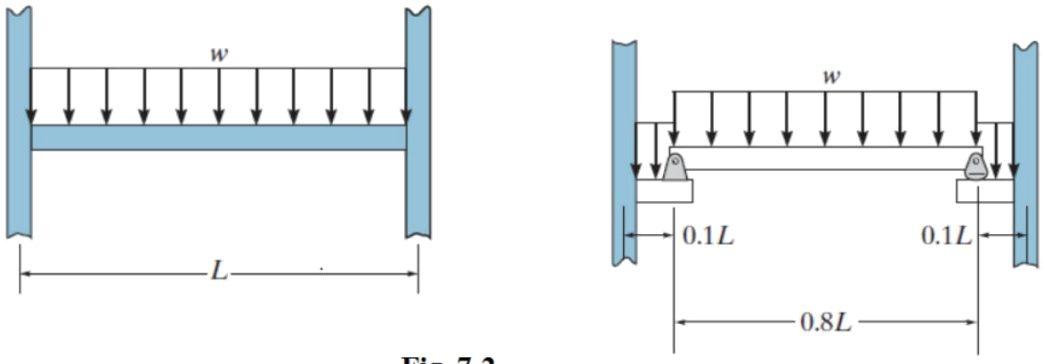

Fig. 7-2

Portal frames having fixed supports are approximately analyzed by assuming there are hinges at the midpoint of each column height, measured to the bottom of the truss bracing. Also, for these, and pin-supported frames, each column is assumed to support half the shear load on the frame.

For fixed-connected building frames subjected to lateral loads, we can assume there are hinges at the centers of the columns and girders. If the frame has a low elevation, shear resistance is important and so we can use the portal method, where the interior columns at any floor level carry twice the shear as that of the exterior columns. For tall slender frames, the cantilever method can be used, where the axial stress in a column is proportional to its distance from the centroid of the cross-sectional area of all the columns at a given floor level.

Force Method Analysis

The analysis of a statically indeterminate structure requires satisfying equilibrium, compatibility, and the force displacement relationships for the structure. A force method of analysis consists of writing equations that satisfy compatibility and the force-displacement requirements, which then gives a direct solution for the redundant reactions. Once obtained, the remaining reactions are found from the equilibrium equations.

International Journal of Engineering, Management, Humanities and Social Sciences Paradigms (IJEMHS)
Volume 30, Issue 02, Quarter 02 (April to June 2018)
An Indexed and Referred Journal with Impact Factor: 2.75
ISSN (online): 2347-601x
www.ijemhs.com

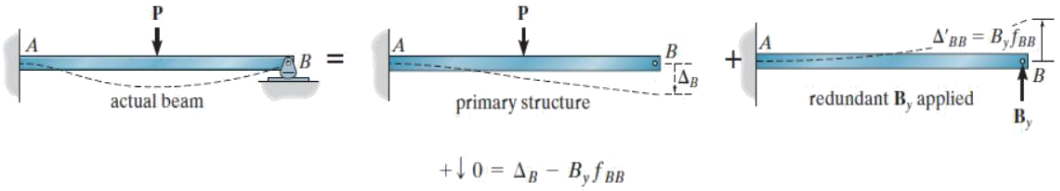

Fig. 7-3

Simplification of the force method is possible, using Maxwell's theorem of reciprocal displacements, which states that the displacement of a point *B* on a structure due to a unit load acting at point *A*, , is equal to the displacement of point *A* when the load acts at *B*.

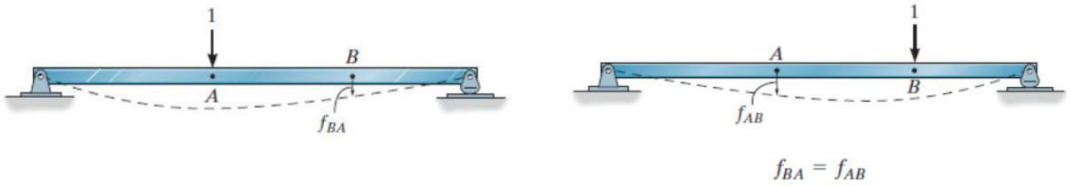

Fig. 7-4

The analysis of a statically indeterminate structure can be simplified if the structure has symmetry of material, geometry, and loading about its central axis. In particular, structures having an asymmetric loading can be replaced with a superposition of a symmetric and antisymmetric load.

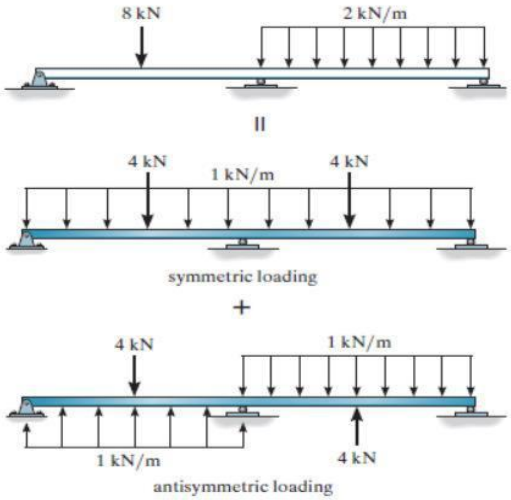

Fig. 7-5

Influence lines for statically indeterminate structures will consist of *curved lines*. They can be sketched using the Müller-Breslau principle, which states that the influence line shape for the reaction, shear, or moment is to the same scale as the deflected shape of the structure when it is acted upon by the reaction, shear, or moment, respectively. By using Maxwell's theorem of reciprocal deflections, it is possible to obtain specific values of the ordinates of an influence line. This can be explained by Fig. 7-6.

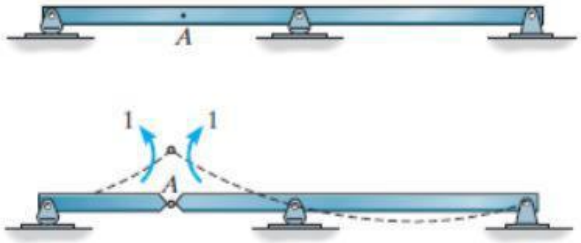

Fig. 7-6

Conclusion

So approximate methods are used to find forces and moments quickly, for the purpose of analysis two methods are used: Portal method and Cantilever method.

Portal Method: It is applicable to low rise frames i.e. height of frame is less than width of the frame.

Assumption in portal method: Point of contra flexure is assumed to be located at midpoint of each beam and column. The horizontal shear is assumed to be divided among all columns such that each interior column takes twice that of exterior column.

With the above two assumptions a statically indeterminate structure becomes a determinate structure. So equation of equilibrium alone is sufficient to find axial force, shear force, bending moment in any part of the structure.

Cantilever Method: It is applicable to tall structures i.e. height of frame is more than width of frame where frame acts as cantilever beam.

References

[1] Standing Committee on Structural Safety Tenth Report SET0 Ltd, 1994.

[2] CIM steel Design for manufacture guidelines The Steel Construction Institute, 1995

[3] British Standards Institution BS 5950: Structural use of steelwork in building Part l : Code of practice for design in single and continuous construction: hot rolled sections BSI, 1990

[4] NERVI, P. L. Structures F. W. Dodge Corporation, 1956

[5] BROHN, D. M., COWAN, J. Teaching towards an improved understanding of structural behaviour The Structural Engineer, Vol. 55, No 1, 1977

[6] BROHN, D. M., COWAN, J. Discussion on the paper 'Teaching towards an improved understanding of structural behaviour'. The Structural Engineer, Vol. 55, No 11, 1977