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Load Analysis and Bending Solutions of Rectangular Thick Plate

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ABSTRACT: Many theories for plate analysis have been developed using linear strain–displacement expressions. It is proven from previous studies that results obtained using linear strain–displacement expressions may be unreliable for nonlinear stress and bending analyses. In the present paper, nonlinear strain–displacement expressions are employed for rectangular plates subjected to uniform distributed loads to suggest a more reliable refined plate theory that satisfies the continuity of all of the transverse stress components. This theory which is based on traditional third-order shear deformation plate is presented and applied in a bending analysis of rectangular thick plate. Governing equations and associated boundary conditions of the theory are obtained using the principle of variational calculus. From the formulated expression, the Formula for calculation of the actual critical lateral imposed load of the plate before deflection reaches the specified maximum specified limit and critical lateral imposed load before plate reaches an elastic yield stress were deduced. By solving elastic static equations developed, closed form solutions for bending analysis of thick rectangular plates with all four edges clamped (CCCC) are obtained. Furthermore, critical lateral loads are detected by employing a criterion bending analysis of rectangular thick plate with free of support at third edge and the other edges clamped (CCFC) to validate the result. The challenge of the normal practice in the structural design which is checking of deflection and crack due to shear after design has proven unreliable and duteous in the process, but if the load (critical lateral imposed load) that causes deflection and crack is known, there may not be any need going through that rigorous process which is unreliable. In the result of CCFC plate, the negative value of critical lateral imposed load q_{iw}(between -0.00037N/mm to -0.0073N/mm) reveals that the plate fail in q_{iw} with a slight increment in width, a of 3000 mm at length-width ratio between 1 to 2 at allowable thickness between 5mm to 15mm respectively. This means that the plate structure is not safe. To remedy such situation in design, it is advised that the thickness t or the allowable deflection w_{a} should be increased. Also, the positive value of critical lateral imposed load q_{iw} and q_{ip} CCCC plate reveals that the plate neither fail in q_{iw} norin q_{ip} for plate span bending curvature (width, a) of 1000mm at allowable deflection, w_{a} of 1000mm to 5000mm for all the boundary conditions in consideration. This means that the plate structure is safe. The effects of aspect ratio on the critical lateral load of isotropic plates is investigated and discussed. It is concluded that present theory satisfied the transverse normal stress continuity and the transverse flexibility of the rectangular plate's condition while predicting the bending behaviour of isotropic rectangular plate.

Keywords: CCCC plate, CCCF plate traditional third-order shear deformation plate theory, variational calculus, shear correction factors, critical lateral imposed load.

I. INTRODUCTION

Plate structures have been extensively used in aerospace, aeronautic, automotive, naval, underwater, and building structures. Critical Load is defined as the highest loading value, which will not cause any lateral deflection or tangential deflection on the structure. The critical load puts the column in a state of unstable equilibrium. As the load is increased beyond the critical load the lateral deflections increase, until it may fail in other modes such as yielding of the material. To keep away from failure occurrences within the structural member, more accurate and practical studies on bending analysis of the plate is required.

Isotropic plates are being widely used in structures subjected to severe uniformly distributed load, which produce a very large stresses on it. In order to evaluate the actual load in the plate when large stresses characterized by non-negligible shear deformations, refined theories are developed [5, 10].

Reddy, Sayyad and Ghugal [3-6, 7-8, 9] developed a more accurate solutions which considers effect of shear deformation (TSDT, HSDT and ESDT respectively) to predict the buckling, bending and free vibration behavior of thick isotropic plates under uniformly distributed lateral load.

Ghugal and Kulkarni [6] have used trigonometric shear deformation theory (TSDT) for the analysis of rectangular plates. Their theory and others [1- 4] incorporates the effect of transverse shear stress and shear deformation in the analysis. Results obtained using the above theories shows slight errors in predicting responses of the lateral load on the structures.

Polynomial displacement functions can be applied successfully to solve CCCC and CCCF boundary condition of thick rectangular plate; a feat that could not be easily achieved using trigonometric, hyperbolic and exponential shape functions. It will contribute in addressing the problem of dearth of literature on the function of polynomial displacement functions. Scholars and practicing engineers will assess, apply and sustain trust in their works/designs. Thereby the psychological trauma due to doubt or not too sure of ones works using Fourier series to analysed thick plates will be done away with.

Ibearugbulem and Onyeka [15] have used polynomial shear deformation theory (PSDT) for the analysis of rectangular plates. Their theory incorporates the effect of transverse shear stress and shear deformation in the analysis. Results obtained using the theories did not introduce much error in the analysis but it ended up determining the displacements, moments and stresses that may occur due to the applied load without obtaining the critical lateral load in predicting responses of the applied load which can lead to failure on the structures.

Furthermore, it is proven that when the critical load is lesser than value of allowable load for the structure, the structure will remain in the straight or limited deflection. When the critical load exceeds the design load of the structure, it will be in deflected position [14]. The deflected position means that the load from the external force is very higher than the designed one. Therefore, there is need to determine the critical load.

In this work, the use of nonlinear strain–displacement polynomial shape function of fourth order shear deformation theory for rectangular thick plate analysis under uniformly distributed load was applied to solve bending problem of rectangular plates with all four edges clamped (CCCC) and plate with free of support at third edge and the other edges clamped (CCFC) using the direct variational energy method. This theory allows the line elements normal to the mid-surface not only to rotate, but also to deform and not necessarily remain straight [13]. The aim is to develop Formula's for calculation of the actual critical lateral imposed load of the plate before deflection reaches the specified maximum specified limit and maximum critical lateral imposed load before plate reaches an elastic yield.

The effect of the lateral load on the two different sets of boundary conditions are adopted; CCCC (all edges clamped) and CCFC (three edges clamped and other one free). More so, effects of aspect ratio on the critical lateral load of isotropic plates is investigated and discussed.

II. GOVERNING EQUATION

A rectangular plate model having length 'a', width 'b' and constant thickness 'h' with mid-plane delamination under transverse loading as shown in Fig. 1, is chosen for present numerical formulation.

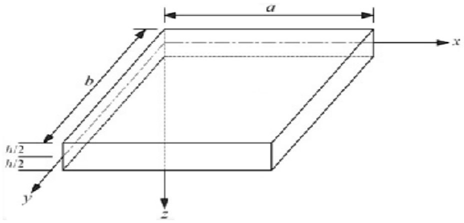

Fig. 1. Geometry of Thick plate.

