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COMPARISON BETWEEN NONLINEAR ANALYSIS AND THE EGYPTIAN CODES FOR THE DESIGN OF FLAT-SLABS WITH DROP PANELS

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INTRODUCTION

Flat-slab and flat-plate floors are very common in Egypt because they have several features which make them attractive in terms of construction, time, appearance and the overall economy, since the cost of form work and the workmanship are substantially reduced, and they provide a great flexibility in locating the interior partitions. Also, the ventilation and the illumination are better because of the absence of the beams which obstruct the light.

The most practicing engineers, whose experience are limited to use the advanced methods of analysis, normally use the codes for the design of such a structural element. It should be realized that the code provisions are based on a combination of theoretical analysis, experience, tests and judgment. With the increasing use of the ultimate load methods for the design of reinforced concrete slabs, it becomes necessary to trace the response history of the structure through, pre and post cracking ranges, until failure. So, the true factor of safety against failure is assessed. The finite element method provides a good technique for such analysis. This method has been developed simultaneously with the increasing use of high-speed digital computers.

While the previous provision of the Egyptian code 1973 [1] provides the frame and the empirical methods for the design of flat-slab with drop panels, The new Egyptian code 1989 [2], with some modifications, provides only the frame method for the design of this case.

The behaviour of the flat-slabs with drop panels are analyzed by the nonlinear finite element analysis at different loading stages and the results are compared with the methods of the design by the Egyptian codes.

APPLICATION EXAMPLE

To show the effects of the drop panels on the behaviour of flat-slab system during different stages of loading, a numerical example for a roof of 18.0 x 18.0 m is presented. The design data are as follows;

- Spacings between columns = 6.00 m.
- Column heights = 3.0 m.
- Column dimensions = 0.40 x 0.40 m.
- Partition weight = 100 kg/m^2.
- Service live loads = 250 kg/m^2.
- Compressive strength of concrete $C_{28} = 300\ kg/cm^2$.
- Tensile strength of concrete $F_t = 30\ kg/cm^2$.
- Yield strength of reinforcement $f_y = 4200\ kg/cm^2$.

The following cases for the reinforced concrete slab thickness t_S and the thicknesses of the drop panels t_D are studied;

Case 1 : t_S = 0.16 m. and t_D = 0.0 (Without drop panel)
Case 2 : t_S = 0.16 m. and t_D = 0.04 m. ($t_d = 0.25\ t_s$)
Case 3 : t_S = 0.16 m. and t_D = 0.08 m. ($t_d = 0.50\ t_s$)

The drop panels considered in this example extent from the center lines of the columns to 0.25 the span length in each direction.

The distribution of the moments are calculated according to the frame methods of the Egyptian code provisions 1973 and 1989, considering the effects of the columns and the variable inertia of the slabs by using the cads program. Also, the general behaviour of these roofs are analyzed by the nonlinear finite element analysis, The results are compared by the results of the empirical and frame methods of the Egyptian codes.

BEHAVIOUR OF FLAT-SLAB THROUGH LOADING

To show the changes in the behaviour of flat-slabs with drop panels during the history of loading, the following stages are considered;

Loading stage 1 : $W_1 = D + L$ (working loads)

Loading stage 2 : $W_2 = 1.5\ W_1$ (ultimate loads)

Loading stage 3 : $W_3 = 2.0\ W_1$

where W = Distributed load per unit area = W_1, or W_2, or W_3 according to the loading stage.

D = dead loads
L = live loads

The example is solved by the nonlinear F. E. program to analyze the behaviour such as the deflections at different locations and the distribution of moments at different stages of loading.

ANALYSIS OF THE FINITE ELEMENT RESULTS

Figures 1, 2, 3 illustrate the contour lines of the deflections for flat-slab without drop panels (case 1) at different stages of loading and Figures 4,5,6 illustrate the contour lines of the flat-slab with drop panels for $t_D = 0.50\ t_S$ (case 3). It is noticed that the deflections decreased at any point within the slab.

The general behaviour of the deflections is also improved whenever the load increased. Figure 7 shows the values of the max. deflections at the center of the exterior panels for slabs with and without drop panels due to the previous cases. The values of the deflections for case 2 and 3. decreased than that of case 1 by about 24% and 40% respectively for loading stage 1 and by about 25% and 50% for loading stage 2 and 28% and 58% for loading stage 3. as shown in the figure.

