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Numerical Analysis & Design of Reinforced Concrete Horizontally Curved Beam

A case study of Residential Building

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***Abstract*—Research will present the comprehensive behavior of horizontally curved Beam with its ability to carry vertical loads in ultimate cases compared with straight Beams behavior, where collapse analysis theories will be used to conduct load-deflection based analysis. which will be compared with (ETABS Software results). The analysis includes effect of reinforcement bars, variation of depth and subtended angle on the ultimate load of beam. And to showcase the results of main difference in torsional moments, which have influence over shear and deflection and other recommendation of load behavior.**

Keywords—Curved beams, concrete structure; concrete design. Straight beams , curved analysis , vertical loads .

I. INTRODUCTION

The main objective of this research to study the response of reinforced horizontally curved beam due to transverse loading, in order to investigate effect of; the reinforced bars, central subtended angle and effective depth variation on the ultimate load resisted by curved beam load. And by comparing between the results of the same model. The rectangular section is also commonly used. Horizontally curved beams, either made of steel or reinforced concrete, can be continuous or monolithic at both ends. And In this paper, equations for calculating bending moments, torsional moments; shearing stresses and deflections solved by digital software (Etabs).

. The analytical reports of such members is very complex. Based on the fact that those members are subjected to combined factors of bending, shear and torsional moments.

Reinforced concrete horizontally curved beams are extensively used in many fields such as the rounded corners of buildings, circular balconies…etc.

LITERATURE REVIEW:-

A horizontally curved beam, loaded transverse to its plane, is subjected to torsion in addition to bending and shear. Therefore, a special feature of the analysis and design of curved beams is the necessity to include torsional effects. Several methods of ultimate strength analysis are available in as by Badawy, H. E. I., Jordan, I. J, and McMullen [3,4]. Moreover Mansur, M. A., and Rangan, B.V have also proposed a general method of collapse load analysis for reinforced concrete indeterminate frames in which the members are subjected to torsion, bending, and shear that useful for this study .

Jordaan, etc. al, (1974) [3, 4], carried an experimental work of the collapse of reinforced concrete curved beams. The analysis has been used to predict the ultimate load of reinforced curved beam depending on the bending moment and torsion. A plastic hinge to be developed at a particular cross section in term of specific equation. Four reinforced concrete curved beams were tested. In addition, six straight beams having the same cross section and reinforcement as the curved beams were tested also. Three beams were tested for each cross sectional type under concentrated load. The results of the test on the straight beams provided the basic information used for prediction of the ultimate loads; the study found the ultimate load based on the load-deflection relationship.

Thomas et al. (1978) [5] presented behavior of reinforced concrete horizontally curved beams. The analysis of a reinforced concrete horizontally curved beams with fixed the supports at the both ends, and subjected to a concentrated load at mid-span. The results showed that for the conventional design of horizontally curved reinforced concrete beams is suitable to calculate the flexure, torsion moments and the shear forces by an elastic analysis using the un-cracked cross section. Since moment redistribution occurs after cracking, design of curved beam using cracked section is, then recommended specifically near supports where torsion moment changes rapidly along the length. For beams designed using this approach the longitudinal bars yields, almost simultaneously at the supports and at center of span. Primary moments in a horizontally curved beam are torsion moments, required by equilibrium. It cannot be reduced or neglected.

Thannon (1987) [10] proposed a full three dimensional finite element model for the nonlinear analysis of a reinforced concrete curved beam. Twenty-node C3D20) isoperimetric elements are used for the standard derivation of the stiffness matrix. Complete bond between the steel and the surrounding concrete was assumed. The model was used to analyze a reinforced concrete beam curved in plan and loaded by a concentrated force. The results showed good agreement with other researchers. In this paper, the application of the proposed method to the case of reinforced concrete curved beams under a point load is analyzed in detail. The theoretical predictions of the distribution of internal actions, modes of hinge formation, collapse modes, and ultimate strength are compared with test results available in the literature.

Sajad A. Hemzah (2009) presented a derivation of stiffness matrix for curved beams using finite element method. Transverse shear deformation was included in the derivation, the derived matrix not only to be used in both linear and nonlinear analysis of concrete but also for steel curved beams. Load-deflection analysis adopted and found that around (9%) differences in results compared with experimental previous studies.

T. Subramani et all (2014) [16], adopted a three dimensional non-linear finite element model to investigate the behavior and the load carrying capacity of reinforced concrete horizontally curved deep beams, the research concluded that the load deflection base analysis result using ASYS Software showed a good agreement compared with the previous experimental work. In addition to the effects amount of longitudinal rebar's, subtended angle and variation of shear length to effective depth ratio beam's cross-section on the ultimate load value.

