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Experimental And Numerical Comparison Of Shear And Buckling Of Metallic Beams With Circular Cuts In Their Webs

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Abstract – Cellular beams are becoming increasingly popular in metal construction due to their ability to meet technical and economic constraints and reduce floor thickness. However, it's essential to comply with regulations to ensure stability and preserve structures. In this work, we focus on the experimental and theoretical results of shear and buckling of IPE A 100 cellular beams with circular cuts in their webs subjected to a concentrated load. Results show that vertical displacement induced by transverse compression is affected by length, cuts in the web, load location, and beam stiffening. Comparison of experimental and theoretical results highlights the importance of conducting experimental tests to validate theoretical outcomes and ensure prediction accuracy.

Keywords – Cellular Beam, Circular Cut, Length, Openings, Load Location, Robot Structures, Euro-Code 3.

I. INTRODUCTION

Cellular beams have become a popular solution in modern metal constructions due to their ability to meet technical and economic constraints, as well as their capacity to reduce floor thickness. These steel beams with circular openings in their cores permit the passage of pipes, which considerably reduces the floor thickness, allowing for larger spaces. This has sparked the interest of designers for many years, even before specific and appropriate calculation procedures were developed. The reduction in weight of these sections is of special interest, as it allows for the increase in the span of the beams, while ensuring the safety and comfort of the occupants [1-3].

Further studies have also shown that the vertical displacement induced by transverse compression on cellular beams is affected by several factors such as the location of the load, size and shape of the perforations, and the length of the beam. Experimental tests are crucial to validate theoretical outcomes and ensure prediction accuracy [4]. The reduction in weight of cellular beams is of special interest as it allows for an increase in the span of the beams, while ensuring the safety and comfort of the occupants. Compliance with regulations is necessary to ensure stability and preserve structures, making the use of cellular beams a popular solution in modern metal constructions due to their ability to meet technical and economic constraints [5,6].

The use of cellular beams in modern metal constructions is growing due to their ability to meet technical and economic constraints while reducing floor thickness. However, compliance with regulations is vital to ensure stability and preserve structures. Experimental tests are crucial to validate theoretical outcomes and ensure prediction accuracy. Research has also been conducted to develop numerical models for predicting the behavior of steel castellated beams. The results have shown that lateral distortional buckling solutions are very close to numerical model results. In addition, the critical opening length and width of the strip located between the openings affect the carrying capacity of the cellular beams. Our study involved carrying out tests on beams with circular cuts in their webs based on IPE A 100 and analyzing the results obtained [7,9]. Our study focused on two main areas, experimental and theoretical. In the experimental aspect, we conducted tests on a series of IPE A 100 cellular beams with circular cuts in their webs. As for the theoretical aspect, we compared the experimental results obtained with the theoretical results from Eurocode 3. Compliance with regulations is essential to ensure the stability and longevity of structures

II. MATERIALS CHARACTERIZATION

A. Beams

The beams used in the experiment were of different lengths to study the influence of length on the behavior of circular cuts in their web. The beams were certified by the German Standards and Standardization Institute (DIN) and were laminated sections.

B. Creation of circular cuts in the web of beams

The process of creating openings in the web of beams involved the use of a CONSTAN 565 radial drill for several days. This specific radial drill was chosen for its versatility and flexibility in terms of movement and inclination, which were necessary for making the openings. The holes were gradually widened to 15 mm, 25 mm, and then 38 mm, in order to create circular cuts of varying size. This process was conducted in a turning workshop, requiring specialized equipment and expertise to ensure precision and accuracy in the cuts. Overall, the creation of the circular cuts was a meticulous process that required careful planning and execution.

C. Test device

The experimental tests involved the use of a SCHENCK-TREBEL compression machine, capable of reaching 3000 kN. The process was divided into four steps. In the first step, a metal support was installed on the lower plate, followed by two simple supports that held the cellular beams CB1, CB2, CB3, and B4. The second step involved welding transverse stiffeners on both sides and in the middle of the beam to reduce the risk of web deformation. In the third step, reference lines were traced, and load transmission elements were manufactured in L/2 using metal tubes filled with concrete. Finally, dial indicators were set up in L/2 and L/3 using appropriate fixing devices to measure displacements. Figures 1 and 2 illustrate the equipment used in the experiment.

Fig. 1. Beams ready to load

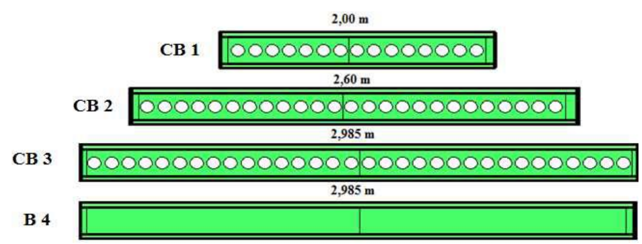

Fig.2. Representation of the beams used

III. ANALYSIS OF EXPERIMENTAL RESULTS

The two histograms in Figures 3 and 4 will compare the different values of shear and buckling calculated from the ultimate load reached during the test for all the tested beams with the theoretical results from Eurocode 3 [10] after carrying out local and global verifications. This comparison will allow the researchers to evaluate the accuracy of the theoretical predictions and to identify any discrepancies between the experimental and theoretical results.

