DYNAMIC ANALYSIS OF CANTILEVER PLATE WITH VARIABLE THICKNESS UNDER THE EFFECT OF PERIODIC LOADING

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بِسْمِ اللهِ الرَّحْمنِ الرَّحِيمِ

قُلْ كُلٌّ يَعْمَلُ عَلَى شَاكِلَتِهِ فَرَبُّكُمْ أَعْلَمُ بِمَنْ هُوَ
أَهْدَى سَبِيلاً * وَيَسْأَلُونَكَ عَنِ الرُّوحِ قُلِ الرُّوحُ مِنْ
أَمْرِ رَبِّي وَمَا أُوتِيتُمْ مِنَ الْعِلْمِ إِلَّا قَلِيلاً

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I certify that this thesis titled (***Dynamic Analysis Of Cantilever Plate With Variable Thickness Under The Effect Of Periodic Loading***) which is being submitted by ***Samir Mohammed Chassib*** was prepared under my supervision at University of Basrah, College of Engineering, Department of Civil Engineering, as a partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering.

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TO

MY PARENTS

WITH LOVE AND APPRECIATION

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ABSTRACT

This study deals with the dynamic analysis of cantilever plates with variable thickness under the effect of periodic load. Two types of plates are analyzed a)***Plate with out stiffeners***, b)***Plate with stiffeners***, The studied cases are modeled by the finite element methods and analyzed by using STAAD PRO. Version 7 program.

The main objective of this study is to predict the effect of periodic load on the deflection of the cantilever plate. For both types of plates stiffened and unstiffened, two length to average thickness ratios are studied (13.4, 8.9).

A periodic load which represents a function of harmonic sine force is used. The amplitude is equal to (50 kN) and distributed on six nodes located in the center of the plates. Each node caries(8.4 kN). The load is applied with different frequencies ranging between 20 cycle/sec to 60 cycle/sec, and the distance between each force is (0.2m). All the results (displacements) are obtained at two points on the free end of the cantilever plate(center and corner points), and normalized to those of static load.

The results shows a significant variation of response across the transverse section of the cantilever plate. The normalized displacement is grater than (1.0) when the frequency of the applied dynamic load is (0.4 – 1.6) from the natural frequency.

CONTENTS

List of Symbols	
a	Depth of beam.
b	Width of beam.
$\mathbf{B}^{I}$	Strain-displacement matrix.
B	Width of plate.
[C]	Damping matrix of the structure.
c	Matrix of material constants
c_s	Matrix of shear modules.
d	Displacement vector for the plate.
de	Displacement vector for all the node in the element.
[D]	Property matrix.
{ F }	Applied load vector.
G	Shear Modulus of plate.
h	Thickness of plate element.
I	Moment of inertia.
Ke	Element stiffness matrix for plate.
[K]	Stiffness matrix of the structure.
L	Length of plate and beam.
L	Differential operator matrix.
[M]	Mass matrix of the structure.
Me	Element mass matrix.
N	Shape function matrix.

N_i	Shape function matrix for nod i.
$\{r\}$	Time dependent vector.
Tn	Natural period of plate
Te	Kinetic energy of plate.
t	time.
t	Average thickness of plate section .
τ	Average shear stress
w	Deflection of plate .
u, v, θ	Displacement at X, Y, directions, and the rotation respectively.
θ_x, θ_y	Nodal rotations around the local X, Y, axes respectively.
$\{\ddot{u}\}$, $\{\dot{u}\}$, $\{u\}$	Global vectors of structure acceleration, velocity, and displacement respectively.
$\{u\}$	Vector of nodal displacements.
$\{\bar{U}\}$	Vector of amplitudes of motion.
x, y, z	Local coordinates system.
υ	Poisson's ratio of the plate.
ω	Natural circular frequency.
χ	Curvature of plate.
γ	The off-plane shear strain.
ζ	Modal damping ratio.
ρ	Density of plate.
ε	The in-plane shear strain.

Φ_i	ith mode shape.
$[\Phi]$	Modal shapes matrix.
$\{\epsilon\}$	Element strain vector.

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Chapter one

INTRODUCTION

INTRODUCTION

1-1 General

In construction of buildings ,particularly in large cities, the current tendency is to make use of every area of land down to the last meter. This is usually achieved by constructing high-rise buildings. Constructing tall buildings necessitates careful attention to building outlooks which may be regarded as an essentiality in tall buildings especially residential tall buildings. In such buildings it is necessary to employ some electrical and mechanical equipments such as [1]:

- air-conditioning and refrigeration units.
- heat ventilation.
- generators.

The use of the above-mentioned equipments may cause undesirable vibrations which cause deformations or failures in some parts of the building such the balconies for example. Accordingly, it is important to take into account such vibrations in the analysis and design of any construction in the tall buildings.

Almost any type of structural system may be subjected to one form or another of dynamic loading during its life time. From an analytical stand point , it is convenient to divide prescribed or deterministic loadings into two basic categories, **periodic** and **nonperiodic.**

Periodic loadings are repetitive loads which exhibit the same time variation successively for a large number of cycles .

A **nonperiodic** loading may be either short – duration impulsive loading or long duration general forms of load[2].

1-2 Aim of Study

The aim behind this work is to study the effect of periodical load on the deflection of two types of plates

1- cantilever plate without stiffeners .

2- cantilever plate with stiffeners.

Both types are rectangular plates with variable thickness. The cases studied are modeled by the finite element methods and analyzed by using *staad pro . program version 2007 .*

The periodic load which represents a function of harmonic sine force is used. It is distributed on six nodes which are located in the center of cantilever plates. The force is applied with different frequencies. The results ***(displacements)*** are predicted at the corner and middle nodes of the free end of the cantilever plate.

Additionally, the present study focuses on:

- The frequency of load.
- The plate dimentions.
    a. Length of plate
    b. Width of plate
    c. Thickness of plate.
- The beam dimentions.

1.3 Layout of thesis

This thesis is arranged into five chapters. The current chapter is being the first. Chapter two presents a review of previous work related to the study. In chapter three the mathematical modeling of problems under study are derived and the available methods of solution are discussed. Different cases are studied, results obtained, and discussion of results are presented in chapter four. Chapter five includes the main conclusions drawn from this study, and suggestions for future works.

Chapter two

REVIEW of LITERATURE

REVIEW of LITERATURE

The analysis of dynamically loaded structures has received a continuous but varying level of attention over the past years. Due to the infinite number of permutations of structural parameters and due to the costs of performing tests on such structures, the amount of available experimental data, while broad, is also scant relative to any particular combination of structure and dynamic load.[3]

This chapter reviews previous studies that deal with the dynamic analysis of different types of plates under the action of general time-dependent loads.

Srinivas and Rao (1970) [4] presented a unified exact method for the static and dynamic analysis of class of thick laminates. A three-dimensional, linear small deformation theory of elasticity solution was developed for bending vibration and buckling of simply supported thick orthotropic rectangular plates and laminates. The solution is formally exact and leads to a simple infinite series for stresses and displacements in flexure. Some numerical results were presented for plates and laminates.

Pica and Hinton (1980) [5] presented a unified approach for the static and transient dynamic linear and geometrically nonlinear analysis of Mindline plates including initial imperfections. The effects of transverse shear deformation and rotary inertia were automatically taken into account. A finite element idealization was adopted and the quadratic

Lagrangian Mindlin plate element was used together with selective integration. Several numerical examples were presented and compared with results from other sources.

