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Experimental and numerical investigation of axially loaded aluminium alloy angle struts with lateral bracing on one leg

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ABSTRACT

This study investigates the buckling behaviour and resistance of aluminium alloy angle struts with lateral bracing on one leg. Axial compressive tests were conducted on eleven simply supported angle struts, each with one leg supported by lateral bracing. The initial geometric imperfections of the specimens were carefully measured using a 3D laser scanner. Finite element models were developed to perform a comprehensive parametric study. The sensitivity to initial imperfections was analysed in detail. The ratio of the flexural buckling load about the rectangular axis $N_{cr,FR}$ to the torsional buckling load $N_{cr,T}$ was found to have a significant effect on the buckling behaviour. Comparison of buckling resistance indicates that existing design codes cannot be directly applied to aluminium alloy angle struts with lateral bracing on one leg. By introducing the elastic buckling load ratio $N_{cr,FR}$ / $N_{cr,T}$, the proposed new design methods demonstrated good accuracy.

1. Introduction

Aluminium alloys components enjoy growing application due to their high strength-to-weight ratio, excellent corrosion resistance and non-magnetic properties [1,2]. Extrusion technology allows for the creation of customized cross-sections, improving material utilization [3]. Unlike traditional steel members, aluminium alloys have a lower Young's modulus and rounded stress-strain curves, with varying nominal yield stress. As a result, aluminium alloy components are more susceptible to buckling and require careful design considerations.

Angle section components are commonly used in practice due to the ease of connecting their legs. Existing research on the axial buckling behaviour of angle struts has focused on aluminium alloys of the 6xxx [4–6] and 7xxx series [7–9]. The flexural buckling about minor axis *v*-*v* and torsional-flexural buckling are two typical failure modes. Different from the minor axis flexural buckling load $N_{cr,F}$, the elastic torsional-flexural buckling load $N_{cr,TF}$ is influenced not only by the flexural slenderness but also by the width-to-thickness ratio of the leg. Therefore, a short component with slender legs and a long component with stronger legs may have the same $N_{cr,TF}$. However, their post-buckling behaviour differs, ranging from plate buckling behaviour to column buckling behaviour as the ratio $N_{cr,TF}$ / $N_{cr,F}$ increases [10–13]. Additionally, reduction factors for aluminium alloy single-angle struts connected by one leg have been proposed based on the axial buckling modes [14]. The mechanical behaviour of aluminium alloy angle-to-plate connections was investigated in detail by Jiang et al. [15]. Besides, extensive research has also been conducted on angle struts made of high-strength steel [16–22] and stainless steel [23–26].

In addition to single-angle struts, angle struts with lateral bracings on one leg are commonly used in practice (Fig. 1(a)). Experimental tests have shown that angle struts with lateral bracing on one leg typically undergo flexural buckling about the rectangular axis (x – x) combined with rotation [27] (Fig. 1(b)). The efficiency of the lateral bracings decreases as the width-to-thickness ratio increases (i.e. as the torsional deformation at buckling increases) [28]. However, the effective slenderness factor used to account for the effect of rotation varies across current design codes, including EN1993–3–1:2006 [29], EN50341–1:2012 [30] and DL/T 5486–2020 [31]. For aluminium alloy angle struts with lateral bracing on one leg, the applicability of existing design rules remains unclear due to the lack of relevant studies.

To investigate the buckling behaviour and resistance of aluminium alloy angle struts with lateral bracing on one leg, this study first assessed the elastic critical buckling load. Compressive buckling tests were then conducted on eleven simply supported aluminium alloy struts with lateral bracing. Material tensile coupon tests and initial imperfection measurements were performed prior to the buckling tests. Finite

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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上午 第一节(08:10-08:50)				建筑材料_03 许照宇 1-7周 1-2节 钱塘校区教C教C106 水工S24-3	工程材料_03 许照宇 2-5,7-8周 1-2节 南浔校区求实楼北106 水工23-3,水工2...	工程材料_03 许照宇 第6周 1-2节 南浔校区博学楼南102 水工23-3,水工2...	
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第三节(09:50-10:30)			工程材料_03 许照宇 1-8周 3-4节 南浔校区求实楼北203 水工23-3,水工23-4				
第四节(10:35-11:15)							
第五节(11:20-12:00)							