*Proceedings of the **12th ICCAE-12** Conference, 3-5 April, 2018*

CS	1

Military Technical College	**12th International Conference on Civil and Architecture Engineering**
Kobry El-Kobbah, Cairo, Egypt	**ICCAE-12-2018**

Design charts for simple &one continuous side paneled reinforced concrete beams.

SamyA.Fawzy

Samy_akeel@cic-cairo.com

Head of Civil Department , CIC- Sheikh Zeid 6th of October

Abstract: The system of reinforced concrete paneled beams is used in large areas as large span halls and mosques and churches. Now days it is considered a first option for high height plus large span structures.

The design of reinforced concrete simple paneled beams depends mainly onthe behavior of the grid action of the reinforced concrete beams with same depth.

The bending moment considered in the design depends on the deflection of the paneled reinforced concrete beams with same depth, where a reduction factor will be considered in the design of a simple reinforced concrete paneled beam.

The case of the reinforced concrete continuous paneled beam and the skew paneled beam both cases can't be considered as the simple case and has to be solved by a computer. In this study the continuous paneled is analyzed as a grid element and a design procedure is considered depending on the behavior of the continuous paneled concrete beam.

The analysis will be considered the effect of the two way deflection of the paneled reinforced concrete beams and the grid action stiffness in both directions taking the effect of both perpendicular beams as being supporting to the other beam.

A verification with the results of a commercial computer software will be considered in this study and a parametric study will be done. This method will be considered as a simple approach in the analysis and design of continuous concrete paneled beams slab system.

Keywords: Continuous Paneled, Skew, Grid action, Same depth beams, deflection, multi span structures.

INTRODUCTION

The design of continuous paneled beams structures is sophisticated if compared to the empirical design method of the simple paneled beam. Which is analyzed as a simple beam two way deflection and the deflection is the same at the point intersecting both beams in the simple paneled grid as shown in figure(1).

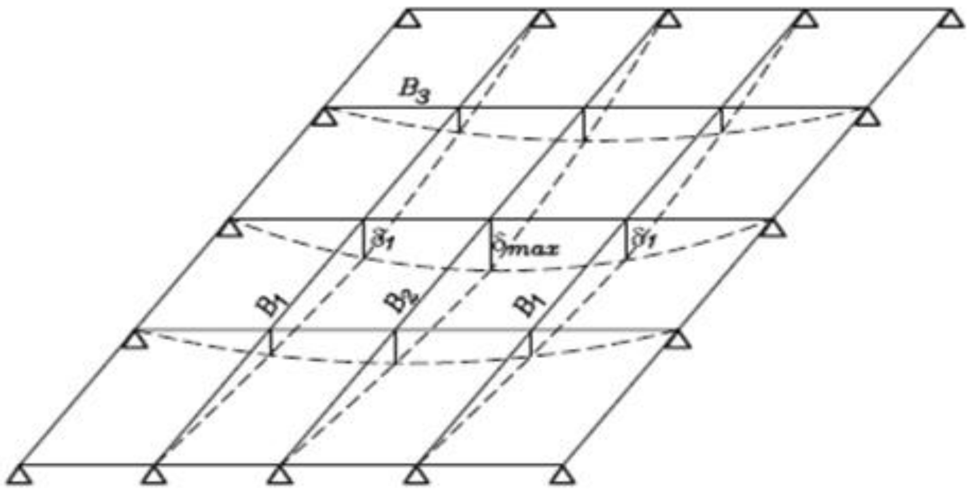
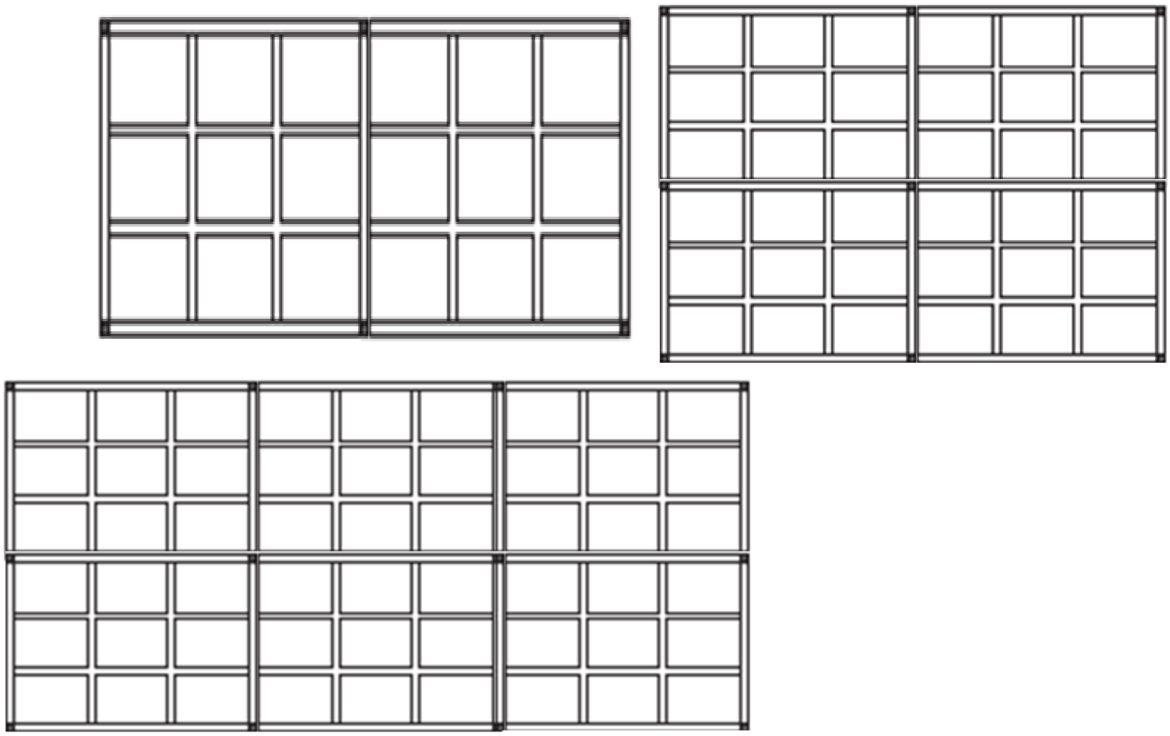