Ammar Y. Ali et all. (2014) [12] Analyzed of reinforced concrete horizontally curved deep beams, loaded transversely to its plan, using a three-dimensional nonlinear finite element model in the pre and post cracking levels and up to the ultimate load, this study also discovered that the effect of internal torsion, acting in the cross section of curved beams, on the ultimate load decreased as the ratio of a/d (Shear length (a) /effective depth (d)) decreased. The ultimate load resisted by curved beams decreases due to releasing the torsional restraint at one ends by 22% for a/d ratio of 4.36%, while it decreased to 12% for a/d 1.75. on the other hand when amount the ultimate load increased with increasing the transverse reinforcement.

Anas H. Yousifany (2015) [13] evaluated behavior of R.C curved beam in plan, included load-deflection relationships, crack pattern and propagation of crack at different stages of load and ultimate load capacity, and found that The reliability of the evaluated models was about 4 to 8% among the available experimental results and the numerical analyses.

Hayder et al. (2016) [17] presented a theoretical study for two horizontally curved beams with hollow and solid cross-sections. A finite element method was used. 3-dimensional continuum element (C3D20) was adopted in the analysis. A 210 curved beams with different cross-sections tested and the results showed that a hollow section was more efficient than the fully solid section in terms of reducing load capacity.

Jeyashree T.M.1, et al. (2020) [18] introduced experimentally study of a horizontally reinforced curved beam, in order to increase transverse shear strength, deferent shapes of shear reinforcement (spiral, vertical and zigzag shape) was used, where a six groups of curved beams casted-in place and tested under an axial load and vertical concentrated load. When used spiral and horizontal shear reinforcing, this two types of shear reinforcement increased load capacity of section around 13% -16%, for cross-sections which was ranged from (150 mm - 200 mm) in depth.

II. METHDOLOGY

I. Properties of building under study :-

.The area that we chose for this study is an empty land with a 320m^2 (20x16) which is perfectly suited for comparing between curved beams and straight ones.

.The multi-story residential building will be four floors plus the ground floor (4 Typical + Ground).

numerical method have been used to study the response of curved beam. Analysis of a horizontally reinforced concrete curved beam subjected to concentrated load, by using finite element method (ETABS software) and compared among experimental results of previous studies.

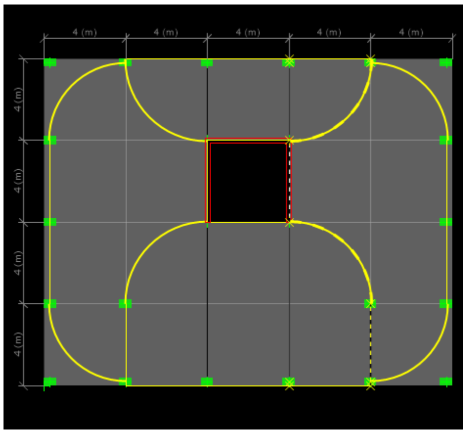

Figure 1 plan view showing dimensions.

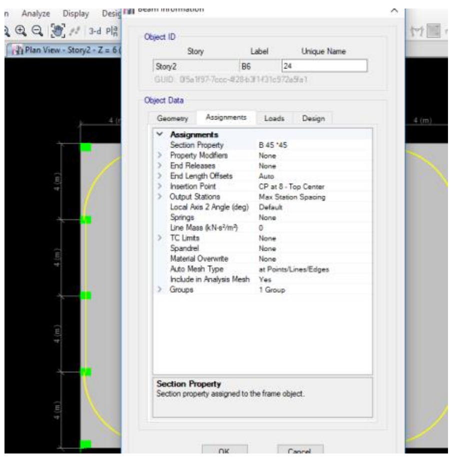

Figure 2 curved beam assignments / design value

I. REASULTS & DISCUSSION

Table 1: Structural members and their sections

Structural Members	Sections (mm)
Beams	450X450
Columns	600X400
Slab	220
Wall	200

Table 2: Load cases

Case	label	Analysis Type	Load (Kn/m^2)
1	Dead	Linear Static	S.W
2	Live	Linear Static	6
3	Finishing	Linear Static	2
4	Partition	Linear Static	2

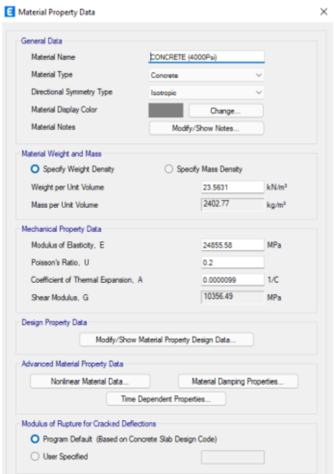

Figure 5 concrete properties and strength .