Dobyns (1981) [6] presented equations for the analysis of simply supported orthotropic plates subjected to static and dynamic loading conditions. Transient loading conditions considered, included sine, rectangular, and triangular pulses, and pulses representative of high explosive blast and nuclear blast. These pulses could be applied as a uniform load over the panel, a concentrated load, a uniform load applied over a small rectangular area, and a cosine loading applied over a small rectangular area. A method for the analysis of low velocity impact was also presented.

Reddy (1983) [7], employed the finite element method to investigate the transient response of isotropic, orthotropic and layered anisotropic composite plates. Numerical convergence and stability of the element was established using Newmark's direct integration technique. Numerical results for deflections and stresses were presented for rectangular plates under various boundary conditions and loadings. The parametric effects of the time step, finite element mesh, lamination scheme and orthotropy on the response were investigated. The presented results agreed very closely with the results available in the literature for isotropic plates.

Grace and Kennedy (1985) [8], investigated the dynamic response of orthotropic plate structures having fixed-simply supported and free-free boundary conditions using orthotropic plate theory. They examined the influences of aspect ratio and rigidity ratio on the natural frequencies and compared the results to those obtained from beam-theory. The analytical

results also compared with experimental test results. The comparison confirmed for this class of structures the natural frequencies beyond the first cannot be reliably estimated by beam-theory.

Ohga and Shigemtsui (1988) *[9]* , applied the finite element method and transfer matrix on the large displacement dynamic analysis of the plate structures subjected to random out-of-plane and in-plane excitations. The transfer matrix relating to the incremental state variables on the left and right boundaries of a strip was derived from the system of equations of motion for a strip. They introduced, an approximation in the equations of motion in order to reduce computational efforts. The Newmark method was employed for time integrations. Equilibrium iterations based on the modified Newton-Raphson method were employed and geometric nonlinearity was considered by using a set of moving coordinate systems. Various numerical examples were proposed and their results were compared with those obtained by other methods.

Khdeir and Reddy(1988) *[10]* presented the transient response of simply supported anti-symmetric rectangular plates subjected to arbitrary loading. The state variable technique was used to solve exactly the equations of motion of the first-order transverse shear deformation theory as well as the classical laminate theory. The solutions of these two theories were considered to bring out the influence of the transverse shear deformation, the degree of anisotropy, and the number of layers.

Mallikarjuna and Kant (1988) *[11]* presented a simple isoparametric finite element formulation based on a higher-order displacement model for the dynamic analysis of multi-layer symmetric composite plates with an explicit time marching scheme. A higher-order theory which was more

accurate than the Mindlin theory was applied, for the evaluation of plate response to different types of dynamic loads. A special mass lumping scheme was adopted which conserves the total mass of the element and includes the effects due to rotary inertia terms. The parametric effects of the time step, finite element mesh, lamination scheme and orthotropy on the transient response were investigated. Several numerical examples were presented and compared with results from other sources.

Cederbaum and Aboudi (1989) [12] investigated the dynamic response of viscoelastic laminated plates subjected to impulsive loading. The Fourier transform of the Boltzmann representation of the viscoelastic phases was incorporated into a micromechanical analysis, which establishes the five frequency-dependent functions characterizing the effective behavior of unidirectional fiber composites. First-order as well as higher-order shear deformation theories were used for the investigation of the laminated plate's response. The inversion of the response function into the time domain was performed by the Fast Fourier transform algorithm. It was shown that the viscoelastic behavior is significantly different from the elastic one. Comparisons between the results obtained from the various theories were discussed.

Kant and Mallikarjuna(1989) [13], employed a finite element method based on Mindlin's theory in the prediction of the dynamic transient response of multilayered composite sandwich plates. Numerical convergence and stability of 4-noded linear, 8-noded serendipity, and 9-noded Lagrangian elements were established using an explicit time integration technique. A special mass matrix diagonalization scheme was adopted which conserves the total mass of the element and includes the

effects due to rotary inertia terms. The parametric effects of the time step, finite element mesh, lamination scheme, and orthotropy on the transient response were investigated. Numerical results for deflections and stresses are presented under various boundary conditions and loadings.

Yung and Chang (1989), [14] presented a transient dynamic finite element analysis for studying the response of laminated composite plates due to transverse foreign object impact. The analysis can be used to calculate displacements of composite plate during impact and transient stress and strain. the Newmark scheme was adopted to perform time integration from step by step .

Katsikadelis et al. (1990), [15] developed a boundary element approach for the static and dynamic analysis of Kirchhoff's plates of arbitrary shape which, in addition to the boundary supports, were also supported inside the domain on isolated points (columns), lines (walls) or regions (patches). They treated all kinds of boundary conditions. The supports inside the domain of the plate may yield elastically. The method used the Green's function for the static problem without the internal supports to establish an integral representation for the solution which involves the unknown internal reactions and inertia forces within the integrand of the domain integrals. The Green's function was established numerically using boundary element method. Subsequently, using an effective Gauss integration for the domain integrals and a boundary element method technique for line integrals a system of simultaneous equations. In general, nonlinear algebraic equations is obtained which is solved numerically. Several examples for both the static and dynamic problem are presented to illustrate the efficiency and the accuracy of the proposed method.

leads to a decrease in the max. dynamic displacement for the point which lies in the middle of the free end with ratio (3%-20%) for the same case.

Table (4-4):natural frequency and natural period for plate sections of case 4

Dimensions of plate (B*L) M	Natural frequency Cycle/sec.	Natural period Sec.
2×4	41.513	0.0240
3×4	25.791	0.0387
4×4	19.063	0.0524
5×4	15.226	0.0656

