COMPUTER AIDED ANALYSIS ON THOUGH TYPE OF R.C.C FOLDED PLATE

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***Abstract*—** Folded plates are a very useful form of structure which has many advantages. Several methods are available for the analysis of this type of structure. Conventional methods are simple and essay, but they have the limitations of generality of application and precision. Rigorous methods are involved and some of these become costly due to the use of large-capacity computers. In this research paper Computer programs have been developed to analysis of though type folded plate by the using the beam slab method. In this method also correction analysis to carry out at each joints of the folded plate and calculated longitudinal stresses and deflection. It is shown that these programs give acceptable results for the preliminary analysis of folded plate structures.

Keywords— **Analysis of though type folded plate, analysis programming in visual basic, correction analysis, slab beam method**

I. INTRODUCTION

Whenever new software is thought of, the very first question arises is that why to go for a software when software's are already available in the market with extraordinary versatility such as STAAD, SAP, STRUDS, STRAP, consisting design skills of developer. Though such software's are very powerful and user friendly they lack user friendliness in some areas of structural design. Also, such software's are expensive and not affordable by every engineer. One of the reasons behind software making is that to have a procedure or method of one's own which is of the interest, to work over it, and to provides results, outputs as required.

Visual basic (VB) is one of the most powerful GUI (graphical user interface) development tool for developing Windows based applications. It has evolved from one of the oldest programming languages: the BASIC language. But, today it is capable of delivering virtually anything and everything from simple customized applications to complex commercial software packages.

ABOUT THE FOLDED PLATE

Folded plates are assemblies of flat plates rigidly connected together along their edges in such a way so as to make the structural system capable of carrying loads without the need for additional supporting beams along mutual edges. There are so many types of folded plate to be used on field like

- Prismatic: if they consist of rectangular plates.
- Pyramidal: when non-rectangular plates.
- Prismoidal, triangular or trapezoidal.

Each plate is assumed to act as a beam in its own plane; this assumption is justified when the ratio of the span "length" of the plate to its height "width" is large enough. But when this ratio is small, the plate behaves as a deep beam.

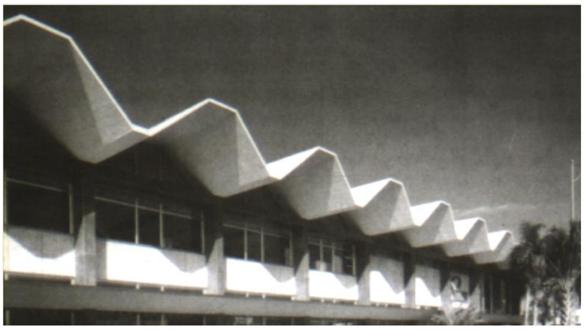


Fig 1, Though type folded plate

ASSUMPTIONS FOR FOLDED PLAT

1- Material is homogenous, elastic, and isotropic, Hook's Law is valid, thickness of plate is small when compared to plate dimensions.
2- Problem will be treated as one-dimension if plate is assumed to behave in beam action, but in two dimensions if based on the theory of elasticity.
3- Joints are assumed to be rigid enough.

II. METHODS OF ANALYSIS OF FOLDED PLATE:

Folded plate can be analyzed by the following methods.

- Beam method
- Elasticity method
- Slab beam analysis with correction analysis for stresses and rotation.

Modern method of strip method (FSM) can be used for the analysis of these shells, but we will deal only with the classical method in this dissertation.

In the beam method, the folded plate is treated as a beam of irregular cross section in the longitudinal direction and as a continuous slab in the transverse direction. The result of rigorous analysis shows that their results are not satisfactory.

The second elasticity method for the calculation of stress in folded plate is difficult to carry out by ordinary calculations. The slab beam method popularly know as the "folded plate theory" is the most convenient and satisfactory method for engineering design

The modern slab beam analysis of folded plates can be divided in to the following procedures. Normally this method is dividing in to major to step i) preliminary analysis ii) correction analysis

III. DESCRIPTION OF PRELIMINARY ANALYSIS:

(In the following descriptions, we must distinguish between the terms procedures and step in each procedure)

The following are the first three procedures in preliminary analysis

1. Transverse slab analysis
2. Longitudinal beam analysis
3. Making compatibility of stresses

We will deal with the above three procedures for preliminary analysis in more detail in the following eight step. (See in Example 15.3.) The following are the step in preliminary analysis.