Figure (1) simple paneled grid beams

A reduction factor is taken according to the deflection line and its similarity to the sin curve thus the reduction factor of $R = \frac{sin\emptyset}{\sin 90}$ is considered in calculating the flexure moment of the paneled simple beam.

The continuous beam case must be solved by any structural analysis method as stiffness method for grid beam or finite element method using computer.



Figure(2) various types of reinforced continuous paneled beams.

In order to simplify the analysis procedure for the aim of concrete design basis, a simplified charts are used for different paneled beams types as the case of continuous from one direction as shown in the previous figure or continuous from both direction paneled beam slab or simple at edge ends.

And also the case of continuous at all directions or continuous in 3 directions and simple in one direction or all fixed support paneled beam slab as shown in figure(3).

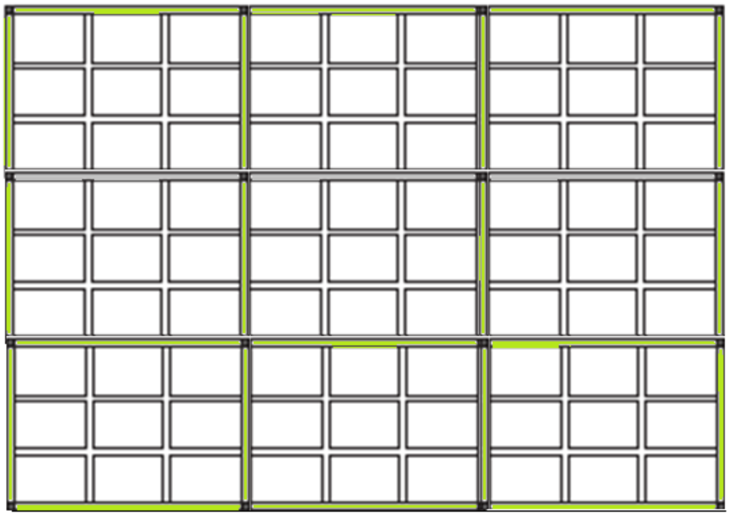


Figure (3) Continuous paneled beam (two ,three and four directions).

A design charts based on the stiffness method and finite element is presented in order to simplify the computing the flexure moment in the continuous paneled beams in one direction.

METHOD

The analysis:

The analysis of the grid paneled beam is considered using stiffness method,

Stiffness method or displacement method is an important approach to the analysis of structures .This is an important approach to the analysis of structures. This is used in its basic form for the analysis of structures that are linear and elastic although it can be adapted to non linear analysis. This method in its basic form considers the nodal displacements of the structures as unknown.

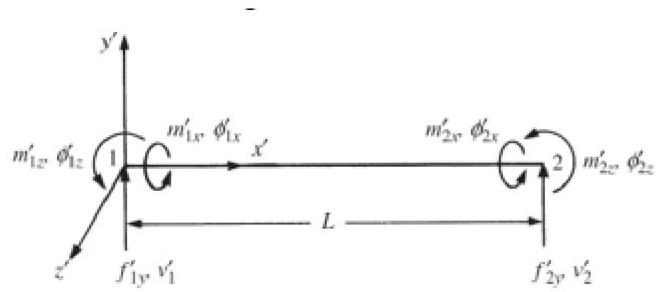


Figure (4) The grid element with degree of freedom.