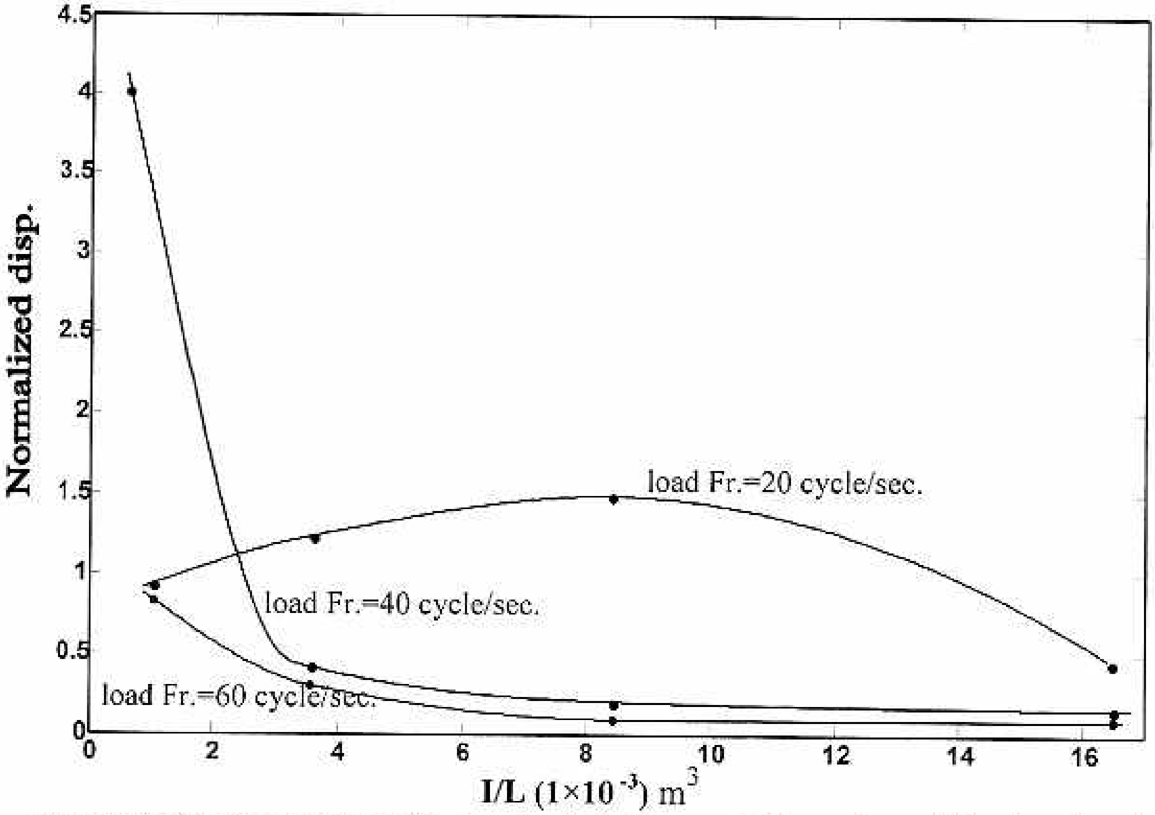

Figure (4-18): the variation of normalized displacement (dynamic amplification factor) with stiffness of plate for point 1, case 4

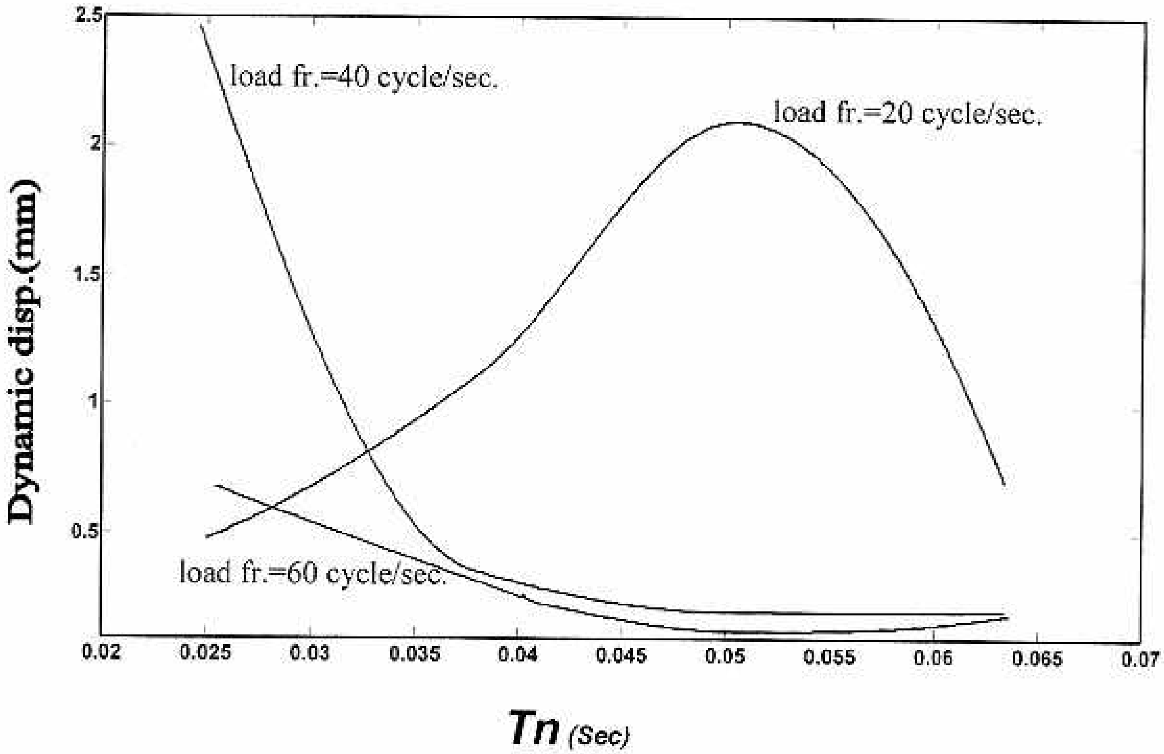

Figure (4-19): the variation of dynamic displacement of point 1 with natural period of plate, case 4

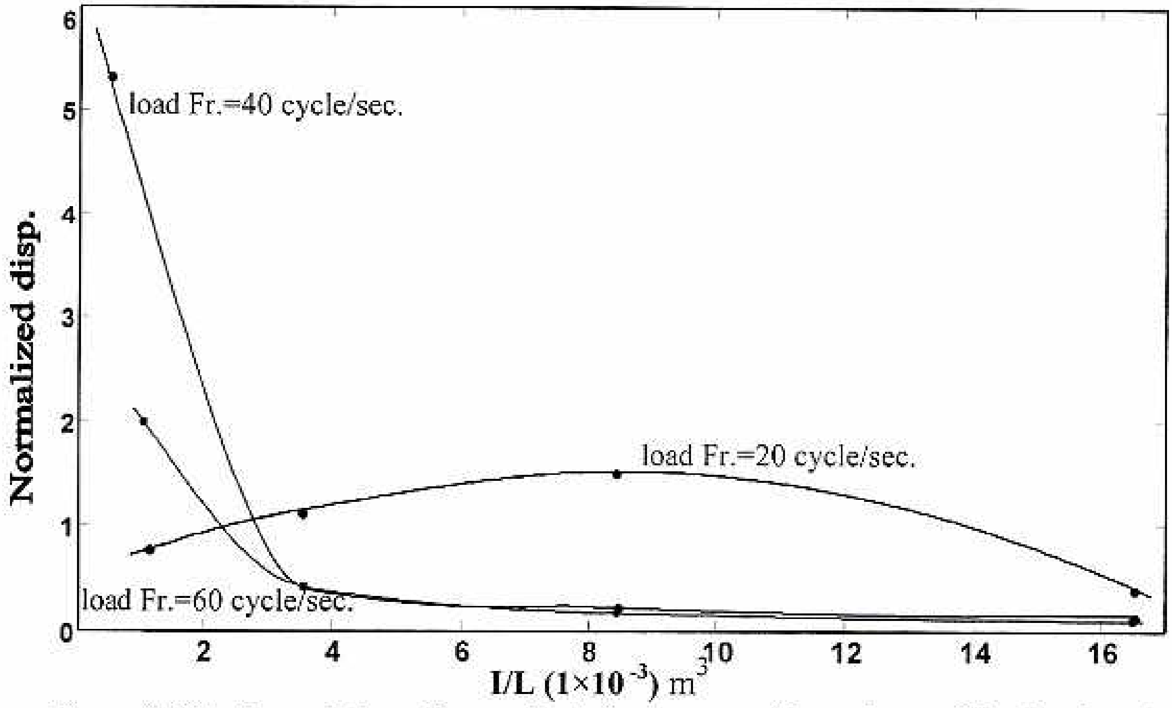

Figure (4-20): the variation of normalized displacement (dynamic amplification factor) with stiffness of plate for point 2, case 4