The total potential energy functional(Π), the deflection and in – plane displacement functions $(w,\ v\ and\ u)$of thick isotropic plate were derived in Onyeka (2018) as

$$\begin{aligned}\Pi = \frac{D}{2}\int_0^a\int_0^b \Bigg[\Bigg| & g_1{A_1}^2\left(\frac{\partial^2 h}{\partial x^2}\right)^2 - 2g_2A_1A_2\left(\frac{\partial^2 h}{\partial x^2}.\frac{\partial^2 h}{\partial x^2}\right) \\ & + g_3{A_2}^2\left(\frac{\partial^2 h}{\partial x^2}\right)^2\Bigg| \\ & + \Bigg|2g_1{A_1}^2\left(\frac{\partial^2 h}{\partial x\partial y}\right)^2 \\ & - 2g_2A_1A_2\left(\frac{\partial^2 h}{\partial x\partial y}.\frac{\partial^2 h}{\partial x\partial y}\right) \\ & - 2g_2A_1A_3\left(\frac{\partial^2 h}{\partial x\partial y}.\frac{\partial^2 h}{\partial x\partial y}\right)\Bigg| \\ & + \Bigg|(1+\mu)g_3A_2A_3\left(\frac{\partial^2 h}{\partial x\partial y}\right)\left(\frac{\partial^2 h}{\partial x\partial y}\right)\Bigg| \\ & + \frac{(1-\mu)}{2}\Bigg|g_3{A_2}^2\left(\frac{\partial^2 h}{\partial x\partial y}\right)^2 \\ & + g_3{A_3}^2\left(\frac{\partial^2 h}{\partial x\partial y}\right)^2\Bigg| \\ & + \Bigg|g_1{A_1}^2\left(\frac{\partial^2 h}{\partial y^2}\right)^2 \\ & - 2g_2A_1A_3\left(\frac{\partial^2 h}{\partial y^2}.\frac{\partial^2 h}{\partial y^2}\right) \\ & + g_3{A_3}^2\left(\frac{\partial^2 h}{\partial y^2}\right)^2\Bigg| \\ & + \Bigg|\frac{(1-\mu)}{2}g_4{A_2}^2\left(\frac{\partial h}{\partial x}\right)^2 \\ & + \frac{(1-\mu)}{2}g_4{A_3}^2\left(\frac{\partial h}{\partial y}\right)^2\Bigg|\Bigg|\partial x\partial y \\ & - \int_0^a\int_0^b qA_1h\,\partial x\partial y \qquad (1)\end{aligned}$$

where:

$$w = A_1.h = \overline{A_1}h\left(\frac{qa^4}{D}\right) \qquad (2)$$

and,

$$u = [-\overline{A_1}s + \overline{A_2}F(s)]\frac{dh}{dR}\left(\frac{tqa^3}{D}\right) \qquad (3)$$

That is:

$$u = [-\overline{A_1}s + \overline{A_2}F(s)]\frac{dh}{dR}\left(\frac{qa^4}{\rho D}\right) \qquad (4)$$

Similarly,

$$v = \frac{1}{\propto}[-\overline{A_1}s + \overline{A_3}F(s)]\frac{dh}{dQ}\left(\frac{tqa^3}{D}\right) \qquad (5)$$

That is,

$$u = [-\overline{A_1}s + \overline{A_3}F(s)]\frac{dh}{dQ}\left(\frac{qa^4}{\rho D}\right) \qquad (6)$$

$$\sigma_x = 12\left[[-\overline{C_1}s + \overline{C_2}F(s)]\frac{d^2h}{dR^2} + \frac{\mu}{\propto^2}[-\overline{C_1}s + \overline{C_3}F(s)]\frac{d^2h}{dQ^2}\right](q\rho^2) \qquad (7)$$

Similarly,

$$\sigma_y = q\rho^2\left[12\left[\mu[-\overline{C_1}s + \overline{C_2}F(s)]\frac{d^2h}{dR^2}\right] + \frac{\mu}{\propto^2}[-\overline{C_1}s + \overline{C_3}F(s)]\frac{d^2h}{dQ^2}\right] \qquad (8)$$

Similarly,

$$\tau_{xy} = 6\frac{(1-\mu)}{\propto}\left[-2\overline{C_1}s + \overline{C_2}F(s) + \overline{C_3}F(s).\frac{1}{\propto}\right]\frac{d^2h}{\partial R\partial Q}(q\rho^2) \qquad (9)$$

Similarly,

$$\tau_{xz} = 6(1-\mu)\overline{C_2}\frac{dF(z)}{dz}\frac{dh}{dR}(q\rho^2) \qquad (10)$$

Similarly,

$$\tau_{yz} = \frac{6(1-\mu)}{\propto}\overline{C_3}\frac{dF(z)}{dz}\frac{dh}{dQ}(q\rho^2) \qquad (11)$$

III. FORMULATION OF EXPRESSION FOR THE CRITICAL IMPOSED LOAD BEFORE DEFLECTION REACHES SPECIFIED MAXIMUM LIMIT, q_{iw}

The maximum critical lateral load on the plate before its deflection reaches allowable value will be determined. This is to ensure that deflection does not exceed specified maximum limit.

Recall that:

$w = A_1.h$

But;

$$A_1 = \frac{qa^4}{D}.k \qquad (12)$$

Let:

$$k = \frac{k_q}{k_T} \qquad (13)$$

Where,

$$k_T = k_1 + \frac{2}{\propto^2}k_2 + \frac{1}{\propto^4}k_3 \qquad (14)$$

And;

$$k_6 = \int_0^1\int_0^1 h.dRdQ \qquad (15)$$

To ensure that the critical lateral load of the plate is determined before its deflection reaches allowable value;

$$w = A_1\mathrm{h} < \mathrm{w_a} \qquad (16)$$

That is:

$$w = \frac{qa^4}{D}.k.\mathrm{h} < \mathrm{w_a} \qquad (17)$$

where,

$\mathrm{w_a} = \text{Allowable deflection}$

And;

$$D = \frac{Et^3}{12(1-\mu^2)} \qquad (18)$$

Also,

$$q = q_{\ d} + q_{\ iw} \qquad (19)$$

This gives:

$$q_{\ iw} < \left[\frac{\mathrm{w_a}\,Et^3}{12(1-\mu^2)a^4.k.\mathrm{h}}\right] - q_{\ d} \qquad (20)$$

where;

$q_{\ d} = \text{Self weight of the plate}$

And,

$q_{\ iw} = \text{Critical Imposed load of the plate}$

But;

$$q_{\ d} = \gamma t \qquad (21)$$

where;

$\gamma = Unit\ weight$

Thus:

$$q_{\ iw} < \left[\frac{\mathrm{w_a}\,Et^3}{12(1-\mu^2)a^4.k.\mathrm{h}}\right] - \gamma t \qquad (22)$$

where;

$$\beta = \left[\frac{\mathrm{w_a}\,E}{12(1-\mu^2)a^4.k.\mathrm{h}}\right] \qquad (23)$$

Therefore:

$$q_{\ iw} < \beta t^3 - \gamma t \qquad (24)$$

IV. FORMULATION OF EXPRESSION FOR THE CRITICAL LOAD BEFORE PLATEREACHES ELASTIC YIELD STRESS, $q_{\ ip}$

Here, the critical lateral load on the plate before it reaches yielding point will be determined. This is to ensure that the stress due to the imposed load on the plate does not exceed elastic yield stress.

