

Detailed Study of Perforated Beams with Closely Spaced Novel Web Openings

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Summary

This paper presents a detailed study of the behaviour of perforated steel beams with closely spaced web openings. Seven specimens including two typical cellular beams (i.e. circular web openings) and five perforated beams with novel web opening shapes were tested previously by the authors, to investigate the failure mode and load strength of the web-post between two adjacent web openings. These new novel web opening shapes improve the structural performance of the perforated beams with respect to web-post buckling failure. In addition, the manufacturing procedure of these novel web openings is improved and leads to sustainable design. The effects of web opening spacing/web opening depth of web-posts as well as the web opening depth/web thickness were studied to investigate the stability (slenderness) of the web-post subjected to vertical shear load. In comparison with the conventional cellular beams, significant advantages were obtained.

Keywords: Perforated steel beams; cellular beams; non-linear finite element analysis; web-post buckling; novel web opening shapes; web-post width; vertical shear capacity; parametric study; strut model; web-post stability

1. Introduction

The use of perforated steel beams has resulted in longer span floors. Their popularity has also increased because of an architectural emphasis on exposed structures, with cellular, castellated and elongated web openings being typical in structural steel sections. Sections having webs penetrated by large closely spaced openings over almost the full span are now common. Although the best application of these beams appears to be for long spans which are to carry a light uniform load, some heavy-mass structures, such as bridges, have been constructed using perforated beams for the full span. Also, with greater automation, the cost of their fabrication has been reduced to the level where for certain applications they may be competitive with open-web steel joists [1].

The last decade researchers examine standard web opening shapes (i.e. circular, rectangular and hexagonal) of perforated steel sections in order to provide a better understanding of the stress distribution in the vicinity of the web openings [2,3]. The current work presents a further investigation on perforated beams with closely spaced non-standard elliptically-based novel web opening shapes as first proposed by Tsavdaridis and D'Mello [4].