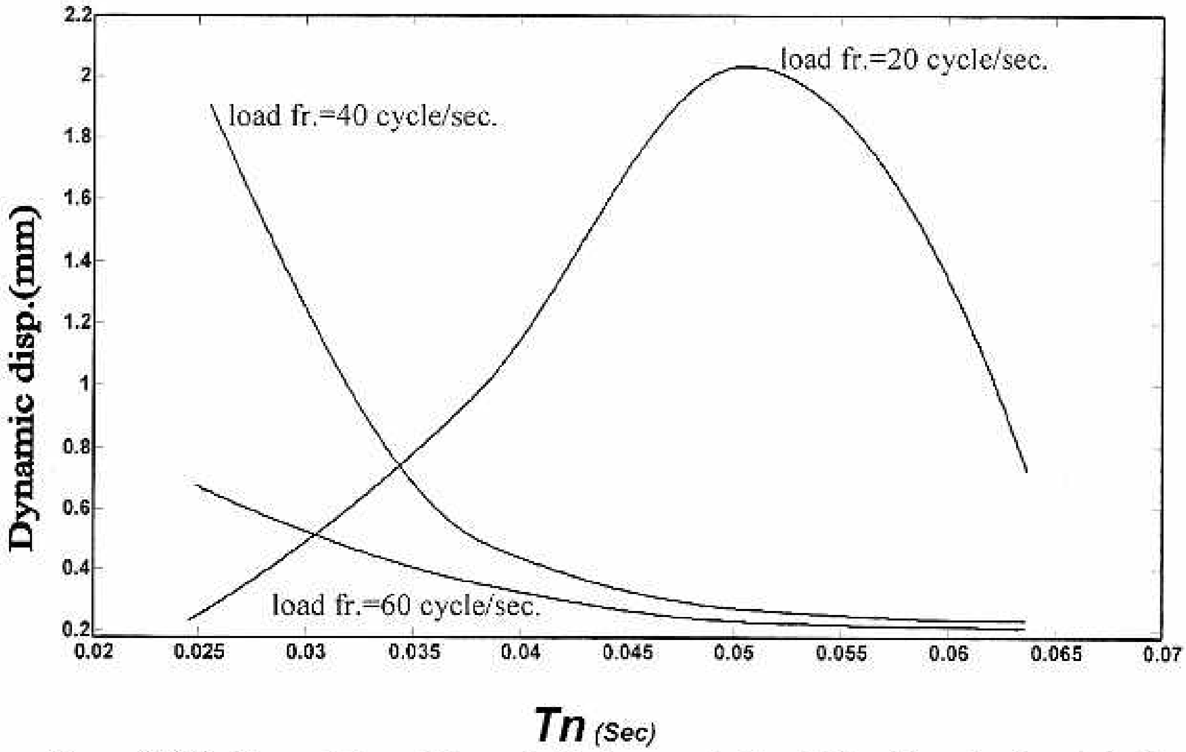

Figure (4-21): the variation of dynamic displacement of point 2 with natural period of plate, case 4

4-3-9 Case 5: The plates with stiffeners (beams), ***(L/t =13.4)***. The dimension of beam, **(a=0.6m , b=0.25m)**. For **(L/B)** ratios studied ranging from 0.5 to 1.25 . Dimensions of plates, natural frequency and natural period for plate sections are shown in Table (4-5).

Results of point (1) are shown in Fig.(4-22) and Fig.(4-23), which represents the variation of normalized displacement (dynamic amplification factor) with stiffness of plate and variation of dynamic displacement with natural period of plate.

From Fig.(4–22), it can be noted that, the max. normalized displacement varies from 0.9 to 3.75. This min. value (0.9) appears due to the ratio of the period of applied load to the natural period for the section of the plate equal to (62%), while the max. value (3.75) appears due to the period of the applied load is (93%) of the natural period.

Results of point (2) are shown in Fig. (4-24) and Fig. (4-25), which represents the variation of normalized displacement (dynamic amplification factor) with stiffness of plate and variation of dynamic displacement with natural period of plate.

Fig(4-24), it is noted that the max. normalized displacement for the point which lies at the edge of the free end is greater than the max. normalized displacement for the point which lies in the middle of the free end by (7% -280%), although the dynamic displacement for the point which lies at the edge of the free end represents (25%- 65%) of the dynamic displacement for the point which lies in the middle of the free end.

Comparing (case 5) ,(case3) and (case1): It is found that the max. dynamic displacement for the point at the edge in (case 5) represents (53% - 70%) of the max. dynamic displacement for the point which lies at the edge

in case 3 and also represents (30% - 50%) of the max. dynamic displacement for the point which lies at the edge in (case 1). The dynamic displacement for the point which lies in the middle of the free end also decreased in its value compared with (case 1) and (case 3). Except when the value of the frequency of the applied load (40cycle/sec.), the magnitude of the dynamic displacement higher in case 5 when compared it with the dynamic displacement in (case 1) and (case 3).

Table (4-5):natural frequency and natural period for plate sections of case 5

Dimensions of plate (B*L) M	Natural frequency Cycle/sec.	Natural period Sec.
2×4	37.299	0.0268
3×4	22.400	0.0446
4×4	14.648	0.0682
5×4	10.899	0.0917

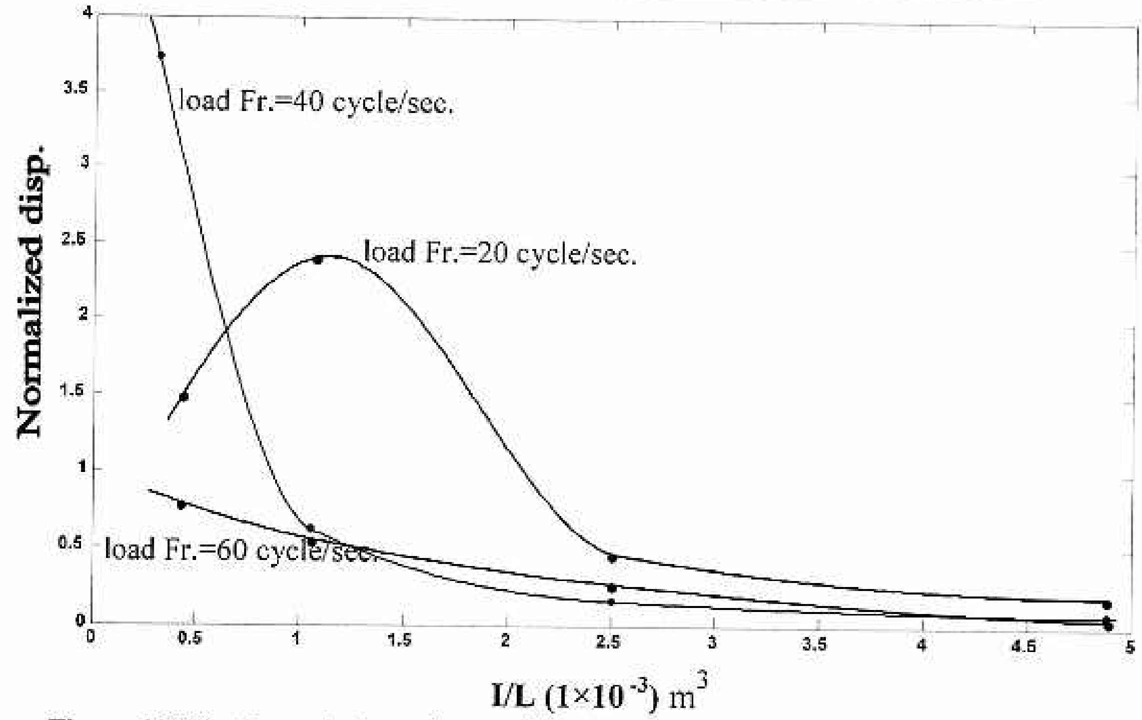

Figure (4-22): the variation of normalized displacement (dynamic amplification factor) with stiffness of plate for point 1, case 5