$$
\begin{Bmatrix} f'_{1y} \\ m'_{1x} \\ m'_{1z} \\ f'_{2y} \\ m'_{2x} \\ m'_{2z} \end{Bmatrix} =
\begin{bmatrix}
\frac{12EI}{L^3} & 0 & \frac{6EI}{L^2} & -\frac{12EI}{L^3} & 0 & \frac{6EI}{L^2} \\
0 & \frac{GJ}{L} & 0 & 0 & -\frac{GJ}{L} & 0 \\
\frac{6EI}{L^2} & 0 & \frac{4EI}{L} & -\frac{6EI}{L^2} & 0 & \frac{2EI}{L} \\
-\frac{12EI}{L^3} & 0 & -\frac{6EI}{L^2} & \frac{12EI}{L^3} & 0 & -\frac{6EI}{L^2} \\
0 & -\frac{GJ}{L} & 0 & 0 & \frac{GJ}{L} & 0 \\
\frac{6EI}{L^2} & 0 & \frac{2EI}{L} & -\frac{6EI}{L^2} & 0 & \frac{4EI}{L}
\end{bmatrix}
\begin{Bmatrix} v'_1 \\ \phi'_{1x} \\ \phi'_{1z} \\ v'_2 \\ \phi'_{2x} \\ \phi'_{2z} \end{Bmatrix}
$$

Figure (5) The grid stiffness matrix

Verifications:

The results were verified using commercial software program for analysis of slab (SAFE),and design charts were presented in order to simplify the design of reinforced concrete paneled beams.

The paneled beam considered in the research is similar in the two directions and of total span from 6 meters till12 meters, which is considered the optimum distance to design the paneled beams.

From similarity of the paneled the deflection of the similar point and the slope in x and y direction were considered equal.

It was concluded the commercial software is capable of estimating the real behavior of the paneled beam grid system.

As an example for verification a slab taken in the design was 120 mm thickness and the dead load as floor cover was considered 3KN/m^2 (without own weight) and the live load was considered to be 2 KN/m^2.

The paneled beams were considered (300x800) mm^2 and the main beams (400x1000) mm^2 .The ultimate case was considered according to ACI code (1.2D.L+1.6L.L).

The points that are mainly important in the design of the paneled are given as:

The points of intersection and midpoint of the paneled beam shown in figures (6),(7).

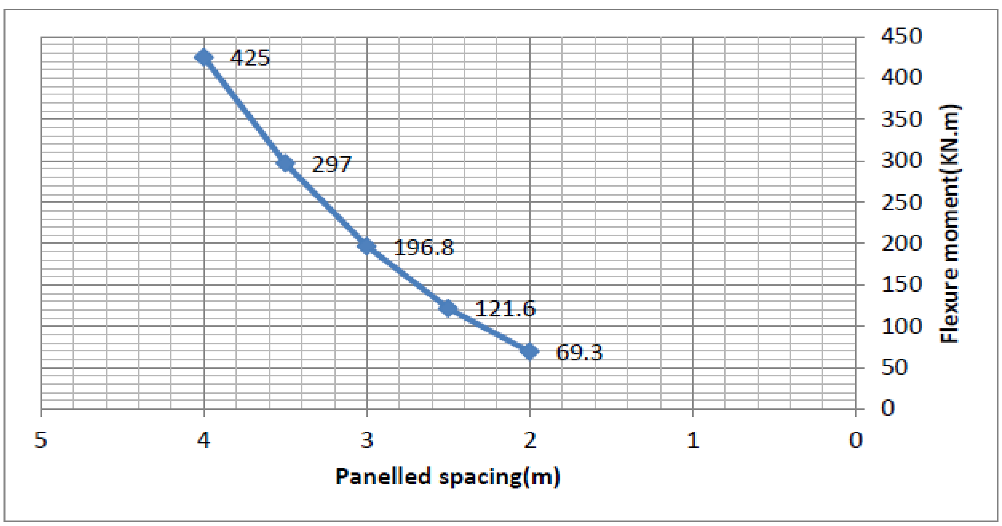


Figure (6)Flexure bending moment for paneled at the intersection.(M2)

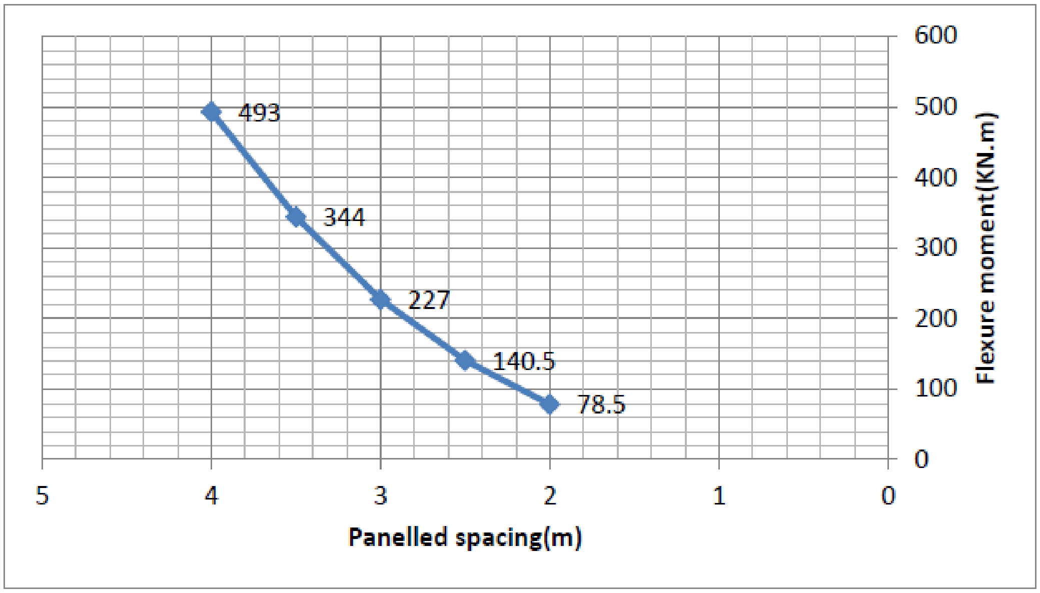


Figure (7) Mid flexure bending moment for paneled. (M1)

Parametric Study:

A study was done for the case of simple paneled concrete beams and continuous from one end and both ends and also the case of continuous from 3 sides and simple in the fourth and also the case of continuous from the 4 directions.

