

INELASTIC ANALYSIS OF FOLDED PLATES

Thesis submitted by

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C E R T I F I C A T E

Certified that this work 'Inelastic analysis of folded plate' by Mr. Ravindra Nath Munshi has been carried out under my supervision and it has not been submitted elsewhere for a degree.



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S Y N O P S I S

Extensive literature is available on the elastic analysis of folded plates, assuming material to be homogeneous, isotropic and linearly elastic. The elastic theory is inadequate for the analysis of reinforced concrete folded plates, as ^{the} reinforced concrete is neither homogeneous and isotropic nor elastic. Few references are available on the ultimate load analysis of folded plate by yield line theory or equivalent beam theory. Only limited work is reported on the study of the behaviour of reinforced concrete folded plates through the entire loading range. Few experimental studies of reinforced concrete folded plates are ^{also} reported in literature. ~~Here~~ ^{Thus} there is a need for the study of behaviour of reinforced concrete folded plates through all stages of loading, considering the actual material properties, both theoretically and experimentally. The present study summarised in the following is an attempt in this direction.

1. A 'Force method' is developed for the elastic analysis of folded plates using the assumptions of ordinary folded plate theory. The structure is ^{assumed to be.} converted into a determinate structure by introducing a suitable release system consisting of cylindrical hinges at interior fold lines and sliding longitudinal releases at all the fold lines. The proposed method has the advantage of having lesser

number of redundant forces ($2n - 2$) as compared to $4(n + 2)$ unknown displacements in direct stiffness method where n is the number of fold lines. It has the additional advantage for inelastic analysis as with the progressive formation of plastic moment hinges, the number of unknowns get further reduced.

2. A 'Matrix force method' is developed for the inelastic analysis of folded plates using the concept of equivalent elasto plastic section of the reinforced concrete member. The concept of equivalent section used in the usual flexural theory of reinforced concrete members is extended for inelastic analysis using Murashev's elastoplastic modulus (also known as secant modulus). The equivalent width of the compression zone is a variable quantity due to the varying modulus across the depth of compression zone. Axial force moment curvature relationships are obtained using elastoplastic section method for reinforced concrete members and compared with those obtained by other theories.

The analysis of folded plates requires correct assessment of the variation of longitudinal edge shear forces along the span. No method of correctly assessing this variation in the inelastic range is available at present (1975). An assessment of distribution of the longitudinal edge shear forces for each fold line was obtained (1966) by trial and error (53). In the method developed herein no separate estimation of the variation of longitudinal edge shear forces along the span is required. The compatibility

of longitudinal fold line strains is ensured at all sections along the span by distributing the residual strains at fold lines at the end of each cycle of iteration, considering equivalent elastoplastic sectional properties of the member plates at the section under consideration, pertaining to the running cycle of iteration. This results in the modification in the shape of the curves showing the longitudinal variation of integrated edge shear forces. This is assumed to be the initial value for the next cycle of iteration. Thus the shape of the longitudinal variation of integrated edge shear forces is continuously modified to increasingly correct values during the iteration process.

A numerical method is proposed to obtain the elastoplastic member flexibility matrix. The solution of the inelastic problem is attempted by successive approximations. The proposed method of inelastic analysis of reinforced concrete folded plates is a full load method.

3. In addition to the proposed general elastoplastic section method, approximate methods are proposed to predict the behaviour of folded plates, which are comparatively easier and faster. The following approximate methods are proposed which are valid for the specified range of loading.

(1) Cracked section methods to predict the behaviour of reinforced concrete folded plates in the regions of

working load, considering the cracked sectional properties but assuming a constant modulus of elasticity (Initial tangent modulus) for the compression zone concrete. The cracked sectional properties at most stressed section are assumed to be representative of the sectional properties along the entire span. Two alternative methods are proposed (a) using Matrix force method (b) Modifying distribution and carry over factors in Gaafar/Simpson's method to account for the cracking of concrete.

(ii) Elastoplastic section method assuming the elastoplastic sectional properties of most stressed section as representative of the sectional properties along the entire span. The longitudinal fold line strain compatibility is ensured only at most stressed cross section and hence a continuous modification of the shape of the longitudinal variation of integrated edge shears is not necessary.

Experimental studies are carried out for the entire range of loading upto collapse, on three microconcrete reinforced folded plate models. The models are identical in shape and size and are provided with the same transverse and diagonal reinforcements. The longitudinal reinforcements was varied in the models.

5. The observed values of the longitudinal strains and deflections of the test models are compared with the corresponding values predicted by different proposed methods.

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