Step 1: Tabulate the dimensions of the folded plate.

Step 2: Tabulate the geometric properties of slab such as areas, etc.

Step 3: For transverse analysis

Assume the system as a frame with 1 m of the span as width and supported at each joint by vertical supports. Calculate loads and support moments for transverse analysis.

Step 4: Analyze the transverse frame by conventional moment distribution at supports (i.e. carry out transverse analysis of the frame).

In moment distribution, the unbalanced moment is distributed in proportion to the stiffness I / L so that the moment on the two sides will be equal in magnitude but opposite in sign. The carry over factor to the other end of beam will be + 1/2.

We take a unit width of the slab in the transverse direction and support it by imaginary support at the joints for the analysis of the structure for UDL by conventional moment distribution. The spans theoretically should be the effective span to center of support, but not much error is introduced if the spans are taken center to center of support. Complete the moment distribution and find the transverse bending moments and also the support reactions.

Step : 5 Calculate the reactions R at the supports.

Support reaction $=(wd/2)\pm(\Delta m/d \cos \Phi)$

Where'd is the width of the plate.

Step: 6 Resolve joint reactions R into P loads action the plane of the slabs.(Consider joint 2 – Let P21 denote load on plate from joint 3 to joint 1.)

Next, we remove the support by applying equal and opposite reactions at the joints. This reaction should be shard by the plates meeting at the joint. Hence, resolve the reaction as forces acting in the planes of the plate as shown in Figure. Then for joint 2, we get (P21 means force from joint 2 to joint 1),

$(R_n / \sin\alpha_{n}) = (P_n / \cos\Phi_{n+1}) = (P_n / \cos\Phi_{n})$

$(R_2 / \sin\alpha_{23}) = (P_{21} / \cos\Phi_{3}) = (P_{23} / \cos\Phi_{2})$

For plate 2.1

$P_{21} = (R_2\cos\Phi_3)/ \sin\alpha_{23}$ (cos Φ of next plate)

For plate 2.3

$P_{23} = (R_2\cos\Phi_2)/ \sin\alpha_{23}$ (cos Φ of previous plate)

Resultant on plate 2 = P21 - P12 = Pn (load on plate)

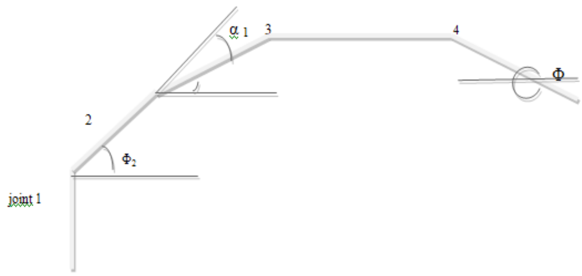


fig 2. Resolution of R2 at joint 2 to plate loads P21 and P23

Step: 7 longitudinal beam analysis—Determination of edge stresses.

The net in plane loads P2 that we get by Step 6 on plates produce bending along the length of the folded plate by acting as a beam.

Bending moment on, say, plate 2 is given by, $M_2 = (P_2L^2/8)$

Where P2 is the resultant of in plane loads of plate 2 from joint above plate 2 (joint 2) and joint 1 below (joint 2). The stresses at the extreme fibers of plate 2 are,

$f_{12}=f_{21}= (P_2L^2/8)(1/Z_2)$

Where, $Z_2 = td^2/6$

Similarly, the stresses on plate 3 will be, *Step: 8 Bringing stress compatibility by stress distribution procedure of Winter and Pei.*

In theory, the stress on the same edge, say, f21 and f23 at joint 2 must be the same in magnitude and sign. But in the foregoing calculations (Step 2), they will not be equal. We correct this and equalize them as follows.