In this research work it is only presented the design charts of the case of simple paneled and the case of continuous from one end.

Where an equation is presented in order to be used directly for the design of reinforced concrete simple and continuous paneled beam.

$$M_{u\,mid} = W_{uslab} x K1_{factor} + \text{b x t x} \frac{\gamma_c x (ultimate\ F.S\ of\ D.L)}{K2_{factor}} x L^2 \qquad (1)$$

Where M_{umid} the ultimate moment at the mid of the paneled beam.

W_{uslab} is the ultimate load acting on slab including dead load and live load.

b is the paneled beam breadth

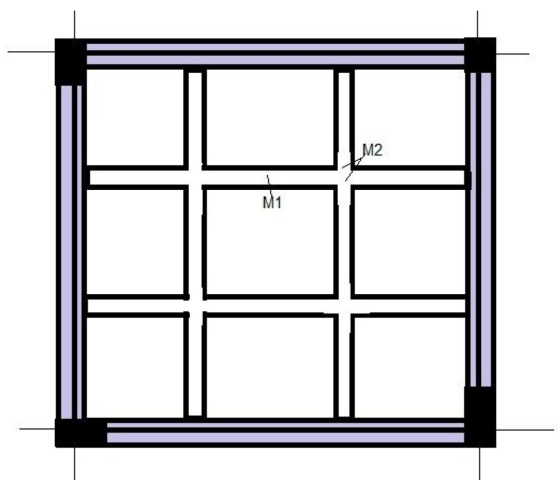
t is the paneled beam total depth including the cover

L is the total span of the paneled beam.(not the spacing)

K1 and K2 factors are factors taken from the design curves.

$\gamma_c is\ the\ weight\ per\ unit\ volume\ of\ concrete.$

As an example for the usage of these charts and equation, we can consider the case of paneled 12 meter length.



Figure(9)Simple paneled with selected points

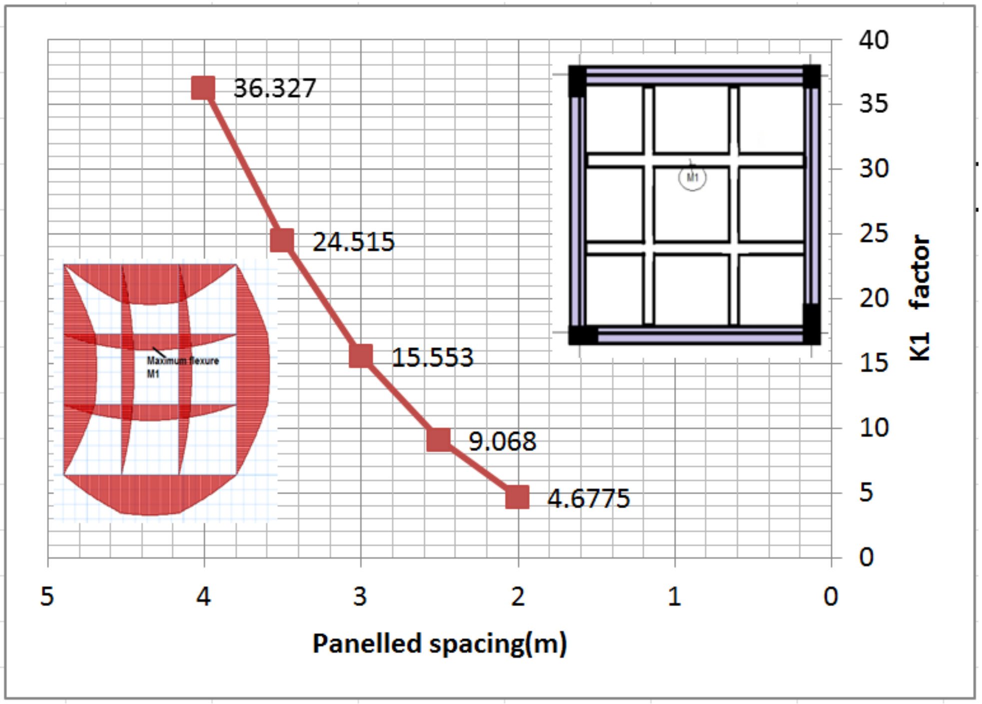


Figure (10) relation between paneled spacing and K1 factor .

