OPTIMIZATION AND INELASTIC ANALYSIS OF FOLDED PLATE STRUCTURES

by

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CERTIFICATE

This is to certify that the thesis entitled, "OPTIMIZATION AND INELASTIC ANALYSIS OF FOLDED PLATE STRUCTURES" being submitted by Mr. Sachchidanand Sinha to the Indian Institute of Technology, Delhi, for the award of the degree of DOCTOR OF PHILOSOPHY, is a record of bonafide research work carried out by him under my guidance and supervision. To the best of my knowledge it has reached the standard fulfilling the requirements of the regulations relating to the said degree.

The matter embodied in this thesis has not been submitted, in part or full, for the award of any degree.

(K. Seetharamulu)
Supervisor

Dated July, 1975

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SYNOPSIS

Considerable work on elastic analysis of single span and continuous folded plate has been reported. Extremely limited work has been done on optimization of folded plate structures. Inelastic and limit analysis of folded plates have been reported for single span structures, but no work has been done for continuous folded plates. Experimental work on reinforced concrete folded plates upto ultimate load has been done for single spans, but extremely limited experimental work is carried out for continuous span.

The present investigation includes the following aspects:-

1. Optimization has been presented with the help of analysis curves for minimum weight and graphical and numerical methods for minimum cost for five shapes of commonly used folded plates.

For optimization with the help of analysis curves, the geometrical parameters selected are, span of folded plate L, width B, inclination θ and thickness T of plates. The curves are prepared in terms of non-dimensional paramters L/B, T/B, θ vs longitudinal stresses $\bar{\sigma}$ and transverse moments $\bar{m}$. Transfer matrix method of analysis has been used in most of the cases of folded plates. This method can be programmed on small storage computers and the running time is very small in comparison to other available method. To facilitate optimization, feasible design zones have been shown on the analysis curves, and an iterative method has been suggested for the determination of optimum geometrical parameters. The corresponding

stress resultants can be obtained with the help of these curves and thus completely eliminate any further use of computer.

Optimization for minimum cost of materials using the graphical method, consists of cost contours vs width and inclination of plate for different spans of the chosen five shapes of folded plates. The cost contours have been separated with the bounds indicating minimum acceptable thicknesses. It provides information for determining optimum design variables for any chosen value of either of B,θ and T or combination of it.

Powell's approach of numerical method of optimization is used to minimise the cost of materials with respect to width, inclination and thickness of plate for different spans of the chosen shapes of folded plates. It requires a substantially big computer and more running time than the other two methods, but it provides accurate results. A set of tables illustrating the design variables for minimum cost are prepared for different spans of the five shapes of folded plates. Suitable span ranges for each shape of folded plate have been shown.

2. Appropriate inelastic analysis of two span folded plate structure has been proposed. Two methods of analysis (i) full load and (ii) incremental load have been developed using transfer matrix method. The actual properties of concrete and steel have been taken into account while computing the

rigidities of the section. The concept of equivalent section as used in 'elastic theory' has been extended for inelastic analysis by developing equivalent elasto plastic sectional properties. In full load method, plate inelasticity has been considered from equivalent elasto plastic sectional properties and slab inelasticity from concentrated angle discontinuity at sections subjected to moments, exceeding the limiting elastic moment, hence based on the descritization of inelasticity by concentrated angle discontinuity the slab length between ends can be considered elastic. The analysis has been done by the method of successive approximation, which permit at each stage the elastic analysis of folded plate using equivalent elasto plastic sectional properties and concentrated angle discontinuity. In incremental load method, load is increased in increments and the analysis for the incremental load is done by considering equivalent elasto plastic sectional properties based on 'tangent modulus' for plate action and segments of the width of plate with their associated stiffness based on bi-linear moment-curvature relationship for slab action.

The study also includes the experimental investigations of two microconcrete folded plate models of single unit trapezoidal section. The models were first tested as single span upto load less than working load. The same models were subsequently tested upto ultimate load after erecting an intermediate support, monolithic with the folded plate.

C O N T E N T S