Recall that;

$$U \quad = \frac{1}{2}\iiint_{-\frac{t}{2}}^{\frac{t}{2}} \cap\, dxdydz \qquad (25)$$

where;

$$\cap = \sigma_x\varepsilon_{x+}\sigma_y\varepsilon_{y+}\tau_{xy}\gamma_{xy} + \tau_{xz}\gamma_{xz} + \tau_{yz}\gamma_{yz} \qquad (26)$$

Substituting values of $\varepsilon_X, \varepsilon_Y, \gamma_{xy}, \gamma_{xy}$, and γ_{yz} above into Equation 26, we have:

$$\cap = \frac{1}{E}\left[\sigma_x{}^2 - \mu\sigma_x\sigma_y - \mu\sigma_x\sigma_y + \sigma_y{}^2 + 2(1+\mu)\tau_{xy}{}^2 + 2(1+\mu)\tau_{xz}{}^2 + 2(1+\mu)\tau_{yz}{}^2\right] \qquad (27)$$

To ensure that the critical lateral load the plate is determined before it reaches yielding;

$$\cap = \frac{1}{E}\left[\sigma_x{}^2 - \mu\sigma_x\sigma_y - \mu\sigma_x\sigma_y + \sigma_y{}^2 + 2(1+\mu)\tau_{xy}{}^2 + 2(1+\mu)\tau_{xz}{}^2 + 2(1+\mu)\tau_{yz}{}^2\right] < \cap_0 \qquad (28)$$

where;

$\cap_0 = \text{yielding point of the plate.}$

For a bar,

$let\ \sigma_X = fy\ and\ \sigma_Y = \tau_{xy} = \tau_{xz} = \tau_{yz} = 0$

Therefore;

$$\cap < \cap_0 > \frac{fy^2}{E} \qquad (29)$$

So, equating Equation 13 with 14; we have:

$$\frac{1}{E}\left[\sigma_x{}^2 - 2\mu\sigma_x\sigma_y + \sigma_y{}^2 + 2(1+\mu)\tau_{xy}{}^2 + 2(1+\mu)\tau_{xz}{}^2 + 2(1+\mu)\tau_{yz}{}^2\right] < \frac{fy^2}{E} \qquad (30)$$

Let,

$$\sigma_Y = n_1\sigma_x \equiv n_1 = \frac{\sigma_Y}{\sigma_x} \qquad (31)$$

$$\tau_{xy} = n_2\sigma_x \equiv n_2 = \frac{\tau_{xy}}{\sigma_x} \qquad (32)$$

$$\tau_{xz} = n_3\sigma_x \equiv n_3 = \frac{\tau_{xz}}{\sigma_x} \qquad (33)$$

$$\tau_{yz} = n_4\sigma_x \equiv n_4 = \frac{\tau_{yz}}{\sigma_x} \qquad (34)$$

Therefore, substituting Equations 31, 32, 33 and 34 into 23, we have:

$$\sigma_x{}^2 - 2\mu n_1\sigma_x{}^2 + n_1{}^2\sigma_x{}^2 + 2(1+\mu)n_2{}^2\sigma_x{}^2 + 2(1+\mu)n_3{}^2\sigma_x{}^2 + 2(1+\mu)n_4{}^2\sigma_x{}^2 < fy^2 \qquad (35)$$

This gives:

$$\sigma_x < \frac{fy}{\sqrt{\left[1 - 2\mu n_1 + n_1{}^2 + 2(1+\mu)n_2{}^2 + 2(1+\mu)n_3{}^2 + 2(1+\mu)n_4{}^2\right]}} \qquad (36)$$

This gave:

$$\sigma_x = \frac{Ez\mathrm{A}_1}{(1-\mu^2)\propto^2}\left(\frac{d^2h}{dR^2} + \frac{\mu}{\propto^2}\frac{d^2h}{dQ^2}\right) \qquad (37)$$

Let,

$$A_1 = \frac{qa^4}{D}\left(\frac{k_q}{k_T}\right) \qquad (38)$$

Recall;

$$D = \frac{Et^3}{12(1-\mu^2)}$$

Thus:

$$\sigma_x = \frac{Ez}{(1-\mu^2)}\left(\frac{d^2h}{dR^2} + \frac{\mu}{\alpha^2}\frac{d^2h}{dQ^2}\right)\frac{qa^2}{\frac{Et^3}{12(1-\mu^2)}}.k \qquad (39)$$

This gives:

$$\frac{12.qa^2.k.z}{t^3}.\beta_2 < \frac{fy}{\beta_3} \qquad (40)$$

where;

$$\beta_2 = \left(\frac{d^2h}{dR^2} + \frac{\mu}{\propto^2}\frac{d^2h}{dQ^2}\right) \qquad (41)$$

and,

$$\beta_3 = \sqrt{\left[1 - 2\mu n_1 + n_1{}^2 + 2(1+\mu)n_2{}^2 + 2(1+\mu)n_3{}^2 + 2(1+\mu)n_4{}^2\right]} \qquad (42)$$

From Equation 40, we get expression for q as:

$$q < \frac{fyt^3}{12.a^2.k.z.\beta_2.\beta_3} \qquad (43)$$

Let;

$$q = q_{\ d} + q_{\ ip} \qquad (44)$$

This gives:

$$q_{ip} < \frac{fyt^3}{12.a^2.k.z.\beta_2.\beta_3} - q_d \qquad (45)$$

This gave:

$$q_{ip} < \frac{fyt^3}{12.a^2.k.z.\beta_2.\beta_3} - \gamma t \qquad (46)$$

This gave:

$$q_{ip} < \beta_4 t^3 - \gamma t \qquad (47)$$

where;

$$\beta_4 = \frac{fy}{12.a^2.k.z.\beta_2.\beta_3} \qquad (48)$$

$q_{ip} =$ critical imposed lateral load before plate reach yield stress; $fy =$ strength

and;

$q_d =$ Self weight of the plate

Thus, rearranging Equation 39; we have:

$$\beta_4 t^3 - \gamma t - q_{ip} > 0 \qquad (49)$$

V. NUMERICAL PROBLEM

The numerical results of the critical imposed lateral load of CCCC and CCFC rectangular plate with different aspect ratio is presented in Table 2 to 19. The value critical lateral imposed load on the plate before its deflection reaches allowable value and the critical imposed lateral load on the plate before it reaches elastic yield stress is presented at the edges of the plate is presented. The effect of the lateral load on the two different sets of boundary conditions are adopted; CCCC (all edges clamped) and CCFC (three edges clamped and other one free). The effects of aspect ratio on the critical lateral load of isotropic plates is investigated and discussed.

A fourth order polynomial displacement function derived for the analysis is given as:

$$w = \frac{F_{a4}.F_{b4}}{576}(R^2 - 2R^3 + R^4) \times (Q^2 - 2Q^3 + Q^4) \qquad (50)$$

Where;

$$h = (R^2 - 2R^3 + R^4) \times (Q^2 - 2Q^3 + Q^4) \qquad (51)$$

And;

$$A_1 = \frac{F_{a4}.F_{b4}}{576} \qquad (52)$$

The k values herein is given in Table 1.

VI. RESULTS AND DISCUSSIONS

The results obtained in Tables 2 to 19 it also reveals that the values of critical lateral imposed load q_{iw} and q_{ip} decrease as the length-width ratio increases, this continues until failure occur. This means that increase in plate width increases the chance of failure in a plate structure. From that table it is observed that the value of q_{ip} if greater than that of q_{iw}, this is because failure of plate in q_{ip} means total failure but that of q_{iw} is like a warning.