As explained in Section, Winter and Pei showed this can be carried out by a method similar to conventional moment distribution. In this method we assume that

1. The free edge stresses are considered as similar to fixed moments in moment distribution.
2. The difference in stresses is then distributed in proportion to (1/Area of section) i.e. [1/ (depth x thickness) of plate]. The distribution should also result in the stresses at the two sides of the joint to be equal in magnitude and sign.
3. In the distribution, the carry over factor to the adjacent joint (the opposite end of plate) will be –1/2 (instead of +1/2 in Hardy Cross moment distribution).

The above procedures(1-3) carried out by step 1 to 10 will give us the transverse moments as well as the final longitudinal stresses at junctions of the plate. [These results need further correction for compatibility of joint displacement, which we will examine in the next chapter.]

[This completes the approximate solution called preliminary analysis by Winter and Pei. But we know corrections are needed for compatibility of deformations, namely, no change in joint angles. The error depends on the configuration of the folded plate and the restraints of one plate over the deflection of the other. In general, the results of the corrections are not negligible and a complete analysis requires this correction which we will deal with in the next chapter.]

Theory of stress distribution method for stress compatibility

Consider two adjacent plants as shown in Figure 15.4. Take joint 1. The stresses obtained by preliminary transverse analysis on the adjacent plates plate 1 and 2 are different. But they should be the same. This becomes possible due to the presence of additional

Shear at there joints which we will deal with later chapters. Hence, we introduce shear forces T0, T1, T2 … at junctions 0, 1, 2 … to make them equal.

Let A=dxt

And Z = I/y = td2 / 6.

Taking the plate 1, we have f01 as the stress in the top of plate 1. Similarly, taking plate 2, f12 is the stress at the bottom of plate 2.

$f_{01}=(T_0-T_1/A_1)[(T_0+T_1)*D/2*1/Z_1] + M_1/Z_1$

$f_{01}= (-2T_0 - 4T_1/A_1) + (M_1/Z_1)$

$f_{12}= (4T_1 + 2T_2/A_1) - (M_2/Z_2)$

as should be equal in magnitude and sign $f_{10}=f_{12}$,we get

$$T_0 (2/A_1) +T_1 (4/A_1 + 4/A_2) + T_2 [2/A_2] + [(M_1/Z_1) + (M_2/Z_2)] =0$$

Where, A1, A_2, Z_1 and Z_2 are constants and T forces vary as M. for UDL, M is parabolic.

This equitation is similar to the well-known three moment equation, from which the Hardy Cross moment distribution is derived.

$$M_A (l_1) +2M_B (l_1+l_2) +M_C (l_2) + [6A_1X_1/L_1] + [6A_2X_2/L_2] =0$$

Hence, we adopt the following "stress distribution method" foe equalization of stresses.

III CORRECTION ANALYSIS

The important condition to be satisfied in our analysis is that as the various joint of the plates of the folded plates are rigid in actual field condition they do not under go any change of angle when they are loaded. However the Preliminary analysis assume that the plate are free to rotate which will cause changes in the angle at the joint. hence, we must find out what are the change that have happened in the preliminary analysis and correct these changes. Correction analysis should ensure that these is no change in the angle at the joints. As already, several methods are available for the analysis. correction analysis can be carry out by two way first is Rotation of Plate and second Rotation of joint.

We must differentiate between rotation of plate or rotation denoted by D and rotation of joint. We take the rotation of the plate positive when it rotates in clockwise direction. The rotation of the joint can be take place due to the difference between the rotation of the two plates joined together at the joint. Thus, the rotation of the plate n-1 (indicated as yn-1) and plate n+1 (indicated as yn+1).

1) Plate rotation: plate rotation is a result of the beam deflection and hence it will be a function of deflection y.From the geometry of folded plate, we can derive the equation for rotation of the plates n and n+1 as follows.