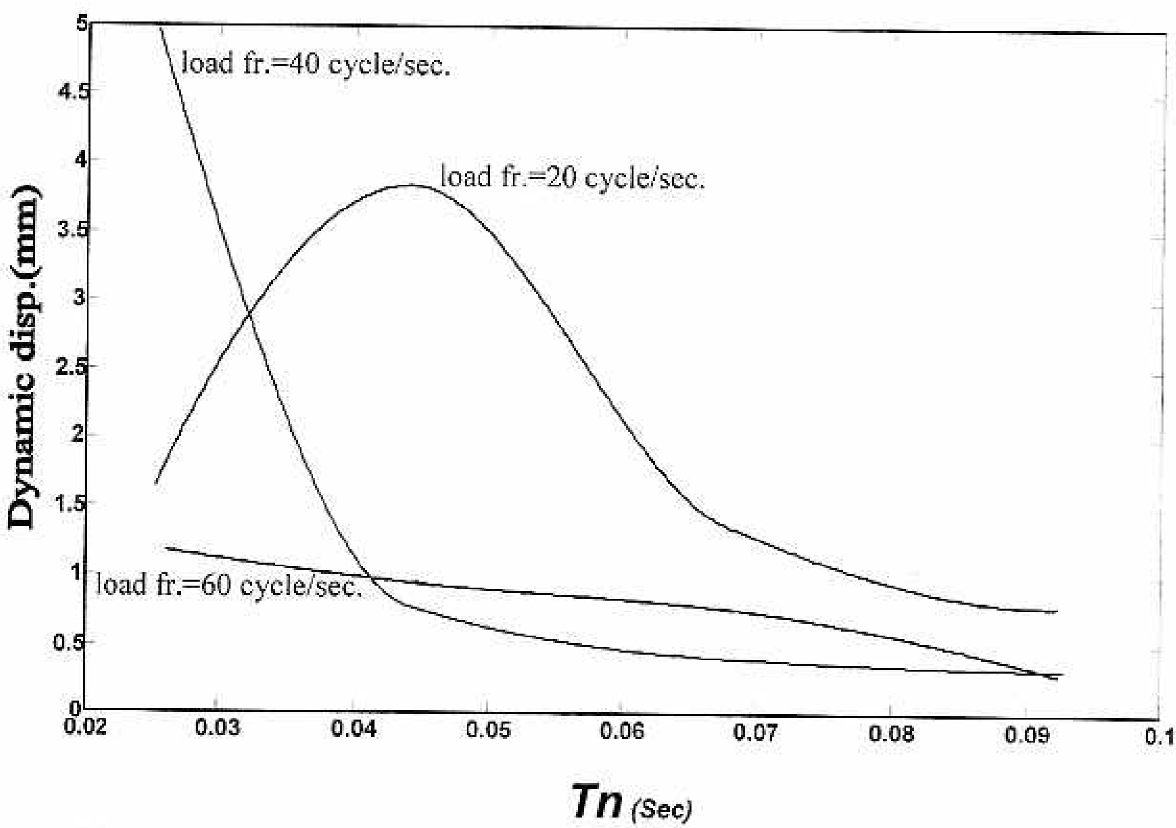

Figure (4-23): the variation of dynamic displacement of point 1 with natural period of plate, case 5

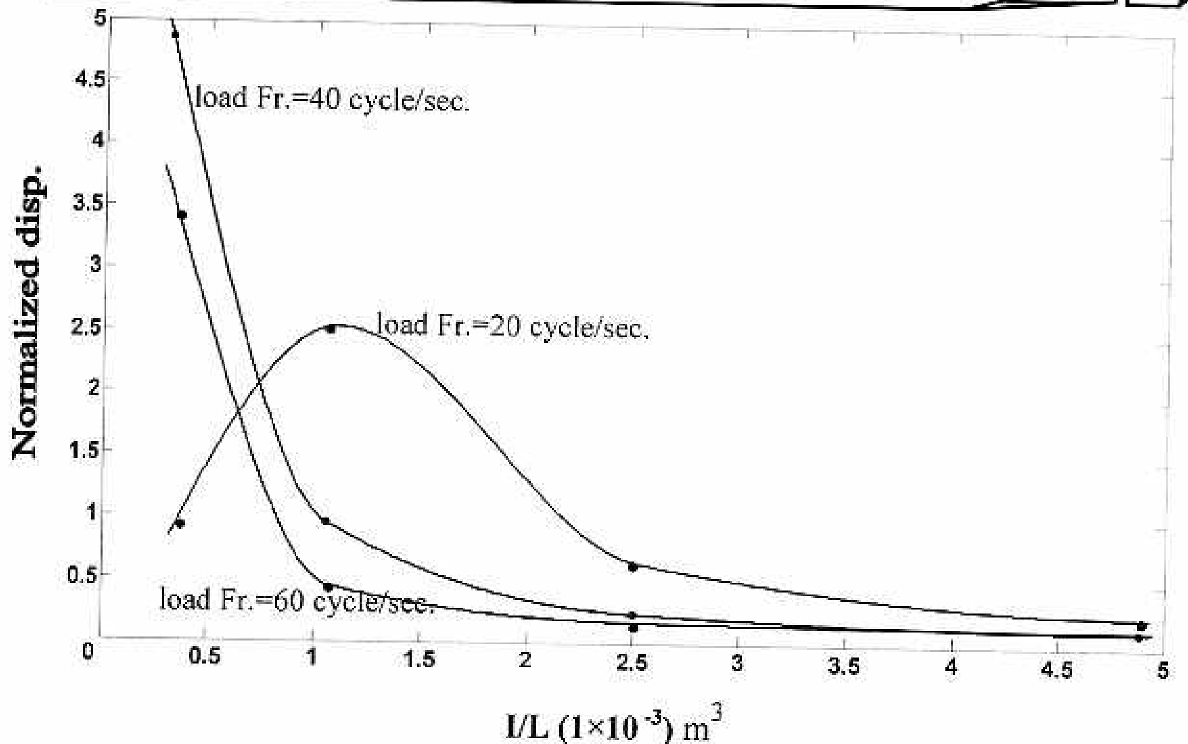

Figure (4-24): the variation of normalized displacement (dynamic amplification factor) with stiffness of plate for point 2, case 5