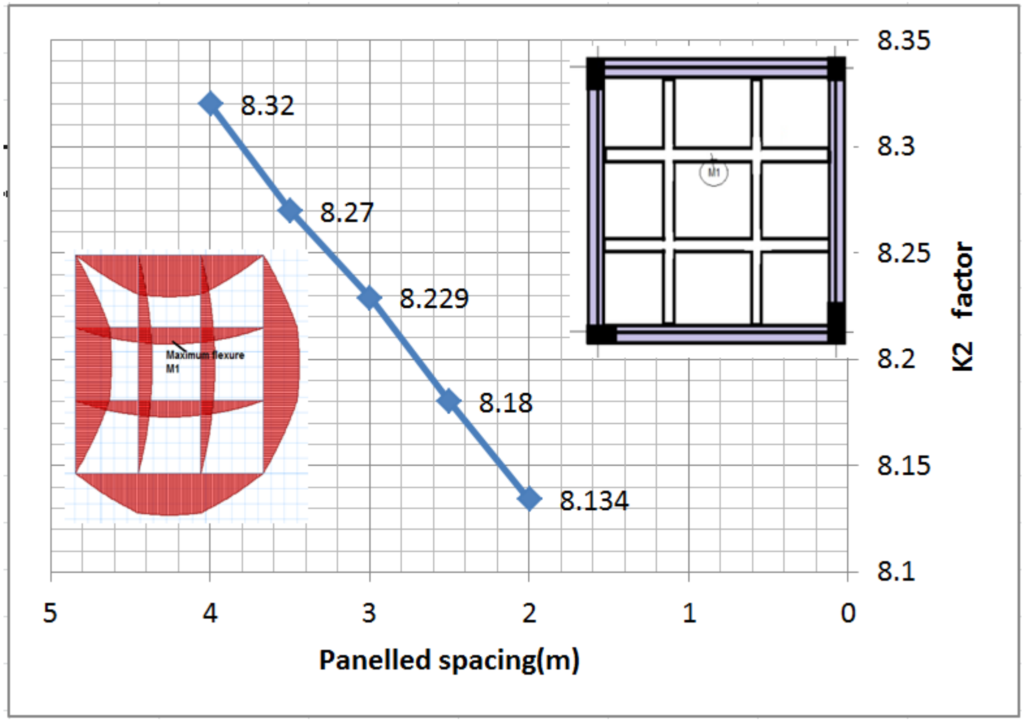
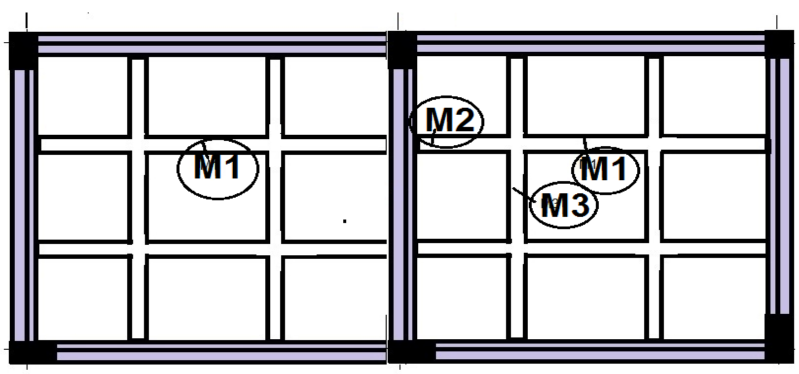


Figure (11) relation between paneled spacing and K2 factor .



Figure(12)Continuous paneled with selected points.

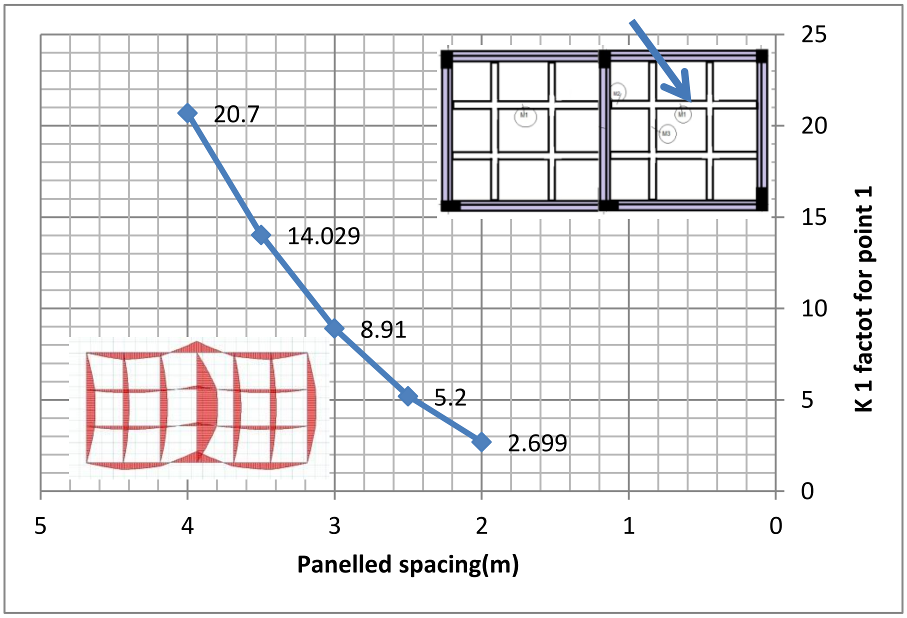


Figure (13) K1 factor for different paneled spacing M1.