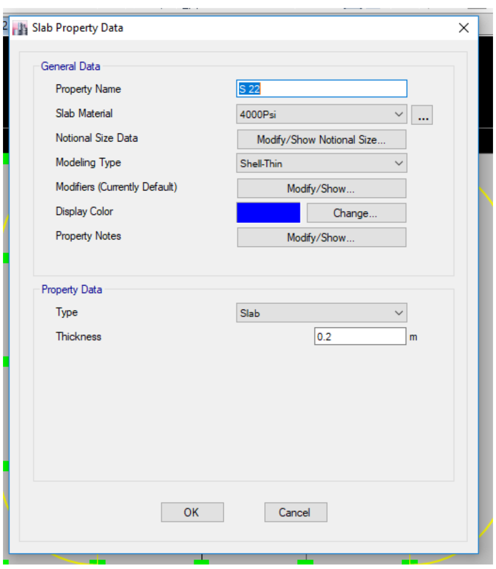

Figure 6- Flat slab properties.

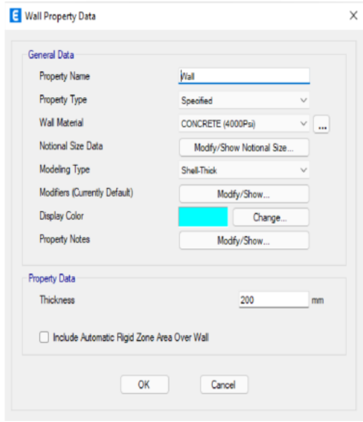

Figure 7- walls properties.

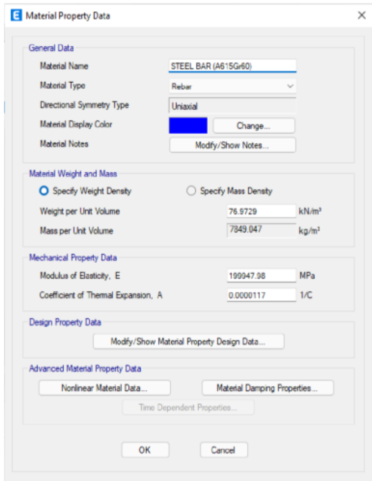

Figure 8- steel Bars & steel links properties.

And as rsulte we can find that the main diffrencs is tortional moment , and the actual values of shear , deflictions which is slightlly different from the same model with straight beams , finally the capasity of ultimate loads , which can reach 12% the values between two beams .

. attaching below the chart that showes the deflection diffrencs according to wong yee chart.

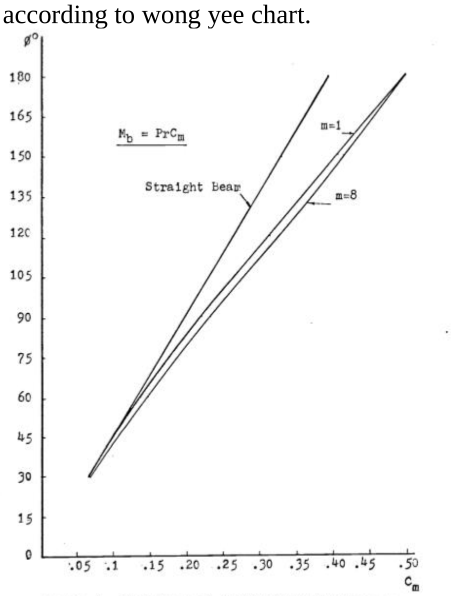

Figure 5. Variation of fixed end bending moment coefficients with span angle for curved beams loaded with concentrated load.

II. CONCLUSION:-

- Depending on the results above we can observe that is the difference is the presence of torsional moments, which, to some extent, will have influence on the bending, shear and deflection values. The more increases in the curve angle the more differ there is.
- The ultimate load resisted by curved beams increased as the shear length to effective depth ratio (a/d) decreased. This increase of ultimate load becomes more effective when the shear length to depth ratio (a/d) was lower than two.