Looking closely at Tables 2 to 19, the positive value of critical lateral imposed load q_{iw} and q_{ip} reveals that the plate neither fail in q_{iw} nor in q_{ip} for plate span bending curvature (width, a) of 1000mm at allowable deflection, w_a of 1000mm to 5000mm for all the boundary conditions in consideration. This means that the plate structure is safe.

For the dimensional values of critical imposed load obtained in the Tables 2 to 10, it also reveals that the values of critical lateral imposed load decrease as the length-width ratio increases, this continues until failure occurs. The positive values of revealing that the plate structure is safe, but the safety, decrease as we increase the span bending curvature a, from 1000mm to 5000mm. This means that an increase in plate width increases the chance of failure in a plate structure.

Table 1: Values of Stiffness Coefficient, k for Various Support (boundary conditions).

Type	Plate	k_1	k_2	k_3	k_4	k_5	k_6
1	CCCC	0.0012698	0.0003628	0.0012698	0.0000302	0.00003023	0.0011
2	CCFC	0.0547463	0.0036039	0.0041506	0.0013035	0.00030033	0.0076

Table 2: Critical Lateral Imposed Load of CCCC Plate for a = 1000 mm and $w_a = 1000$ mm.

$\propto = \frac{b}{a}$	t = 5mm		t = 7.5mm		t = 10mm		t = 12.5mm		t = 15mm	
	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}
1	1.721974	16.92248	5.812385	38.36433	13.7781	69.99991	26.9109	107.2092	46.50254	154.6123
1.1	1.443227	15.79291	4.871615	35.82281	11.54813	65.48165	22.55548	100.1495	38.97638	144.4462
1.2	1.258234	15.02578	4.24726	34.09676	10.06818	62.41312	19.66495	95.35488	33.98155	137.542
1.3	1.130416	14.49604	3.815877	32.90483	9.045641	60.29415	17.66781	92.04399	30.53048	132.7743
1.4	1.039056	14.12397	3.507537	32.06768	8.31476	58.80587	16.24031	89.71855	28.06376	129.4257
1.5	0.971838	13.85801	3.280676	31.46927	7.777016	57.74204	15.19003	88.05631	26.24887	127.0321
1.6	0.921136	13.66442	3.109556	31.0337	7.371398	56.96769	14.3978	86.8464	24.87991	125.2898
1.7	0.882056	13.52089	2.97766	30.71074	7.058756	56.39355	13.78717	85.94929	23.82474	123.998
1.8	0.851359	13.41247	2.874057	30.46681	6.813179	55.95988	13.30753	85.27169	22.99592	123.0222
1.9	0.826842	13.32908	2.791313	30.27917	6.617046	55.62631	12.92446	84.75048	22.33397	122.2717
2	0.806971	13.26379	2.724249	30.13227	6.458077	55.36515	12.61397	84.34242	21.79745	121.6841

Table 3: Critical Lateral Imposed Load of CCCC Plate for a = 1000mm and $w_a = 3000$mm.

$\propto = \frac{b}{a}$	t = 5mm		t = 7.5mm		t = 10mm		t = 12.5mm		t = 15mm	
	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}
1	5.166692	16.92248	17.43831	38.36433	41.33585	69.99991	80.73462	107.2092	139.5099	154.6123
1.1	4.330452	15.79291	14.616	35.82281	34.64593	65.48165	67.66837	100.1495	116.9315	144.4462
1.2	3.775471	15.02578	12.74294	34.09676	30.20608	62.41312	58.99679	95.35488	101.947	137.542
1.3	3.392019	14.49604	11.44879	32.90483	27.13846	60.29415	53.00535	92.04399	91.59375	132.7743
1.4	3.117939	14.12397	10.52376	32.06768	24.94582	58.80587	48.72284	89.71855	84.19358	129.4257
1.5	2.916285	13.85801	9.843183	31.46927	23.33259	57.74204	45.572	88.05631	78.74893	127.0321
1.6	2.764178	13.66442	9.329823	31.0337	22.11573	56.96769	43.19533	86.8464	74.64205	125.2898
1.7	2.646937	13.52089	8.934135	30.71074	21.17781	56.39355	41.36345	85.94929	71.47654	123.998
1.8	2.554846	13.41247	8.623327	30.46681	20.44108	55.95988	39.92452	85.27169	68.99008	123.0222
1.9	2.481296	13.32908	8.375095	30.27917	19.85268	55.62631	38.7753	84.75048	67.00423	122.2717
2	2.421683	13.26379	8.173901	30.13227	19.37577	55.36515	37.84384	84.34242	65.39467	121.6841

Table 4: Critical Lateral Imposed Load of CCCC Plate for a = 1000mm and $\mathrm{w_a} = 5000\mathrm{mm}$.

$\propto=\frac{b}{a}$	t = 5mm		t = 7.5mm		t = 10mm		t = 12.5mm		t = 15mm	
	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}
1	8.611411	16.92248	29.06423	38.36433	68.89359	69.99991	134.5583	107.2092	232.5173	154.6123
1.1	7.217677	15.79291	24.36038	35.82281	57.74373	65.48165	112.7813	100.1495	194.8865	144.4462
1.2	6.292708	15.02578	21.23861	34.09676	50.34398	62.41312	98.32862	95.35488	169.9124	137.542
1.3	5.653622	14.49604	19.0817	32.90483	45.23128	60.29415	88.34289	92.04399	152.657	132.7743
1.4	5.196821	14.12397	17.53999	32.06768	41.57688	58.80587	81.20538	89.71855	140.3234	129.4257
1.5	4.860731	13.85801	16.40569	31.46927	38.88816	57.74204	75.95398	88.05631	131.249	127.0321
1.6	4.60722	13.66442	15.55009	31.0337	36.86007	56.96769	71.99287	86.8464	124.4042	125.2898
1.7	4.411819	13.52089	14.89061	30.71074	35.29686	56.39355	68.93972	85.94929	119.1283	123.998
1.8	4.258333	13.41247	14.3726	30.46681	34.06898	55.95988	66.54151	85.27169	114.9842	123.0222
1.9	4.13575	13.32908	13.95888	30.27917	33.08831	55.62631	64.62614	84.75048	111.6745	122.2717
2	4.036394	13.26379	13.62355	30.13227	32.29346	55.36515	63.07371	84.34242	108.9919	121.6841

Table 5: Critical Lateral Imposed Load of CCCC Plate for a = 3000mm and $\mathrm{w_a} = 1000\mathrm{mm}$.