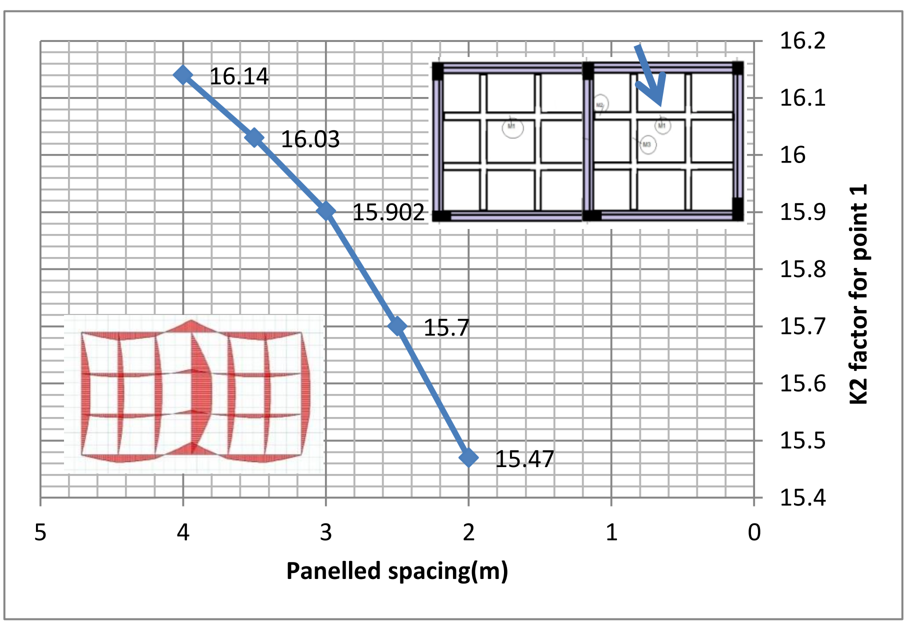


Figure (14) K2 factor for different paneled spacing M1.

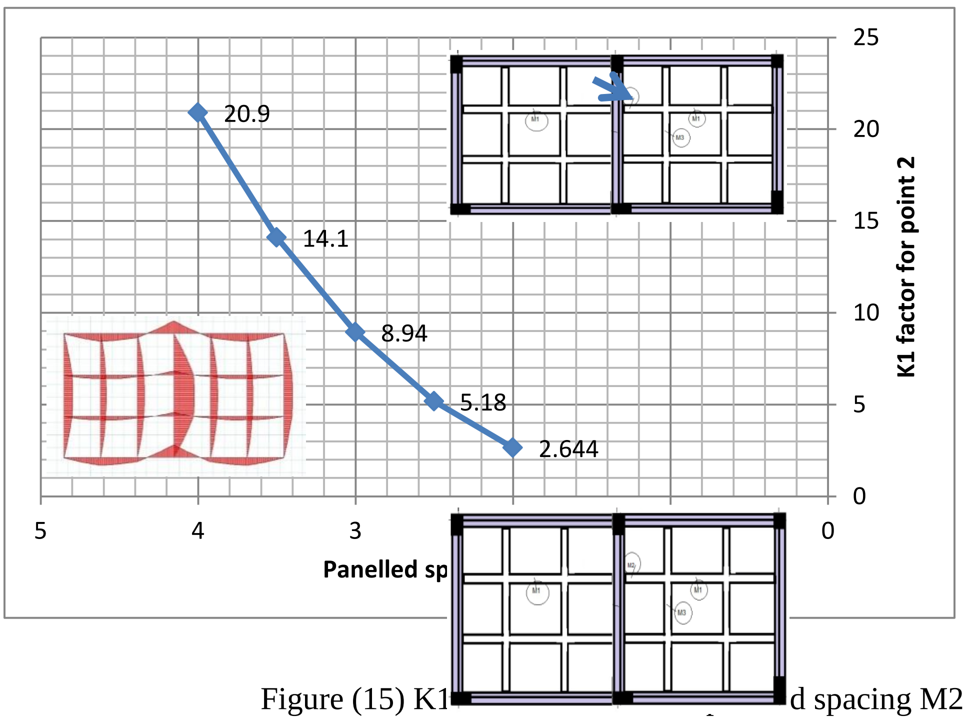


Figure (15) K1 d spacing M2.