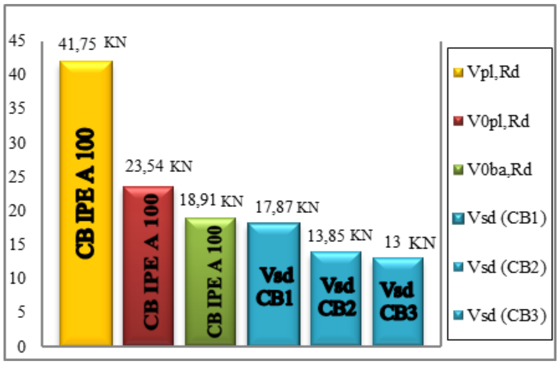

Fig. 3. Comparison of experimental and theoretical results of shear and buckling of beams with circular cuts

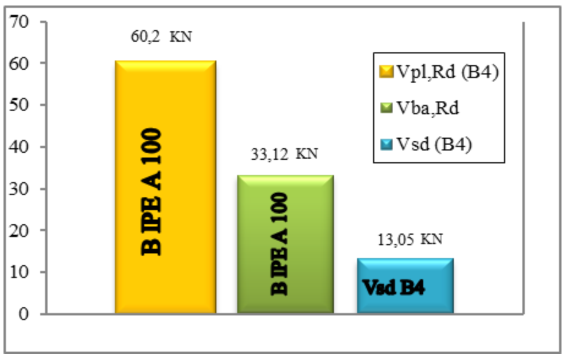

Fig. 4. Comparison of experimental and theoretical results of shear and buckling of beams without circular cuts

The histogram in Figure 3 shows that the results obtained from Eurocode 3 for the plastic buckling resistance of the unperforated cross-section ($V_{pl,Rd}$) give values higher than those obtained from experimental tests. However, the plastic shear resistance of the perforated section ($V_{o,pl,Rd}$) and the shear buckling resistance of the perforated section ($V_{o,ba,Rd}$) given by Eurocode 3 are close to the test results (V_{sd}). This difference is likely due to the consideration of safety factors by Eurocode 3 (e.g., η in the shear buckling calculation). Similarly, in Figure 4, the theoretical values of plastic buckling resistance ($V_{pl,Rd}$) and shear buckling resistance ($V_{ba,Rd}$) are higher than the test results (V_{sd}). This increase in theoretical values is due to the consideration of safety factors by Eurocode 3 to prevent failure.

IV. CONCLUSION

Based on the results of this experimental and theoretical study, the following conclusions could be drawn:

-The presence of stiffeners improves the rigidity of the beams, thereby positively influencing the deflection amplitude and enhancing the shear buckling resistance.

- The comparison of experimental and theoretical results for shear and buckling confirms that Eurocode considers magnification factors that ensure greater safety.

REFERENCES

[1] Bihina, G. (2011). Analyse du comportement au feu des planchers mixtes acier-béton constitutés de poutres cellulaires (Doctoral dissertation).

[2] Bitar, D. (2004). Poutre en I à âme élancée: Vérification de la résistance d'un panneau d'âme muni d'une ouverture circulaire centrée. Construction métallique, 41(4), 71-91.

[3] Sweedan, A. M., & El-Sawy, K. M. (2011). Elastic local buckling of perforated webs of steel cellular beam–column elements. Journal of Constructional Steel Research, 67(7), 1115-1127.

[4] Nseir, J., Lo, M., Sonck, D., Somja, H., Vassart, O., & Boissonnade, N. (2012, April). Lateral torsional buckling of cellular steel beams. In Proceedings of the Annual Stability Conference Structural Stability Research Council (pp. 18-21).

[5] Sweedan, A. M. (2011). Elastic lateral stability of I-shaped cellular steel beams. Journal of Constructional Steel Research, 67(2), 151-163.

[6] Ellobody, E. (2012). Nonlinear analysis of cellular steel beams under combined buckling modes. Thin-Walled Structures, 52, 66-79.

[7] Cashell, K. A., Malaska, M., Khan, M., Alanen, M., & Mela, K. (2019). Numerical analysis of the behaviour of stainless steel cellular beam in fire. ce/papers, 3(3-4), 895-900.

[8] Malaska, M., Cashell, K., Alanen, M., Mela, K., & Afshan, S. (2019). Experimental behaviour of stainless steel cellular beam in fire. ce/papers, 3(3-4), 901-906.

[9] Mimoune, M., & Siouane, S. (2017, July). Numerical analysis on lateral distortional buckling of octagonal castellated steel beams. In Global Civil Engineering Conference (pp. 423-430). Springer, Singapore.

[10] Eurocode 3, Calcul des structures en acier et Document d'Application National. Partie 1: Règles générales et règles pour les bâtiments. Association Française de Normalisation.