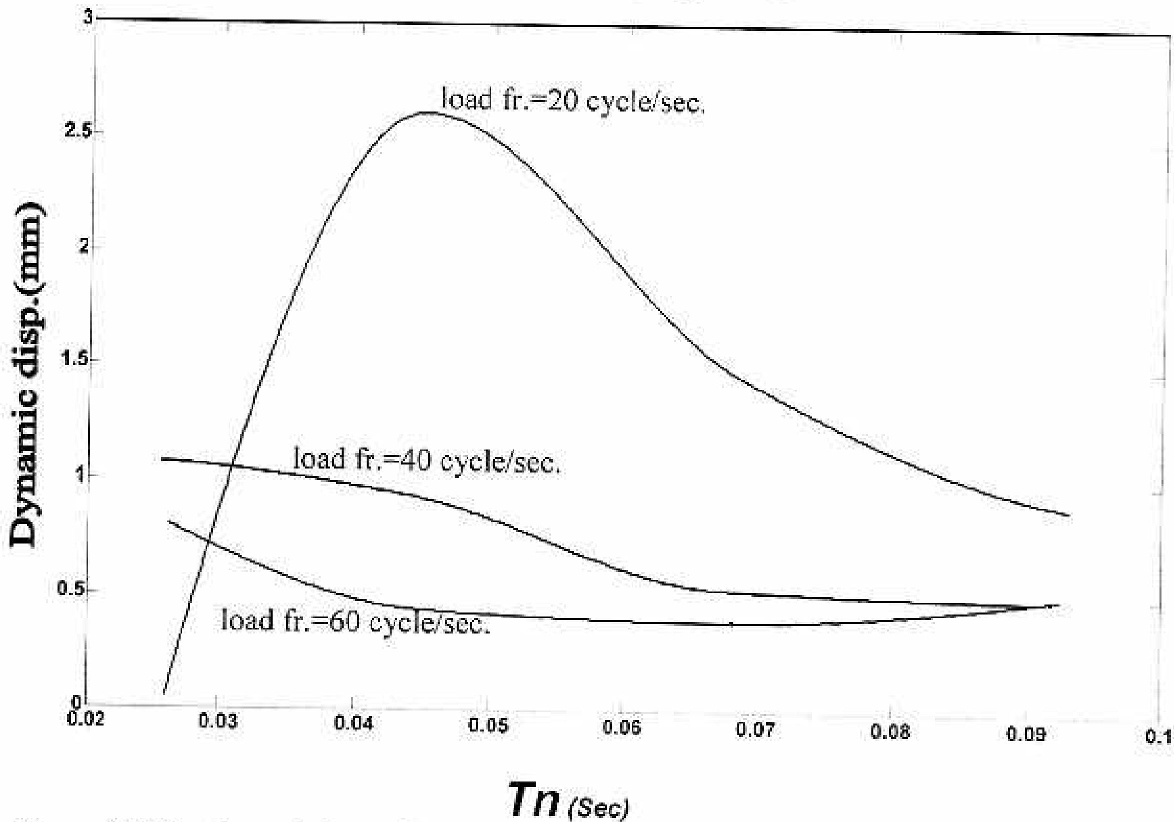

Figure (4-25): the variation of dynamic displacement of point 2 with natural period of plate, case 5

4-3-11 Case 6: The plates with stiffeners (beams), $(L/t = 8.9)$. The dimension of beam, **(a=0.6m , b=0.25m)**. For **(L/B)** ratios are ranging from 0.5 to 1.25 . Dimensions of plates, natural frequency and natural period for plate sections are shown in Table (4-5).

Results of point (1) are shown in Fig.(4-26) and Fig.(4-27), which represents the variation of normalized displacement (dynamic amplification factor) with stiffness of plate and variation of dynamic displacement with natural period of plate.

From Fig. (4–26), it can be shown that, the max. normalized displacement varies from (1.0 –2.4). the value (2.4) appears because the ratio of period of the applied load represents 20% greater than the natural period. The ratio of dynamic displacement to static displacement is equal to (1.0) because the period of the applied load is approximately equal to 20% from the ratio of the natural period of plate.

Results of point (2) are shown in Fig.(4-28) and Fig.(4-29), which represents the variation of normalized displacement (dynamic amplification factor) with stiffness of plate and variation of dynamic displacement with natural period of plate.

Fig.(4–28), it is noted that, the max. normalized displacement of point 2 represents (40% - 99%) from the max. normalized displacement of point 1.

Comparing (case 6) , (case 4) and (case 2): the max. displacement for the point which lies at the edge of the free end in (case6) is equal to (20% - 80%) from the value of max. dynamic displacement for the same point in (case 2), while the point which lies at the mid of the free end for (case 6) represents (52 % - 82%) of the dynamic displacement for the same point in

(case 2). Except for Fig.(4–27), load frequency (60 cycle/sec.) when it is compared with Fig.(4–11), load of frequency (60 cycle/sec.), it is noted that the values of dynamic displacement increase and also there is an increase in the magnitude of normalized displacement. This shows that the value of the static displacement has been effected greatly with the presence of the beams. Also the dynamic displacement for the point which lies at the edge of the free end in (case 6) represents (30% - 94%) of the dynamic displacement for the same point in (case 4). The point which lies in the mid of the free end has seen an increase in the dynamic displacement for (case 6) compare with (case 4). This increase happens only when the ratio of the period of the applied load is equal to 80% of the value of the natural period.

Table (4-6):natural frequency and natural period for plate sections of case 6

Dimensions of plate (B*L) M	Natural frequency Cycle/sec.	Natural period Sec.
2×4	47.878	0.02080
3×4	27.825	0.03600
4×4	19.614	0.05100
5×4	15.345	0.06516

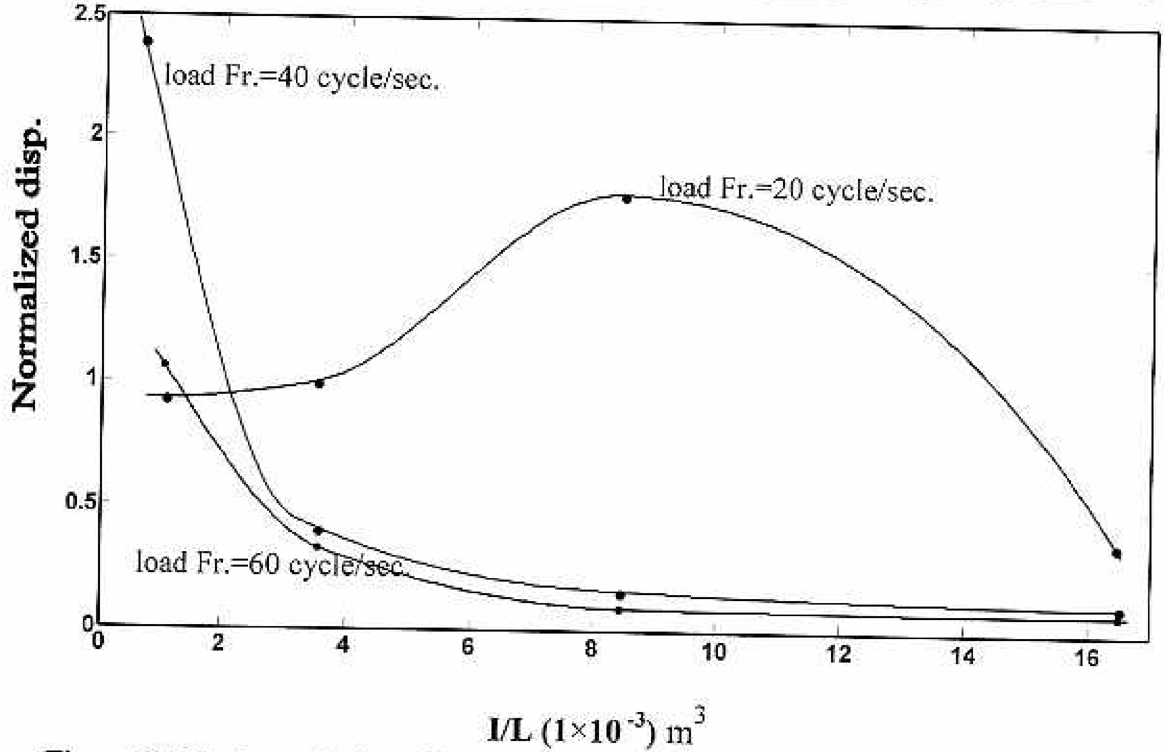

Figure (4-26): the variation of normalized displacement (dynamic amplification factor) with stiffness of plate for point 1, case 6