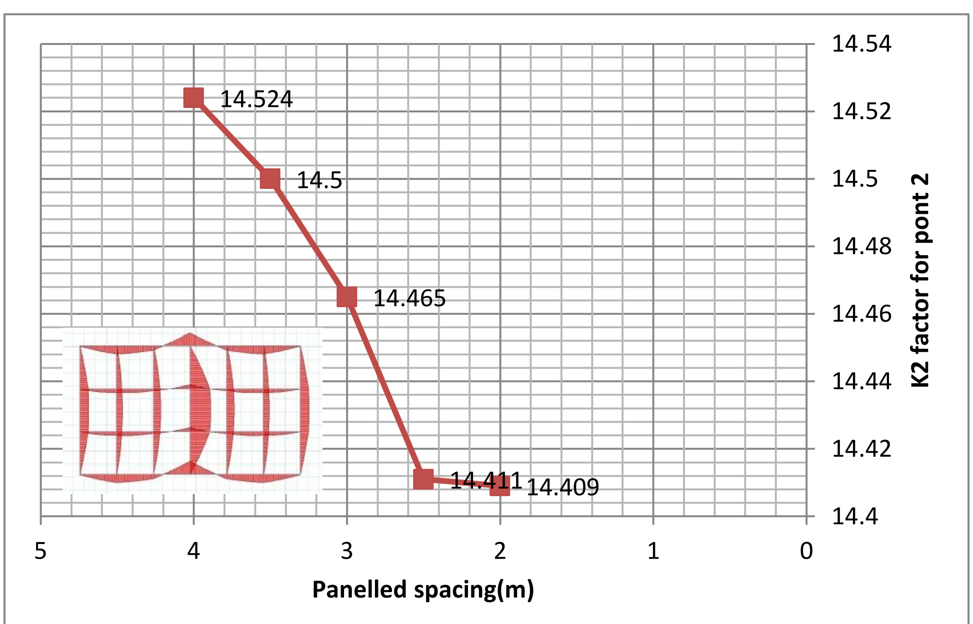


Figure (16) K2 factor for different paneled spacing M2.

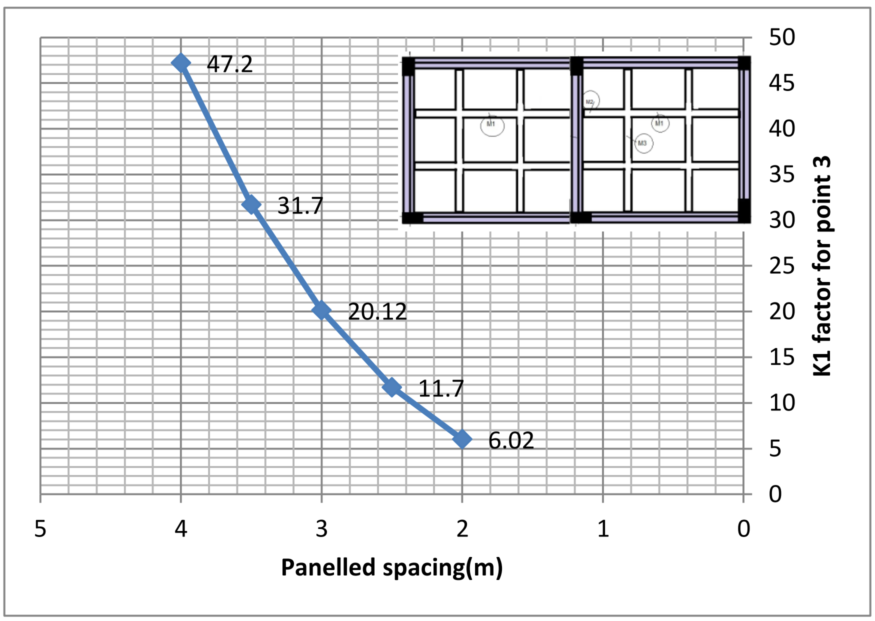


Figure (17) K1 factor for different paneled spacing M3.

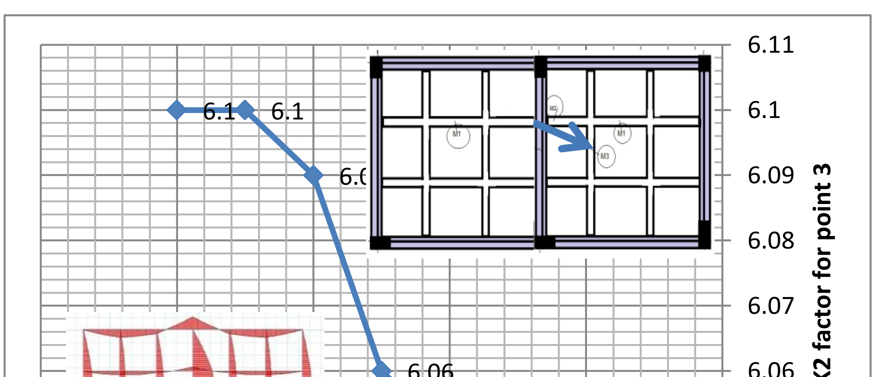


Figure (18) K2 factor for different paneled spacing M3.

In order to calculate the flexure bending moment for the simple paneled beams we can use the design equation with the figures (9), (10) and (11) and the figure (12) describes the critical points taken for the design of continuous beams.

The figures (13),(14) shows the K1 and K2 factors used for the design of continuous paneled beam to calculate the mid bending for the continuous paneled with the next slab.

The figures (15),(16) shows the K1 and K2 factors used for the design of continuous paneled beam to calculate the negative bending for the continuous paneled with the next slab.

The figures (17),(18) shows the K1 and K2 factors used for the design of continuous paneled beam to calculate the mid bending for the simple direction paneled beam.