The rotation of plate n designated as Dn will be a function of deflection of plates n – 1 and n + 1 given by yn-1 and y n+1 and will be as follows,

$$Dn = (-1/dn)[(y\ n\text{-}1/ \sin \alpha n\text{-}1) - yn (\cot \alpha n\text{-}1 + \cot \alpha n) + (yn\text{+}1/\sin\alpha n)]$$

Thus, the rotation of plate n + 1 will be,

$$Dn\text{+}1 = (-1/dn\text{+}1)[(yn/ \sin\alpha n)\text{-}yn\text{+}1(\cot \alpha n + \cot\alpha n\text{+}1)\text{+} (yn\text{+}2/ \sin\alpha n)]$$

(clockwise rotation take positive)

2) Joint Rotation: joint rotation is given by difference in plate rotation of plates joints at a joint. the notation we use joint rotation is as follows. If we take joint n, the rotation due to preliminary analysis as 0, the rotation of the analysis is denoted by D10

As the joint rotation at joint n due to plate rotation Dn0 =Difference in plate rotations at the joint,

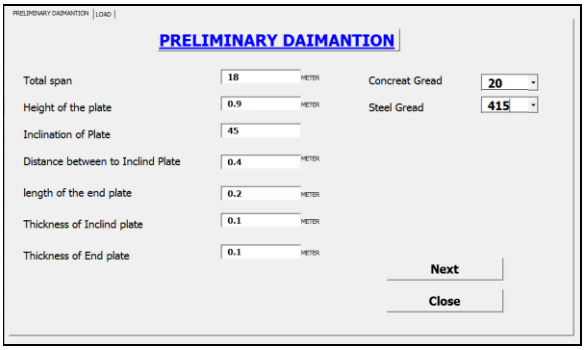
Dno = Dn – Dn+1

For Example ,D20 =D2 –D3

For Correction analysis, We first find the rotation that will result due to the stresses in the plates we arrived at by Winter and pei method.as these should be no rotation,

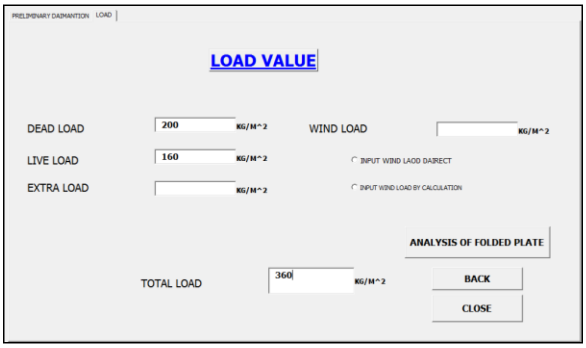
PROGRAMMING FOR ANALYSIS WORK

spreadsheet of the analysis programming is below Insert the preliminary data as per require for analysis of folded plate and click the next button



Spreadsheet 1 for preliminary data input

an enter the all load calculation like dead load, wind load, live load on the folded plate



Spreadsheet 2 for load data input

after entering the all the data require data click on button of analysis work than program to be started to calculation of analysis work step by step, as per which are explain as per above equation and method we get the final stresses which are acting on folded plate as in longitudinal and transverse directions with correction analysis.

FINAL STRESSES AT EACH JOINT

Stresses	JOINTS 1	2	3	4	5
UNCORRECTED STRESSES	-1183	325	-193	-14.5	42
CORRECTION FOR X2	1082	109	-546	636	-278
CORRECTION FOR X3	143	-281	536	-509	223
CORRECTION FOR X4	37	-73	175	-171	71
NET STRESSES(TENSION)	79	76	-	-	59
NET STRESSES(COMPRESSION)	-	-	29	-59	-
TOTAL STRESES kg/cm2	79	79	29	-59	59

Spreadsheet 1 Final result of stress calculation

for data validation normally result of the analysis programming are to be compeer with book examples of different book like p.c Varghese.

IV CONCLUSION

The present author's work satisfies the requirements of analysis of folded plate to the extent possible in comparison with other availed literature and standard codes of practice. In comparisons with other analytical methods here calculations has been carried out by use of slab and beam analysis method for folded plate. Particular method is advantageous by application of correction to the rigid joints of the folded plate. Further work would be consider for advantages of use of the folded plate.

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