I. RECOMMENDATION:-

Based on the data above and considering the degree / angle of curvature we can assume the following result as recommendation to be noted in the future researches

- Increasing the depth of Curved Beams to have better resistance for bending forces & shear &torsional moments.
- Using curved beams can reduce the amount of structural sections duo to the near values of ultimate loads capacity but taking care for the torsional, and shear forces.
- More studies to be conducted on such research to better understanding of load path & concrete behavior.
- Finally it is not recommended for tall buildings or structure with huge amount of elevation.

II. REFERENCES:-

[1] Jeyashree T.M. and M. Nethaji. (2020). Experimental investigation on flexural behavior of reinforced concrete curved beams with different types of shear reinforcement. International journal on emerging technologies 11(3): 615-618(2020).
[2] Hayder, M. K. Al-Mutairee and Dolfocar A. U. Witwit. (2016). Analytical Study of reinforced concrete horizontally curved beam of rectangular hollow section. International institute for science and technology Vol. (8) No.5
[3] T. Subraman, M. Subramani and K. Prasath. (2014). Analysis of Three Dimensional Horizontal Reinforced Concrete Curved Beam Using Ansys. ‘‘Journal of Engineering Research and Applications www.ijera.com ISSN : 2248-9622, Vol. 4, Issue 6, (Version 6), June 2014, pp.156-161.
[4] Ammar Yaser Ali. and Sadjad Amir Hemzah. (2014) “Nonlinear Analysis for Behavior of RC Horizontally Curved Ring Beams with Openings and Strengthened by CFRP Laminates.” Jordan Journal of Civil Engineering, Volume 8, No.4
[5] M.Vahidi, V.Jafari, M.Rahimian, and Sh.Vahdani. (2014). “A full nonlinear curved beam element with mixed formulation in state space.” Blucher mechanical engineering proceedings. Vol. 1 No.1.
[6] Anas H. Yousifany (2010), “Evaluation of the Behavior of Reinforced Concrete Curved in-Plane Beam.” Iraqi Journal of Civil Engineering Vol. 6, No. 2, pp. 14-25.
[7] Al-Mutairee H.M.K. (2008), “Nonlinear Static and Dynamic Analysis of Horizontally Curved Beams”, Ph.D Thesis, University of Babylon.
[8] Yeong-Bin_Yang., “Nonlinear framed Structures”, Prentice Hall 1994
[9] Thannon, A. Y., (1993). "Nonlinear three dimensional finite element analysis of reinforced concrete curved beams", Al-Rafidain Engineering, Vol. 1, No. 2, pp. 2-16.
[10] Yeong-Bin Yang, Shyh-Rong Kuo, and Yunn-Dar Cherng (1989). “CURVED BEAM ELEMENTS FOR NONLINEAR ANALYSIS” Journal of Engineering Mechanics, Vol. 115, No. 4
[11] E. N. Dvorkin., E. Orate., and J. Oliver., (1988). “On nonlinear formulation curved Timoshenko beam element considering large displacement and rotations.” International journal for numerical methods in engineering. Vol. 26 1567-1613.
[12] Yeong-Bin Yang and Shyh-Rong Kou. (1987) “EFFECT OF CURVATURE ON STABILITY OF CURVED BEAMS” Journal of Structural Engineering, Vol. 113, No. 6, June, 1987. ©ASCE, ISSN 0733-. Paper No. 21552.
[13] Yeong-Bin Yang, Shyh-Rong Kuo, and Yunn-Dar Cherng (1986). “Effect of Curvature on Stability of Curved Beams” Journal of Structural Engineering, Vol. 113, No. 6,
[14] Chen, W., "Plasticity in Reinforced Concrete", McGraw-Hill Book Company, U.S.A., pp.592, 1982.
[15] Thomas. T., C. Leonard, F. and Mehmet J., (1978). "Behavior of reinforced concrete horizontally curved beams." ACI, Vol. 75, PP. 112-123.
[16] Badawy H. E. I., McMullen A. E. and Jordaan, I. J., (1977), “Experimental Investigation of the Collapse of Reinforced Concrete Curved Beams”, Magazine of Concrete Research, Vol. 29, No. 99, pp. 59-69.
[17] Jordaan I.J., Khalifa M.M.A. and McMullen, A.E., Nov. 1974, “Collapse of Curved Reinforced Concrete Beams”, Journal of ASCE, Vol.100, No.ST11.
[18] Yee-Chit Wong, (1969), horizontally curved beams analysis and design, Mater thesis, Oregon state university.