$\propto=\frac{b}{a}$	t = 5mm		t = 7.5mm		t = 10mm		t = 12.5mm		t = 15mm	
	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}
1	0.020879	1.538053	0.071187	3.749369	0.16934	8.462212	0.331283	11.05658	0.572965	16.15248
1.1	0.017437	1.412546	0.059573	3.466978	0.141809	7.960184	0.277512	10.27216	0.480049	15.02291
1.2	0.015154	1.327309	0.051865	3.275195	0.123538	7.619236	0.241827	9.739431	0.418385	14.25578
1.3	0.013576	1.268449	0.046539	3.142759	0.110914	7.383795	0.21717	9.371554	0.375779	13.72604
1.4	0.012448	1.227108	0.042733	3.049742	0.101891	7.21843	0.199547	9.113172	0.345325	13.35397
1.5	0.011618	1.197557	0.039932	2.983252	0.095252	7.100227	0.186581	8.928479	0.322919	13.08801
1.6	0.010992	1.176047	0.037819	2.934856	0.090244	7.014188	0.1768	8.794044	0.306019	12.89442
1.7	0.010509	1.160099	0.036191	2.898972	0.086385	6.950394	0.169261	8.694366	0.292992	12.75089
1.8	0.01013	1.148052	0.034912	2.871868	0.083353	6.902209	0.16334	8.619077	0.28276	12.64247
1.9	0.009828	1.138786	0.03389	2.851019	0.080931	6.865145	0.158611	8.561164	0.274587	12.55908
2	0.009582	1.131532	0.033062	2.834697	0.078969	6.836128	0.154777	8.515824	0.267964	12.49379

Table 6: Critical Lateral Imposed Load of CCCC Plate for a = 3000mm and $\mathrm{w_a} = 3000\mathrm{mm}$.

$\propto=\frac{b}{a}$	t = 5mm		t = 7.5mm		t = 10mm		t = 12.5mm		t = 15mm	
	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}
1	0.063406	1.538053	0.214717	3.749369	0.509559	8.462212	0.995773	11.05658	1.721204	16.15248
1.1	0.053082	1.412546	0.179874	3.466978	0.426967	7.960184	0.834461	10.27216	1.442457	15.02291
1.2	0.046231	1.327309	0.15675	3.275195	0.372154	7.619236	0.727405	9.739431	1.257464	14.25578
1.3	0.041497	1.268449	0.140773	3.142759	0.334282	7.383795	0.653436	9.371554	1.129646	13.72604
1.4	0.038113	1.227108	0.129353	3.049742	0.307213	7.21843	0.600566	9.113172	1.038286	13.35397
1.5	0.035623	1.197557	0.12095	2.983252	0.287296	7.100227	0.561667	8.928479	0.971068	13.08801
1.6	0.033745	1.176047	0.114613	2.934856	0.272273	7.014188	0.532325	8.794044	0.920366	12.89442
1.7	0.032298	1.160099	0.109728	2.898972	0.260694	6.950394	0.509709	8.694366	0.881286	12.75089
1.8	0.031161	1.148052	0.10589	2.871868	0.251598	6.902209	0.491945	8.619077	0.850589	12.64247
1.9	0.030253	1.138786	0.102826	2.851019	0.244334	6.865145	0.477757	8.561164	0.826072	12.55908
2	0.029517	1.131532	0.100342	2.834697	0.238447	6.836128	0.466257	8.515824	0.806201	12.49379

Table 7: Critical Lateral Imposed Load of CCCC Plate for a = 3000mm and $\mathrm{w_a} = 5000\mathrm{mm}$.

$\propto=\frac{b}{a}$	t = 5mm		t = 7.5mm		t = 10mm		t = 12.5mm		t = 15mm	
	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}
1	0.105933	1.538053	0.358247	3.749369	0.849778	8.462212	1.660264	11.05658	2.869444	16.15248
1.1	0.088727	1.412546	0.300175	3.466978	0.712125	7.960184	1.391411	10.27216	2.404866	15.02291
1.2	0.077308	1.327309	0.261635	3.275195	0.62077	7.619236	1.212983	9.739431	2.096543	14.25578
1.3	0.069418	1.268449	0.235006	3.142759	0.55765	7.383795	1.089702	9.371554	1.883514	13.72604
1.4	0.063778	1.227108	0.215973	3.049742	0.512534	7.21843	1.001585	9.113172	1.731247	13.35397
1.5	0.059629	1.197557	0.201969	2.983252	0.47934	7.100227	0.936753	8.928479	1.619217	13.08801
1.6	0.056499	1.176047	0.191406	2.934856	0.454302	7.014188	0.88785	8.794044	1.534713	12.89442
1.7	0.054087	1.160099	0.183264	2.898972	0.435003	6.950394	0.850157	8.694366	1.46958	12.75089
1.8	0.052192	1.148052	0.176869	2.871868	0.419844	6.902209	0.820549	8.619077	1.418418	12.64247
1.9	0.050678	1.138786	0.171761	2.851019	0.407737	6.865145	0.796903	8.561164	1.377557	12.55908
2	0.049452	1.131532	0.167622	2.834697	0.397924	6.836128	0.777737	8.515824	1.344438	12.49379

Table 8: Critical Lateral Imposed Load of CCCC Plate for a = 5000mm and $\mathrm{w_a} = 1000\mathrm{mm}$.

$\propto=\frac{b}{a}$	t = 5mm		t = 7.5mm		t = 10mm		t = 12.5mm		t = 15mm	
	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}
1	0.002371	0.307299	0.008723	0.980173	0.021276	3.539196	0.042096	3.364369	0.073251	5.075692
1.1	0.001925	0.262117	0.007218	0.878512	0.017708	3.358466	0.035128	3.081978	0.061209	4.669049
1.2	0.001629	0.231431	0.006219	0.80947	0.01534	3.235725	0.030503	2.890195	0.053217	4.392881
1.3	0.001424	0.210242	0.005529	0.761793	0.013704	3.150966	0.027308	2.757759	0.047696	4.202174
1.4	0.001278	0.195359	0.005035	0.728307	0.012535	3.091435	0.025024	2.664742	0.043749	4.068228
1.5	0.001171	0.18472	0.004673	0.704371	0.011674	3.048882	0.023343	2.598252	0.040845	3.972484
1.6	0.001089	0.176977	0.004399	0.686948	0.011025	3.017908	0.022076	2.549856	0.038655	3.902792
1.7	0.001027	0.171235	0.004188	0.67403	0.010525	2.994942	0.021099	2.513972	0.036966	3.851119
1.8	0.000978	0.166899	0.004022	0.664272	0.010132	2.977595	0.020331	2.486868	0.03564	3.81209
1.9	0.000939	0.163563	0.00389	0.656767	0.009819	2.964252	0.019718	2.466019	0.034581	3.782068
2	0.000907	0.160951	0.003782	0.650891	0.009564	2.953806	0.019221	2.449697	0.033723	3.758563

Table 9: Critical Lateral Imposed Load of CCCC Plate for a = 5000mm and $\mathrm{w_a} = 5000\mathrm{mm}$.