Figure 8 shows the distributions of the average moments at the column strip for the case of the drop $t_D = 0.5\ t_S$. It is noticed that when the load increased the negative moment decreased and the field moment increased. These attribute to the propagation of cracks over the column lines at the top surface of the slabs.

COMPARISON BETWEEN THE F.E.A. AND THE EGYPTIAN CODES

The results of the nonlinear finite element analysis are compared with the results of the Egyptian code provisions. Figures 9, 10, 11 compare the average moments / W for the column strip at exterior negative, field and interior negative moments by the finite elements, empirical, and frame methods for the different thicknesses of the drop panels at the previous loading stages.

According to the finite element results, it is noticed from Figure 9 that whenever the ratio of t_D / t_S increased,the exterior negative moments increased at any loading stage. The empirical method (73) and frame method (89), over- estimate the exterior negative moments with respect to the F.E. and the Egyptian frame method (73) as shown.

Figure 10 shows that the positive field moments decreased whenever the thickness of the drops increased. The Egyptian frame methods (73, 89) agree with the results of the finite elements. It is shown also that the empirical method (73) does not consider the effects of the increase of the drops from $t_D / t_S = .25$ to 0.5.

Figure 11 shows that the interior negative moments increased whenever the thickness of the drop panels increased. The empirical method (73) underestimates the values of these moments by about 25% for the slab without drop panel and by about 37% for $t_D / t_S = 0.5$ and the frame method (73) underestimates the values of these moments by about 7% for the slab without drop panels and by about 18% for $t_D / t_S = 0.50$. The results of the frame method (89) agree with the results of the finite element methods.

CONCLUSIONS

From the analysis of flat-slabs with drop panels through different stages of loading, it can be concluded that;

- Whenever the thickness of the drop panels increased, the deflections decreased at any point of the slab. Also, the negative moments increased and the field moments decreased.
- The formation of cracks due to the transverse loading re-distribute the moments of flat-slabs with drop panels. When the load increased in this study, the negative moments decreased and the field moments increased at different loading stages. These attribute to the propagation of cracks over the column lines.

- The empirical method (73) underestimates the values of the interior moments by about 25% for the slab without drop Panels and this difference increased whenever the thickness of the drop increased because the empirical method does not consider the effect of the increase in the thickness of the drop panels from $t_D / t_S = .25$ to 0.5. Also, the Egyptian frame method (73) underestimates the interior negative moments.

- The new Egyptian code (89) has modified the results of the previous (73) by considering the following;

  1- Considering the effective moments for the design at the faces of the columns instead of the moments at the critical sections of shear which specified by the previous code 1973.

  2- Increasing the percent carried by column strip of the total negative moments obtained by the an a lysis of continuous frames at the exterior panels from 75% to 80%.

These modifications improve the results with respect to the finite element analysis and accommodate the safety of the structure with drop panels not exceed half the thickness of the slab.

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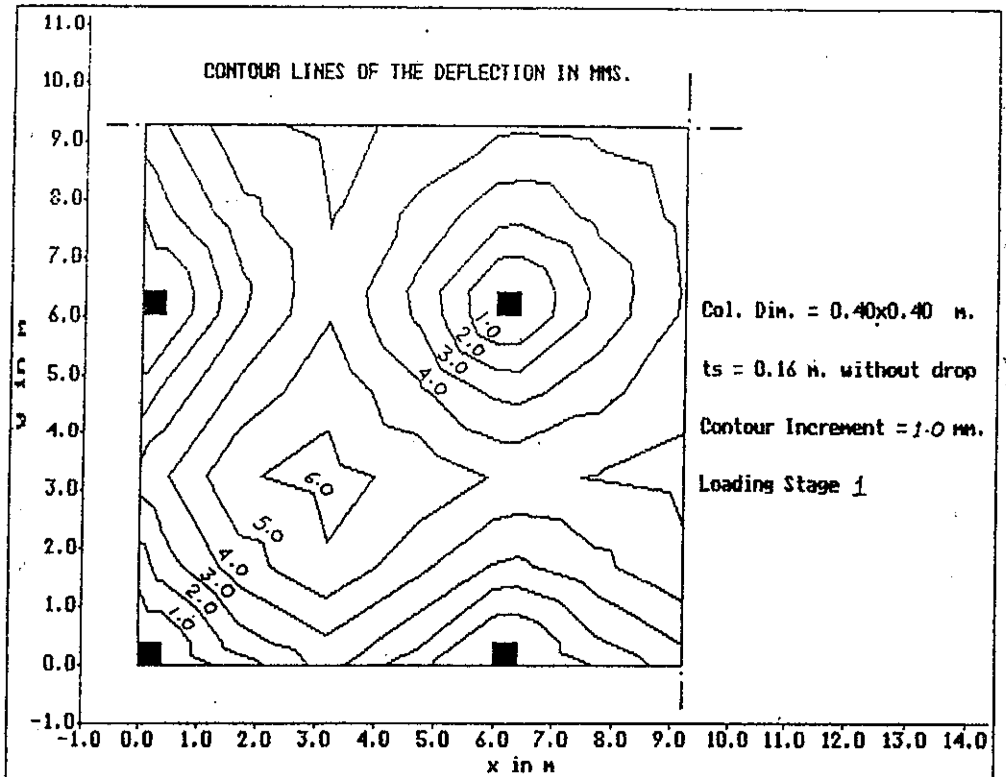