RESULTS

A design charts was presented in order to simplify the calculations of straining action affecting the reinforced paneled grid system of either simple or continuous type.

The design charts unable the designer to calculate from the charts the flexure moment at different sections especially at the intersection of beams and in the mid span, also the charts simplify the design by calculating the moment in the external beams, taking an assumption of greater inertia than the paneled beams.

.

DISCUSSION

The design of simple paneled beam was considered taken a reduction factor for the similar deflection in the intersection.

Rankine – Grashoff's method

The Rankine – Grashoff's method is an approximate method which equates the deflection of ribs at junctions. A typical grid floor pattern is given in Figure (1).The spacing of ribs are given by a1 and b1 in the x and y directions respectively.

The deflections of ribs at junctions are made equal and is given by

$$\Delta = \frac{5q_1a^4}{384} = \frac{5q_2b^4}{384} \qquad (2)$$

where, q1 and q2 are the loads shared in X and Y directions, respectively and is given by

$$q_1 = q\left(\frac{b^4}{a^4+b^4}\right) \quad q_2 = q\left(\frac{a^4}{a^4+b^4}\right)$$

where ,q is the total load the slab per unit area.

The bending moments for the central ribs are given by

$$M_{AB} = \left(\frac{q_1 b_1 a^2}{8}\right) \qquad M_{BD} = \left(\frac{q_2 a_1 b^2}{8}\right)$$

Timoshenko's Plate theory*:*

The vertical deflection at the middle is expressed as

$$\Delta = \frac{16q}{\Pi^6}\left[\frac{\sin\left(\frac{\Pi x}{ax}\right)\sin\left(\frac{\Pi y}{by}\right)}{\frac{Dx}{a^4}+\frac{2H}{a^2b^2}+\frac{Dy}{b^4}}\right] \qquad (3)$$

where q is the total uniformly distributed load per unit area. ax and by are the plate length in x and y directions respectively. Dx and Dy are the flexural rigidity per unit length of plate along x and y directions respectively. Cx and Cy are the torsional rigidity per unit length along x and y directions. If a1 and b1 are the spacing of ribs in x and y directions, then the relations are

$$Dx = \frac{EI_1}{b_1}$$

$$Dy = \frac{EI_2}{a_1}$$

$$Cx = \frac{GC_1}{b_1}$$

$$Cx = \frac{GC_2}{a_1}$$

where EI1 and EI2 are the flexural rigidity and GC1 ,GC2 are the torsional rigidities. The bending moments, torsional moments and shears are computed using the following expressions.

A design charts is presented to solve the continuous one direction and simple type for the grid paneled beam and a design procedure was presented also for the two , three and four directions and a similar procedure need to be taken for the skew paneled beam, and a design charts is needed for the case of different spacing of grid beams.

P Desayi, K Muralidharan(1974) computed deflections of reinforced concrete grids

Sandesh (2012) has worked on Dynamic Analysis of Special Moment Resisting Frame Building with Flat Slaband Grid Slab.

CONCLUSION

A design charts is presented to simplify the design of continuous and simple paneled beams and calculate the maximum flexure moment in the grid system given with the aid of the K factor chart to change the loading or combination factors.

REFERENCES

Baishali Das(2010) StaticAnd Dynamic Analysis Of Grid Beams:Project report for Bachelor of Technology, Department of civil engineering, National Institute of technology, Rourkela.

Logan L.Dary (2007).A first course in finite element method: University of Wisconsin-Platteville-fourth edition.

Mario paz (2004) Structural dynamics- theory and computation: 5th edition.

P Desayi, K Muralidharan(1974) Deflections of reinforced concrete grids: - Materials and Structures, - Springer

https://link.springer.com/content/pdf/10.1007/BF02473841.pdf

Ramanujan J. (2013) Finite element analysis and parametric study of grid floor slab: American Journal of Engineering Research (AJER) e-ISSN : 2320-0847 p-ISSN : 2320-0936 Volume-3 pp-20-27.

SAFE Manual (2016).Integrated design of slabs, mats and footings:

S. Timoshenko and S. Woinowsky-Krieger Theory of plates and shell: (McGraw-Hill Book Company).

S. Timoshenko and J. N. Goodier(1951) Theory of Elasticity: (McGraw-Hill Book Company.

S. A. Halkude, S. V. Mahamuni (2014) Comparison of Various Methods of Analysis of Grid Floor Frame:*International Journal of Engineering Science Invention ISSN (Online): .2319 – 6734, ISSN (Print): 2319 – 6726 www.ijesi.org Volume 3 Issue 2‖ February 2014 ‖ PP.01-07*

Sandesh D. Bothara, Dr.Valsson Varghese(2012) Dynamic Analysis Of Special Moment Resisting Frame Building With Flat Slab And Grid Slab: / International Journal of Engineering

Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 2, Issue 4, July-August 2012, pp.275-280 275 .

Witt F. j (1964) Analysis of simply supported grids of perpendicular beams: OAK RIDGE NATIONAL LABORATORY Oak Ridge, Tennessee operated by UNION CARBIDE CORPORATION for the U. S. ATOMIC ENERGY COMMISSION.