$\propto=\frac{b}{a}$	t = 5mm		t = 7.5mm		t = 10mm		t = 12.5mm		t = 15mm	
	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}
1	0.013394	0.307299	0.045926	0.980173	0.109461	3.539196	0.214332	3.364369	0.370875	5.075692
1.1	0.011164	0.262117	0.0384	0.878512	0.091621	3.358466	0.179489	3.081978	0.310665	4.669049
1.2	0.009684	0.231431	0.033405	0.80947	0.079782	3.235725	0.156365	2.890195	0.270707	4.392881
1.3	0.008661	0.210242	0.029954	0.761793	0.071601	3.150966	0.140388	2.757759	0.243098	4.202174
1.4	0.007931	0.195359	0.027487	0.728307	0.065754	3.091435	0.128968	2.664742	0.223364	4.068228
1.5	0.007393	0.18472	0.025673	0.704371	0.061452	3.048882	0.120565	2.598252	0.208845	3.972484
1.6	0.006987	0.176977	0.024304	0.686948	0.058207	3.017908	0.114228	2.549856	0.197894	3.902792
1.7	0.006675	0.171235	0.023248	0.67403	0.055706	2.994942	0.109343	2.513972	0.189452	3.851119
1.8	0.006429	0.166899	0.02242	0.664272	0.053742	2.977595	0.105505	2.486868	0.182822	3.81209
1.9	0.006233	0.163563	0.021758	0.656767	0.052173	2.964252	0.102441	2.466019	0.177526	3.782068
2	0.006074	0.160951	0.021221	0.650891	0.050901	2.953806	0.099957	2.449697	0.173234	3.758563

Table 10: Critical Lateral Imposed Load of CCCC Plate for a = 5000mm and $\mathrm{w_a} = 3000\mathrm{mm}$.

$\propto=\frac{b}{a}$	t = 5mm		t = 7.5mm		t = 10mm		t = 12.5mm		t = 15mm	
	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}
1	0.007882	0.307299	0.027325	0.980173	0.065369	3.539196	0.128214	3.364369	0.222063	5.075692
1.1	0.006544	0.262117	0.022809	0.878512	0.054665	3.358466	0.107308	3.081978	0.185937	4.669049
1.2	0.005656	0.231431	0.019812	0.80947	0.047561	3.235725	0.093434	2.890195	0.161962	4.392881
1.3	0.005043	0.210242	0.017741	0.761793	0.042653	3.150966	0.083848	2.757759	0.145397	4.202174
1.4	0.004604	0.195359	0.016261	0.728307	0.039145	3.091435	0.076996	2.664742	0.133557	4.068228
1.5	0.004282	0.18472	0.015173	0.704371	0.036563	3.048882	0.071954	2.598252	0.124845	3.972484
1.6	0.004038	0.176977	0.014351	0.686948	0.034616	3.017908	0.068152	2.549856	0.118274	3.902792
1.7	0.003851	0.171235	0.013718	0.67403	0.033116	2.994942	0.065221	2.513972	0.113209	3.851119
1.8	0.003703	0.166899	0.013221	0.664272	0.031937	2.977595	0.062918	2.486868	0.109231	3.81209
1.9	0.003586	0.163563	0.012824	0.656767	0.030996	2.964252	0.06108	2.466019	0.106054	3.782068
2	0.00349	0.160951	0.012502	0.650891	0.030232	2.953806	0.059589	2.449697	0.103478	3.758563

Table 11: Critical Lateral Imposed Load of CCFC Plate for a = 1000mm and $\mathrm{w_a} = 1000\mathrm{mm}$.

$\propto=\frac{b}{a}$	t = 5mm		t = 7.5mm		t = 10mm		t = 12.5mm		t = 15mm	
	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}
1	0.001112	24.88463	0.004476	56.27917	0.011208	101.8485	0.022431	156.9727	0.03927	226.2717
1.1	0.001054	25.27427	0.004279	57.15585	0.010743	103.4071	0.021523	159.4079	0.0377	229.7784
1.2	0.001014	25.5953	0.004143	57.87817	0.010419	104.6912	0.020892	161.4144	0.036609	232.6677
1.3	0.000984	25.85528	0.004044	58.46314	0.010186	105.7311	0.020435	163.0393	0.035821	235.0076
1.4	0.000963	26.06523	0.003971	58.93551	0.010012	106.5709	0.020096	164.3514	0.035233	236.8971
1.5	0.000946	26.23546	0.003915	59.31854	0.009879	107.2518	0.019836	165.4154	0.034784	238.4292
1.6	0.000933	26.37453	0.003871	59.63145	0.009775	107.8081	0.019632	166.2846	0.034433	239.6808
1.7	0.000923	26.48916	0.003836	59.88936	0.009692	108.2666	0.01947	167.001	0.034153	240.7124
1.8	0.000914	26.58452	0.003808	60.10392	0.009624	108.6481	0.019339	167.597	0.033926	241.5707
1.9	0.000907	26.66457	0.003784	60.28404	0.009569	108.9683	0.019231	168.0973	0.03374	242.2912
2	0.000902	26.73237	0.003765	60.43658	0.009523	109.2395	0.019141	168.5211	0.033584	242.9013

Table 12: Critical Lateral Imposed Load of CCFC Plate for a = 1000mm and $\mathrm{w_a} = 3000\mathrm{mm}$.

$\propto=\frac{b}{a}$	t = 5mm		t = 7.5mm		t = 10mm		t = 12.5mm		t = 15mm	
	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}
1	0.004107	24.88463	0.014582	56.27917	0.035163	101.8485	0.069219	156.9727	0.120119	226.2717
1.1	0.003932	25.27427	0.013993	57.15585	0.033768	103.4071	0.066494	159.4079	0.115411	229.7784
1.2	0.003811	25.5953	0.013584	57.87817	0.032798	104.6912	0.0646	161.4144	0.112136	232.6677
1.3	0.003723	25.85528	0.013288	58.46314	0.032097	105.7311	0.063231	163.0393	0.109772	235.0076
1.4	0.003658	26.06523	0.013068	58.93551	0.031575	106.5709	0.062212	164.3514	0.10801	236.8971
1.5	0.003608	26.23546	0.0129	59.31854	0.031176	107.2518	0.061432	165.4154	0.106663	238.4292
1.6	0.003569	26.37453	0.012768	59.63145	0.030864	107.8081	0.060822	166.2846	0.105609	239.6808
1.7	0.003538	26.48916	0.012663	59.88936	0.030615	108.2666	0.060336	167.001	0.104769	240.7124
1.8	0.003513	26.58452	0.012578	60.10392	0.030413	108.6481	0.059942	167.597	0.104088	241.5707
1.9	0.003492	26.66457	0.012508	60.28404	0.030247	108.9683	0.059618	168.0973	0.103529	242.2912
2	0.003475	26.73237	0.01245	60.43658	0.030109	109.2395	0.059349	168.5211	0.103063	242.9013

Table 13: Critical Lateral Imposed Load of CCFC Plate for a = 1000mm and $\mathrm{w_a} = 5000\mathrm{mm}$.