Figure (1)

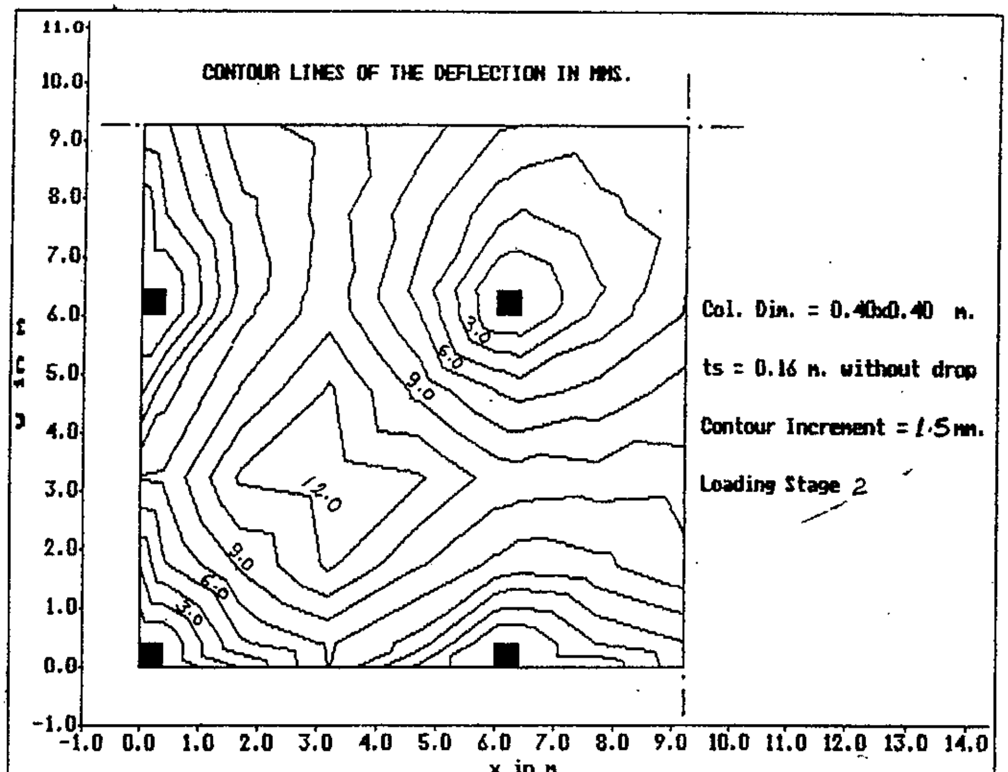
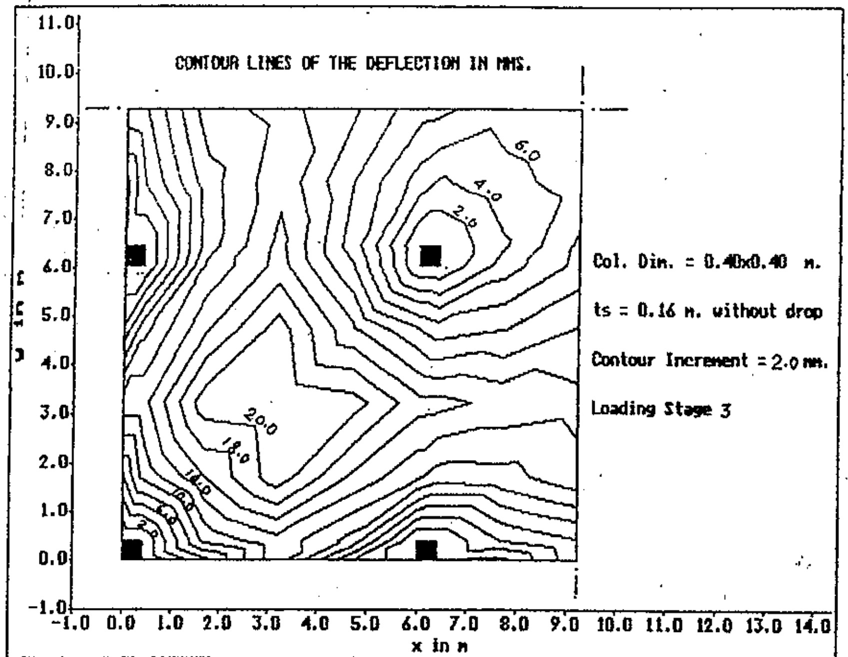