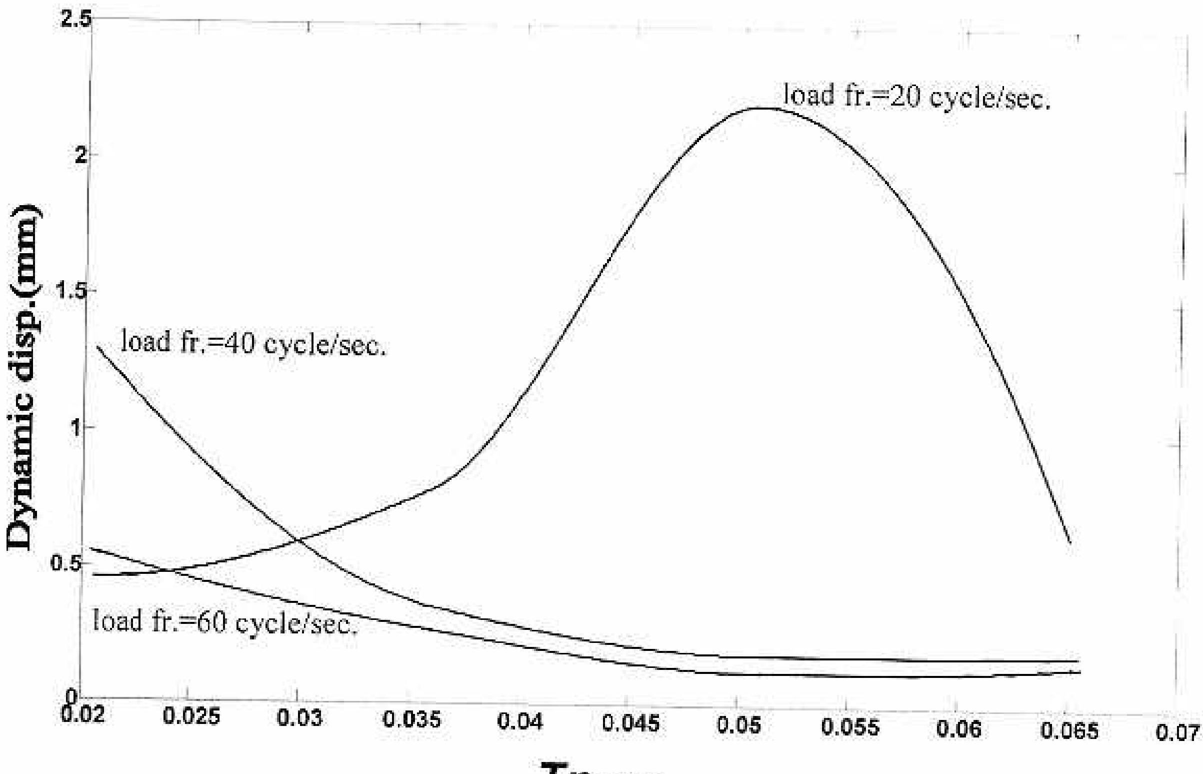

Figure (4-27): the variation of dynamic displacement of point 1 with natural period of plate, case 6

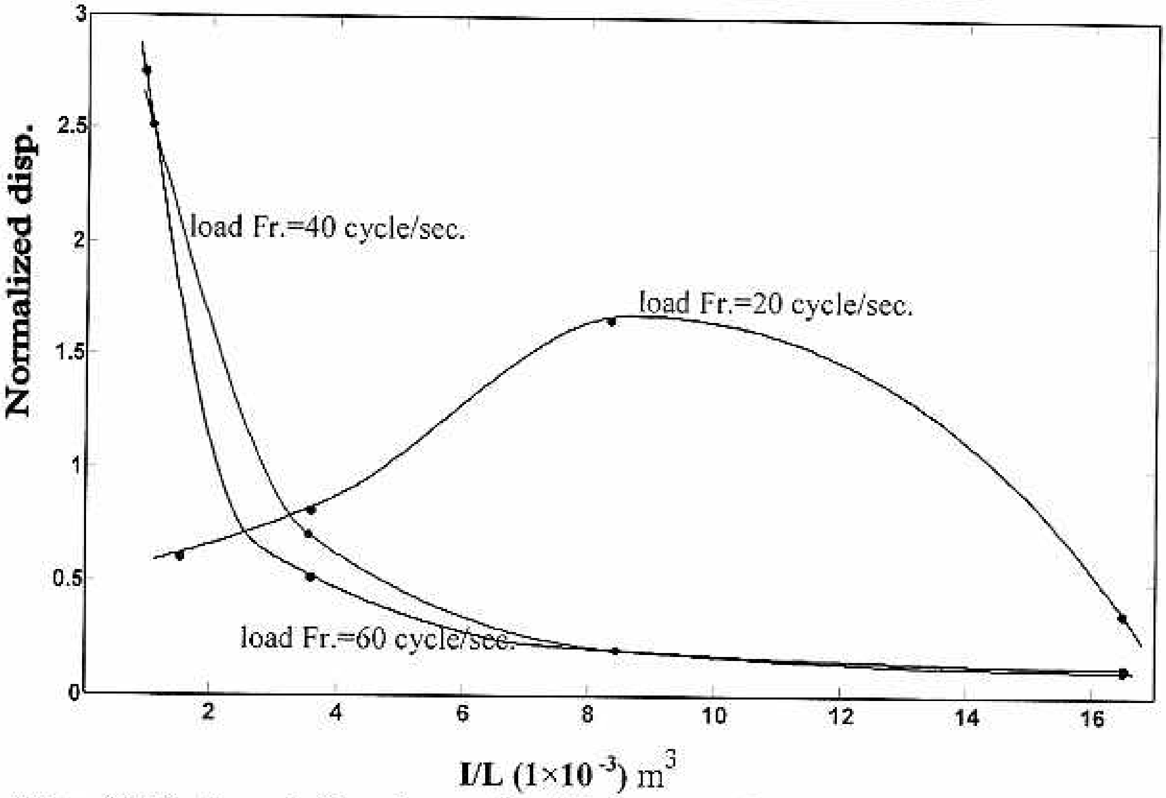

Figure (4-28): the variation of normalized displacement (dynamic amplification factor) with stiffness of plate for point 2, case 6