$\propto=\frac{b}{a}$	t = 5mm		t = 7.5mm		t = 10mm		t = 12.5mm		t = 15mm	
	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}
1	0.007101	24.88463	0.024688	56.27917	0.059119	101.8485	0.116007	156.9727	0.200969	226.2717
1.1	0.00681	25.27427	0.023707	57.15585	0.056793	103.4071	0.111466	159.4079	0.193121	229.7784
1.2	0.006608	25.5953	0.023025	57.87817	0.055176	104.6912	0.108308	161.4144	0.187664	232.6677
1.3	0.006462	25.85528	0.022532	58.46314	0.054009	105.7311	0.106027	163.0393	0.183723	235.0076
1.4	0.006354	26.06523	0.022165	58.93551	0.053139	106.5709	0.104328	164.3514	0.180787	236.8971
1.5	0.00627	26.23546	0.021884	59.31854	0.052473	107.2518	0.103028	165.4154	0.178541	238.4292
1.6	0.006205	26.37453	0.021665	59.63145	0.051953	107.8081	0.102012	166.2846	0.176784	239.6808
1.7	0.006153	26.48916	0.02149	59.88936	0.051538	108.2666	0.101201	167.001	0.175384	240.7124
1.8	0.006111	26.58452	0.021348	60.10392	0.051202	108.6481	0.100545	167.597	0.17425	241.5707
1.9	0.006077	26.66457	0.021232	60.28404	0.050926	108.9683	0.100006	168.0973	0.173318	242.2912
2	0.006048	26.73237	0.021135	60.43658	0.050696	109.2395	0.099557	168.5211	0.172542	242.9013

Table 14: Critical Lateral Imposed Load of CCFC Plate for a = 3000mm and $\mathrm{w_a} = 1000\mathrm{mm}$.

$\propto=\frac{b}{a}$	t = 5mm		t = 7.5mm		t = 10mm		t = 12.5mm		t = 15mm	
	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}
1	-0.00037	2.422737	-0.00052	5.739908	-0.00062	12.00095	-0.00067	16.58585	-0.00066	24.11463
1.1	-0.00037	2.46603	-0.00052	5.837317	-0.00063	12.17412	-0.00068	16.85644	-0.00068	24.50427
1.2	-0.00037	2.5017	-0.00052	5.917575	-0.00063	12.3168	-0.00069	17.07937	-0.00069	24.8253
1.3	-0.00037	2.530587	-0.00052	5.982571	-0.00063	12.43235	-0.0007	17.25992	-0.0007	25.08528
1.4	-0.00037	2.553914	-0.00052	6.035057	-0.00064	12.52566	-0.0007	17.40571	-0.00071	25.29523
1.5	-0.00037	2.572829	-0.00052	6.077616	-0.00064	12.60132	-0.00071	17.52393	-0.00071	25.46546
1.6	-0.00037	2.588281	-0.00052	6.112383	-0.00064	12.66313	-0.00071	17.62051	-0.00072	25.60453
1.7	-0.00037	2.601018	-0.00052	6.14104	-0.00064	12.71407	-0.00071	17.70011	-0.00072	25.71916
1.8	-0.00037	2.611613	-0.00052	6.16488	-0.00064	12.75645	-0.00071	17.76633	-0.00072	25.81452
1.9	-0.00037	2.620508	-0.00052	6.184893	-0.00064	12.79203	-0.00071	17.82193	-0.00072	25.89457
2	-0.00037	2.628041	-0.00052	6.201842	-0.00064	12.82216	-0.00071	17.86901	-0.00073	25.96237

Table 15: Critical Lateral Imposed Load of CCFC Plate for a = 3000mm and $\mathrm{w_a} = 3000\mathrm{mm}$.

$\propto=\frac{b}{a}$	t = 5mm		t = 7.5mm		t = 10mm		t = 12.5mm		t = 15mm	
	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}
1	-0.00037	2.422737	-0.00039	5.739908	-0.00033	12.00095	-9.6E-05	16.58585	0.000342	24.11463
1.1	-0.00037	2.46603	-0.0004	5.837317	-0.00034	12.17412	-0.00014	16.85644	0.000284	24.50427
1.2	-0.00037	2.5017	-0.0004	5.917575	-0.00036	12.3168	-0.00015	17.07937	0.000244	24.8253
1.3	-0.00037	2.530587	-0.00041	5.982571	-0.00036	12.43235	-0.00017	17.25992	0.000214	25.08528
1.4	-0.00037	2.553914	-0.00041	6.035057	-0.00037	12.52566	-0.00018	17.40571	0.000193	25.29523
1.5	-0.00037	2.572829	-0.00041	6.077616	-0.00038	12.60132	-0.00019	17.52393	0.000176	25.46546
1.6	-0.00037	2.588281	-0.00041	6.112383	-0.00038	12.66313	-0.00020	17.62051	0.000163	25.60453
1.7	-0.00037	2.601018	-0.00041	6.14104	-0.00038	12.71407	-0.00021	17.70011	0.000153	25.71916
1.8	-0.00037	2.611613	-0.00042	6.16488	-0.00039	12.75645	-0.00021	17.76633	0.000144	25.81452
1.9	-0.00037	2.620508	-0.00042	6.184893	-0.00039	12.79203	-0.00022	17.82193	0.000137	25.89457
2	-0.00037	2.628041	-0.00042	6.201842	-0.00039	12.82216	-0.00022	17.86901	0.000132	25.96237

Table 16: Critical Lateral Imposed Load of CCFC Plate for a = 3000mm and $\mathrm{w_a} = 5000\mathrm{mm}$.

$\propto=\frac{b}{a}$	t = 5mm		t = 7.5mm		t = 10mm		t = 12.5mm		t = 15mm	
	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}
1	-0.00037	2.422737	-0.00027	5.739908	-3.07E-05	12.00095	0.000482	16.58585	0.00134	24.11463
1.1	-0.00037	2.46603	-0.00028	5.837317	-5.97E-05	12.17412	0.000426	16.85644	0.001243	24.50427
1.2	-0.00037	2.5017	-0.00029	5.917575	-7.93E-05	12.3168	0.000387	17.07937	0.001176	24.8253
1.3	-0.00037	2.530587	-0.00029	5.982571	-9.37E-05	12.43235	0.000358	17.25992	0.001127	25.08528
1.4	-0.00037	2.553914	-0.0003	6.035057	-0.000105	12.52566	0.000337	17.40571	0.001091	25.29523
1.5	-0.00037	2.572829	-0.0003	6.077616	-0.000113	12.60132	0.000321	17.52393	0.001063	25.46546
1.6	-0.00037	2.588281	-0.0003	6.112383	-0.000119	12.66313	0.000309	17.62051	0.001042	25.60453
1.7	-0.00037	2.601018	-0.00031	6.14104	-0.000124	12.71407	0.000299	17.70011	0.001024	25.71916
1.8	-0.00037	2.611613	-0.00031	6.16488	-0.000128	12.75645	0.000291	17.76633	0.00101	25.81452
1.9	-0.00037	2.620508	-0.00031	6.184893	-0.000131	12.79203	0.000284	17.82193	0.000999	25.89457
2	-0.00037	2.628041	-0.00031	6.201842	-0.000135	12.82216	0.000278	17.86901	0.000989	25.96237

Table 17: Critical Lateral Imposed Load of CCFC Plate for a = 5000mm and $\mathrm{w_a} = 1000\mathrm{mm}$.