Figure (2)



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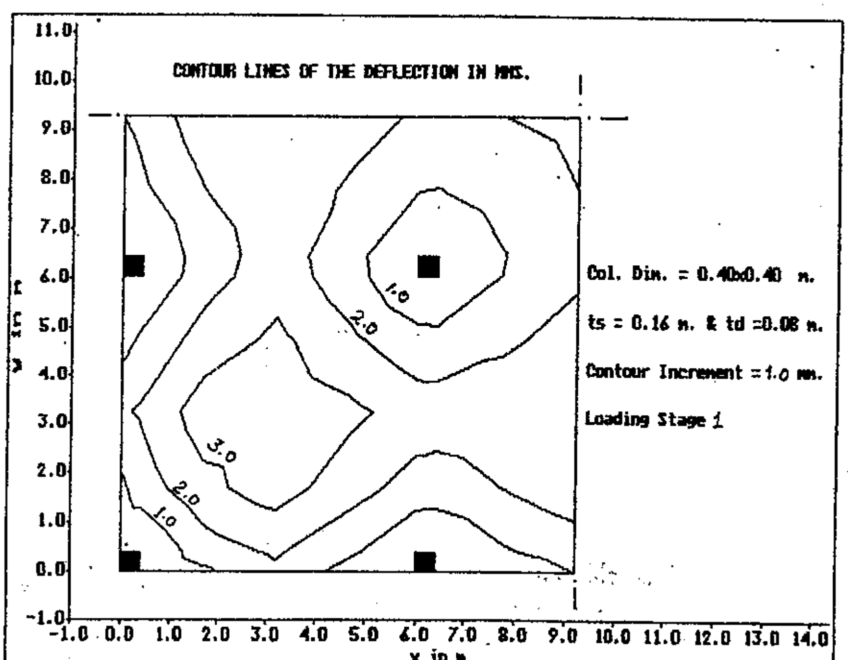

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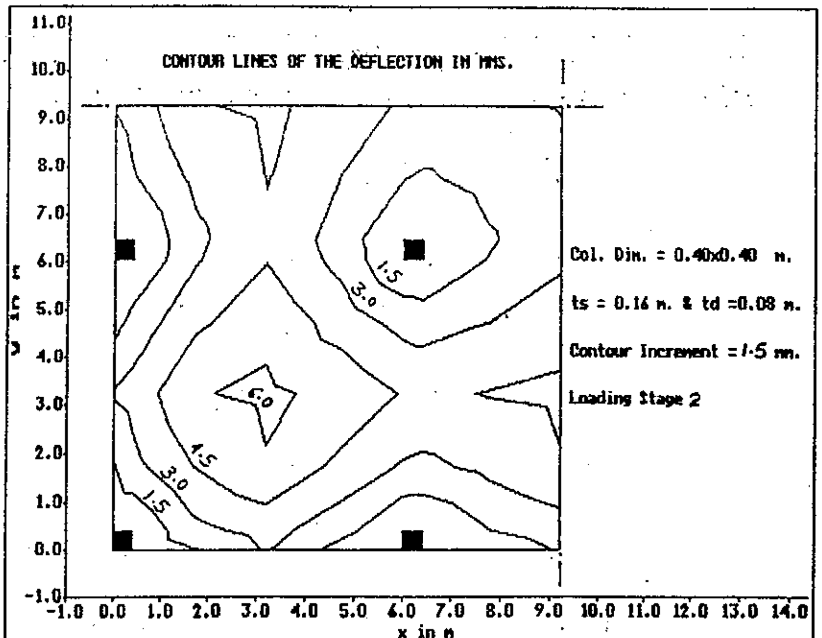

