BUILDING RESEARCH CENTER

COMPUTER ANALYSIS OF

ORTHOTROPIC FOLDED-PLATE STRUCTURES

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INTRODUCTION

Folded-plate structures have been increasingly used in many countries in a wide variety of shapes for roofing large clear areas and for storage of fluids and solid substances. This type of structures has proved to be economical compared with other systems of construction[1]. Beside having statical characteristics similar to those of continuously curved shells, folded plates require a simpler form work. Although flat plates are usually adopted as the elements of a folded-plate structure, ribbed plates may be used.

A survey of available literature on the stress analysis of folded-plate structures reveals that a common assumption is that the structural material is isotropic. This assumption, while applicable to metallic folded plates, may be unjustifiable for the majority of these structures which are constructed from reinforced concrete as well as for those built from timber combined with plywood sheathing. The difference of reinforcements in the two perpendicular directions of a rectangular plate will result in difference in the flexural rigidities in the corresponding directions giving rise to a plate of orthotropic nature. On the other hand, timber combined with plywood sheathing will have two different sets of elastic constants in the two corresponding directions.

The main existing methods of analysis for isotropic folded plates under working Loads have evoluted through three basic stages which may be termed the beam, the conventional and the elasticity methods. The beam method considers the whole structure

as a beam supported at the end diaphragms. In the conventional method of analysis [3], the transverse supporting action is considered to be that of a continuous one-way slab over elastic supports at the common ridges of the plates whereas the longitudinal supporting action of each plate is considered to be that of a beam supported at the end diaphragms. According to the elasticity method [4], the out-of-plane action of each plate is analysed by the theory of thin isotropic plates under lateral loads and the in-plane action by the two dimensional theory of elasticity for isotropic materials. The solution is then completed by considering equilibrium of forces and compatibility of displacements at the common ridges.

The object of the work presented herein is to develop an analytical solution for folded-plate structures loaded within the working stage based on the more realistic assumption of orthotropy. The solution covers those structures having cross-sections composed of single or multiple cells that can be either open or closed as shown in Fig.1 and which are uniformly loaded. The intensity of the load as well as the elastic constants may differ from one plate to another. Although the analysis is developed for structures composed of flat plate elemamts, it can be extended to those of ribbed plates in which case they may be transformed to equivalent flat plates having orthotropic properties.