$\propto=\frac{b}{a}$	t = 5mm		t = 7.5mm		t = 10mm		t = 12.5mm		t = 15mm	
	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}
1	-0.00038	0.625785	-0.00057	1.696767	-0.00075	4.813141	-0.00093	5.354908	-0.00109	7.942067
1.1	-0.00038	0.641371	-0.00057	1.731834	-0.00075	4.875483	-0.00093	5.452317	-0.00109	8.082336
1.2	-0.00038	0.654212	-0.00057	1.760727	-0.00075	4.926848	-0.00093	5.532575	-0.00109	8.197907
1.3	-0.00038	0.664611	-0.00057	1.784126	-0.00075	4.968446	-0.00093	5.597571	-0.0011	8.291502
1.4	-0.00038	0.673009	-0.00057	1.803021	-0.00075	5.002036	-0.00093	5.650057	-0.0011	8.367082
1.5	-0.00038	0.679818	-0.00057	1.818342	-0.00075	5.029274	-0.00093	5.692616	-0.0011	8.428366
1.6	-0.00038	0.685381	-0.00057	1.830858	-0.00075	5.051525	-0.00093	5.727383	-0.0011	8.478432
1.7	-0.00038	0.689966	-0.00057	1.841174	-0.00075	5.069866	-0.00093	5.75604	-0.0011	8.519698
1.8	-0.00038	0.693781	-0.00057	1.849757	-0.00075	5.085123	-0.00093	5.77988	-0.0011	8.554027
1.9	-0.00038	0.696983	-0.00057	1.856962	-0.00075	5.097932	-0.00093	5.799893	-0.0011	8.582847
2	-0.00038	0.699695	-0.00057	1.863063	-0.00075	5.108779	-0.00093	5.816842	-0.0011	8.607253

Table 18: Critical Lateral Imposed Load of CCFC Plate for a = 5000mm and $\mathrm{w_a} = 3000\mathrm{mm}$.

$\propto=\frac{b}{a}$	t = 5mm		t = 7.5mm		t = 10mm		t = 12.5mm		t = 15mm	
	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}
1	-0.00038	0.625785	-0.00055	1.696767	-0.00071	4.813141	-0.00085	5.354908	-0.00096	7.942067
1.1	-0.00038	0.641371	-0.00055	1.731834	-0.00071	4.875483	-0.00085	5.452317	-0.00097	8.082336
1.2	-0.00038	0.654212	-0.00055	1.760727	-0.00072	4.926848	-0.00086	5.532575	-0.00097	8.197907
1.3	-0.00038	0.664611	-0.00056	1.784126	-0.00072	4.968446	-0.00086	5.597571	-0.00098	8.291502
1.4	-0.00038	0.673009	-0.00056	1.803021	-0.00072	5.002036	-0.00086	5.650057	-0.00098	8.367082
1.5	-0.00038	0.679818	-0.00056	1.818342	-0.00072	5.029274	-0.00086	5.692616	-0.00098	8.428366
1.6	-0.00038	0.685381	-0.00056	1.830858	-0.00072	5.051525	-0.00086	5.727383	-0.00098	8.478432
1.7	-0.00038	0.689966	-0.00056	1.841174	-0.00072	5.069866	-0.00086	5.75604	-0.00099	8.519698
1.8	-0.00038	0.693781	-0.00056	1.849757	-0.00072	5.085123	-0.00087	5.77988	-0.00099	8.554027
1.9	-0.00038	0.696983	-0.00056	1.856962	-0.00072	5.097932	-0.00087	5.799893	-0.00099	8.582847
2	-0.00038	0.699695	-0.00056	1.863063	-0.00072	5.108779	-0.00087	5.816842	-0.00099	8.607253

Similarly, the value of q_{ip} if greater than that of q_{iw}, this is because the failure of plate in means total failure, but that of like a warning requesting attention for the maintenance.

Looking closely at Tables 14 which shows the result of plate with free of support at third edge and the other edges clamped (CCFC) plate, the negative value of critical lateral imposed load q_{iw} (between -0.00037N/mm to -0.0073N/mm) reveals that the plate fail in q_{iw} with a slight increment in width, a of 3000mm at length-width ratio between 1 to 2 at allowable thickness between 5mm to 15mm respectively. This means that the plate structure is not safe. To remedy such situation in design, it is advised that the thickness *t* or the allowable deflection w_a should be increased.

Looking closely at Tables 15 which shows the result of CCFC plate, the negative value of critical lateral imposed load q_{iw} (between -0.00037N/mm to -0.000218N/mm) reveals that the plate fail in q_{iw} at width, a of 3000mm at length-width ratio between 1 to 2 at allowable thickness between 5mm to 12.5mm, no failure is seen when the thickness is increased to 15mm at allowable deflection $w_a = 3000$. While Tables 18 the result of CCFC plate of critical lateral imposed load q_{ip} between (-0.07535N/mm to 0.013348N/mm) reveals that the plate fail in q_{ip} at width, a of 5000mm at length-width ratio between 1.0 to 2.0 at allowable deflection $w_a = 1000\ \mathrm{mm}$ at allowable thickness between 5mm and 7.5mm. This means total failure of CCFC at allowable thickness between 5mm and 7.5 mm only.

It is conclude that the values of critical lateral load obtained by this theory gives realistic variation of transverse shear stress through the thickness of plate and satisfied the transverse flexibility of the rectangular plate's condition while predicting the bending behaviour of isotropic thick rectangular plate. Therefore, using this theory it is possible to predict actual load that cause the bending behaviour of isotropic rectangular plate.

Table 19: Critical Lateral Imposed Load of CCFC Plate for a = 5000mm and $\mathbf{w_a = 5000mm}$.

$\propto = \frac{b}{a}$	t = 5mm		t = 7.5mm		t = 10mm		t = 12.5mm		t = 15mm	
	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}	q_{iw}	q_{ip}
1	-0.00037	0.625785	-0.00054	1.696767	-0.00067	4.813141	-0.00078	5.354908	-0.00083	7.942067
1.1	-0.00037	0.641371	-0.00054	1.731834	-0.00068	4.875483	-0.00078	5.452317	-0.00084	8.082336
1.2	-0.00037	0.654212	-0.00054	1.760727	-0.00068	4.926848	-0.00079	5.532575	-0.00085	8.197907
1.3	-0.00037	0.664611	-0.00054	1.784126	-0.00068	4.968446	-0.00079	5.597571	-0.00086	8.291502
1.4	-0.00037	0.673009	-0.00054	1.803021	-0.00068	5.002036	-0.00079	5.650057	-0.00086	8.367082
1.5	-0.00037	0.679818	-0.00054	1.818342	-0.00068	5.029274	-0.0008	5.692616	-0.00087	8.428366
1.6	-0.00037	0.685381	-0.00054	1.830858	-0.00069	5.051525	-0.0008	5.727383	-0.00087	8.478432
1.7	-0.00037	0.689966	-0.00054	1.841174	-0.00069	5.069866	-0.0008	5.75604	-0.00087	8.519698
1.8	-0.00037	0.693781	-0.00054	1.849757	-0.00069	5.085123	-0.0008	5.77988	-0.00087	8.554027
1.9	-0.00037	0.696983	-0.00054	1.856962	-0.00069	5.097932	-0.0008	5.799893	-0.00088	8.582847
2	-0.00037	0.699695	-0.00054	1.863063	-0.00069	5.108779	-0.0008	5.816842	-0.00088	8.607253

Conflict of Interest. On behalf of all authors, I Onyeka Festus the corresponding author hereby states that there is no conflict of interest.

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