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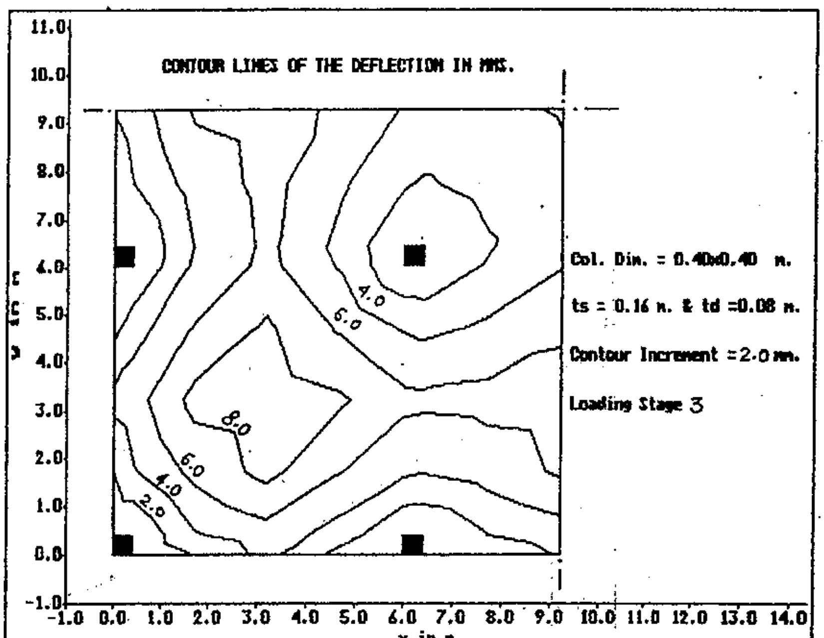

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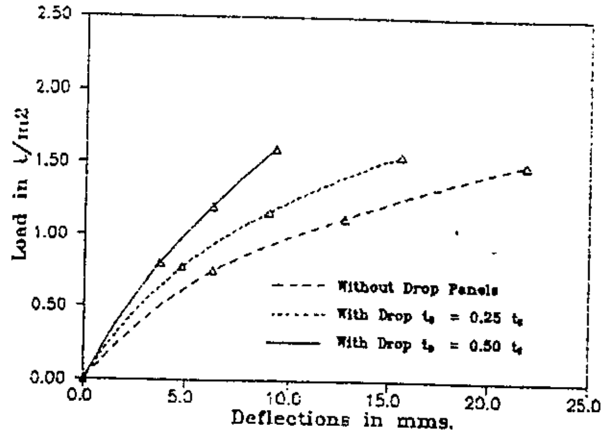
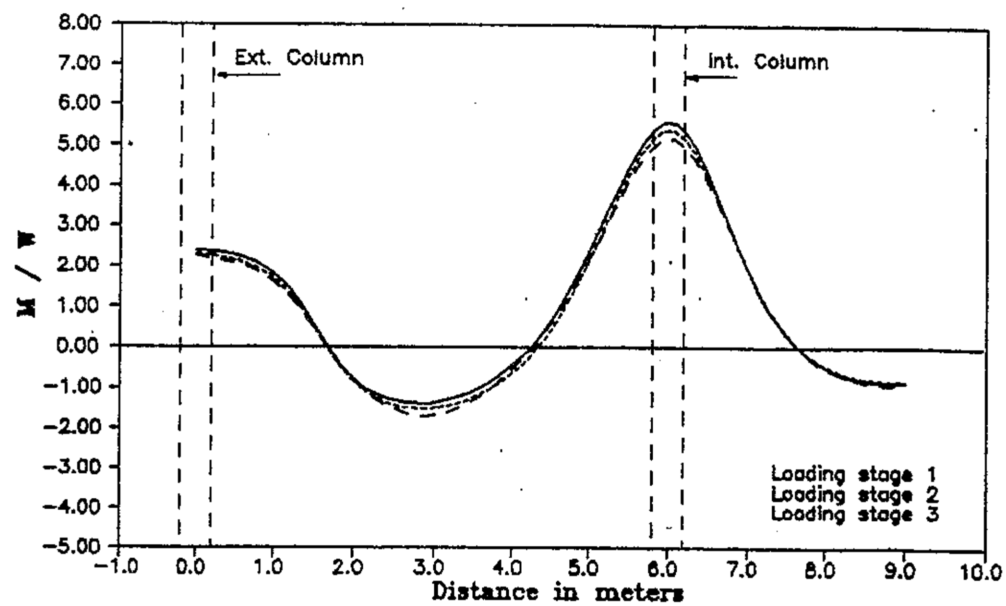