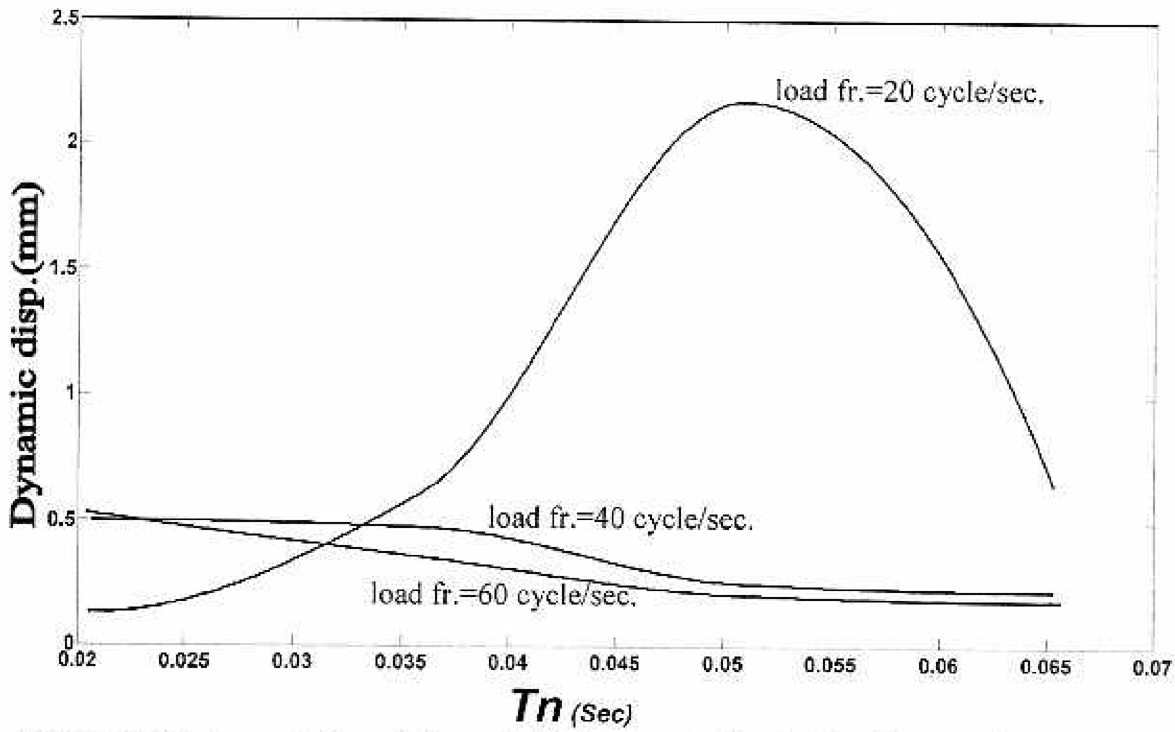

Figure (4-29): the variation of dynamic displacement of point 2 with natural period of plat, case 6

Chapter Five

Conclusions And Recommendations

5-1CONCLUSIONS

The main conclusions from this work for the dynamic analyses of cantilever plates are listed below:

1- For the cantilever plate with variable thickness, the normalized displacement is grater than (1.0) when the frequency of the applied dynamic load is (0.4 – 1.6) from the natural frequency. Therefore, this ratio must be taken into consideration in geometrical design in order to avoid the resonance.

2- The maximum normalized displacement for the point located on the corner of the free end is (1 - 2.85) of the maximum normalized displacement for the point located in the middle of the free end for the cases studied.

3- For plate with beams, when the ratio of stiffness factor of plate to stiffness factor of beam is ranging from (0.011) to (3.056), the maximum normalized displacement for the point located at the corner of the free end is (1 – 3.8) of the maximum normalized displacement for the point located at the middle of the free end.

4- For plate with beams, when the stiffness factor of beam is equal to (5.3×10^{-3}) m^3, the maximum dynamic displacement for the point located at the middle of the free end is (0.75 – 0.99) of the maximum dynamic displacement for the same point of the plates without beams. Also, the maximum dynamic displacement for the point located at the corner of the free of plate with beams is

(0.4 – 0.9) of the maximum dynamic displacement for the same point of the plates without beams.

5- For plate with beams, when the stiffness factor of beam is equal to (0.018) m^3, the maximum dynamic displacement for the point located at the middle of the free end is (0.2 – 0.8) of the maximum dynamic displacement for the same point of the plate without beams.

6- The reduction of (length to average thickness) ratio, from 13.4 to 8.9, or the addition of beams to plates does not necessarily result in a decrease in the maximum normalized displacement.

5-2 RECOMMENDATIONS

The following are some recommendations for future work :

1 – Studying the effect of presence of beams all around the plate.

2– Studying the effect of presence of line loads on beams which represent walls.

3– Changing the position of the load.

4– Changing the properties of plate.

Appendix

1- Shape function of beam element :

The displacement for the nods of element is given as :

$$d_e = A_e \alpha \qquad \text{.............(1)}$$

where :

$$d_e = \begin{Bmatrix} v_1 \\ \theta_1 \\ v_2 \\ \theta_2 \end{Bmatrix} \qquad \text{.............(2)}$$

and α is a constant vector given as :

$$\alpha = \begin{Bmatrix} \alpha_0 \\ \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{Bmatrix} \qquad \text{.............(3)}$$

from Eq. 1

$$\alpha = A_e^{-1} de \qquad \text{.............(4)}$$

where :

$$A_e^{-1} = \frac{1}{4} \begin{bmatrix} 1 & \alpha & 2 & -\alpha \\ -3 & -\alpha & 3 & -\alpha \\ 0 & -\alpha & 0 & \alpha \\ 1 & \alpha & -1 & \alpha \end{bmatrix} \qquad \text{.............(5)}$$

$$v = N(\xi)\, d_e \qquad \text{.............(6)}$$

where:

N is a matrix of shape function given as :

$$N(\xi) = PAe\text{-}1 = [N_1(\xi) \quad N_2(\xi) \quad N_3(\xi) \quad N_4(\xi)] \quad \text{........(7)}$$

In which the shape functions are given as :

$$N_1(\xi) = \frac{1}{4} \ (2 - 3\xi + \xi^3)$$

$$N_2(\xi) = \frac{1}{4} \alpha \ (1 - \xi - \xi^2 + \xi^3)$$

$$N_3(\xi) = \frac{1}{4} \ (2 - 3\xi - \xi^3)$$

$$N_4(\xi) = \frac{\alpha}{4} \ (1 - \xi - \xi^2 + \xi^3)$$

2- The matrix of material constant is given as :

$$c = \frac{E}{1 - \nu^2} \begin{bmatrix} 1 & \nu & 0 \\ \nu & 1 & 0 \\ 0 & 0 & (1-\nu)/2 \end{bmatrix}$$

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خلاصـــــة

تبحث الدراسة التحليل الديناميكي للصفائح الناتئة ذات السمك المتغير تحت تأثير الحمـــل الدوري . تم تحليل نوعين من الصفائح :

1- صفائح بدون وجود عتبات ساندة.   2- صفائح بوجود عتبات طولية ساندة .

الحالات التي تمت دراستها تم تنفيذها بطريقة العناصر المحددة ، وتم تحليلها باســـتخدام برنامج (Staad Pro.version 7) .

الهدف الرئيسي من الدراسة هو لمعرفة تأثير الحمل الدوري على الازاحة العمودية . تم دراسة نسبتين مختلفتين (الطول الى معدل السمك) تمثلت بالقيم (8.9 , 13.4) لكلا النوعين من الصفائح (المقواة بجسور ساندة وغير المقواة) . ان الحمل الدوري المستخدم في الدراســـة تـــم تمثيله بدالة (Sine-Force) بـــ (Amplitude) مقدارها (50 KN) موزعة على ستة نقاط تقع فـــي وســـط الـــصفيحة الناتئـــة . تـــم تـــسليط الحمـــل بتـــرددات مختلفـــة تتـــراوح بـــين (20-60) cycle\min والمسافة بين القوى المسلطة كانت (0.2m) .

كل النتائج (الازاحات) من تأثير الحمل الدوري تم حسابها لنقطتين (مركـــز وطـــرف) النهاية الحرة للصفيحة الناتئة وتم أخذها نسبة الى الازاحات الناتجة من الحمل الساكن .

نسبة الازاحة (الازاحة الناتجة من الحمل الدوري الى الازاحـــة الناتجـــة مـــن الحمـــل الساكن) أكبر من (1.0) عندما يكون تردد القوة المـــسلطة يـــشكل (1.6 – 0.4) مـــن التـــردد الطبيعي للمقطع ، لذا يجب أخذ هذه النسبة بعين الاعتبار عند التصميم الهندسي لتلافي حـــدوث ظاهرة الرنين . كما ان اضافة العتبات الساندة الى الصفائح يكون له التـــأثير الاكبـــر بتقليـــل الازاحة عندما تكون الصفيحة محملة ستاتيكياً.

التحليل الديناميكي للصفائح الناتئة ذات السمك المتغير تحت تأثير حمل دوري

رسالة مقدمة إلى

كلية الهندسة في جامعة البصرة

كجزء من متطلبات نيل درجة ماجستير علوم في الهندسة المدنية

من قبل

سامر محمد جاسب

2009م

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