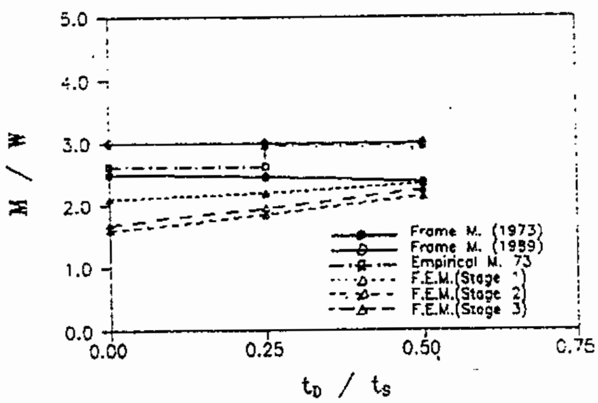
Load Deflection Curves of the Flat Slabs at the Center of the Exterior Panels

Figure 7



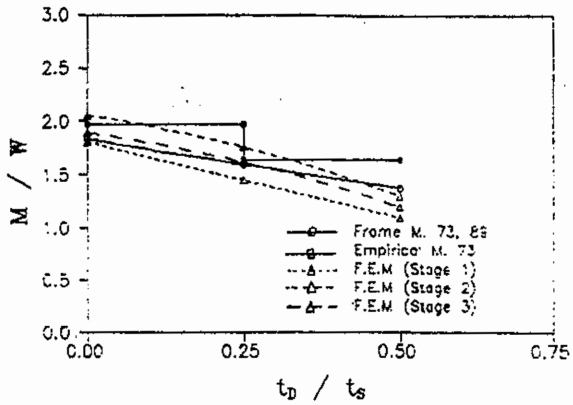
Distribution of moments in column strip at different loading stages for flat-slab with drop panels.
(t_d = 0.5 t_s)

Figure 8



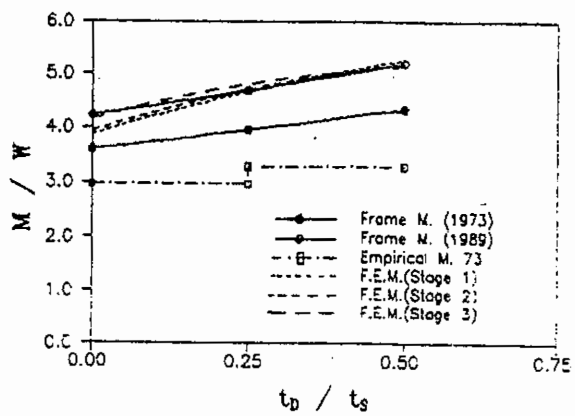
Average moments for the column strip of flat slabs with drop panels (Exterior negative moments)

Figure 9



Average moments for the column strip of flat slabs with drop panels (Exterior field moments)

Figure 10



Average moments for the column strip of flat slabs with drop panels (Interior negative moments)

Figure 11

" مقارنة بين التحليل اللاخطى والكود المصرى لتصميم البلاطات المستوية ذات السمك الأكبر حول الأعمدة "

أ٠د/"منير حسين سليمان و م/ ناجح نعيف مليكه

الملخص العربي :-

فى هذا البحث تم اِستخدام طريقة العناصر المحددة اللاخطية لتحليل البلاطات المستوية ذات سمك أكبر مختلف حول الأعمدة عند مراحل تحميل مختلفة ٠ ومقارنة النتائج بتلك المستنتجة باستخدام الكود المصرى لتصميم البلاطات المماثلة لعام ١٩٧٣م وكذلك الكود المصرى المعدل لعام ١٩٨٩م وبذلك أمكن التوصل الى بعض التوصيات ٠