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DISCRETE MODELLING METHOD FOR POST-BUCKLING OF SHEAR PANELS

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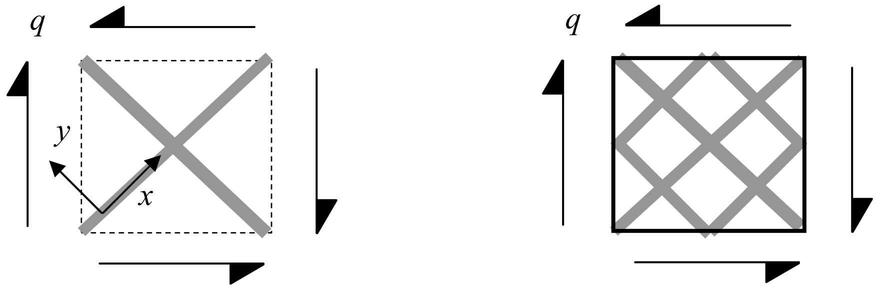
ABSTRACT

Stiffened panel beams are used extensively in aerospace structures, forming components such as the spars, ribs and skin of an aircraft. They are deep beams comprising thin panels with vertical and horizontal stiffeners. Such structures are advantageous owing to their stable post-buckling behaviour under shear loading, allowing them to carry ultimate loads in excess of their critical buckling load, [1].

However, understanding the post-buckling behaviour of stiffened panels has been considered difficult due to the non-linearity. Full-scale non-linear finite element (FE) modelling is not straight forward and the associated computational cost is high, hence not suitable for design iterations. Therefore, design for buckling and post-buckling in practice has traditionally been driven by empirical approaches applicable only to rectangular continuous panels, which are inappropriate for non-rectangular geometries and complex loadings.



(a) 1-cell (n = 1) (b) 4-cell (n = 2)

Figure 1. Truss-lattice configuration

It has been proposed that a discrete truss-lattice configuration can represent continuous panel buckling and post-buckling under shear. Recent studies have demonstrated that it is possible to model the buckling of a continuous panel by a discrete truss-lattice configuration under shear as well as under more complex combined loading [2, 3]. It has also been shown that a one-cell discrete truss-lattice panel exhibits a similar stable post-buckling path to that of a continuous panel under shear [2]. In addition, a computational strategy has been developed to analyse post-buckling of a truss-lattice configuration by extending the exact initial mode method [4], thus achieving fast solution time, lack of imperfection requirement, reliable convergence and accuracy.

This paper presents the development in understanding of post-buckling in a truss-lattice with frames. The investigation of a multiple cell truss-lattice buckling revealed that increasing the number of cells improves the prediction of buckling asymptotically, [2]. The n = 2 model shown in figure 1(b) was observed to follow a stable post-buckling path, where the loads in the compression struts are gradually transferred into the tension struts, figure 2.

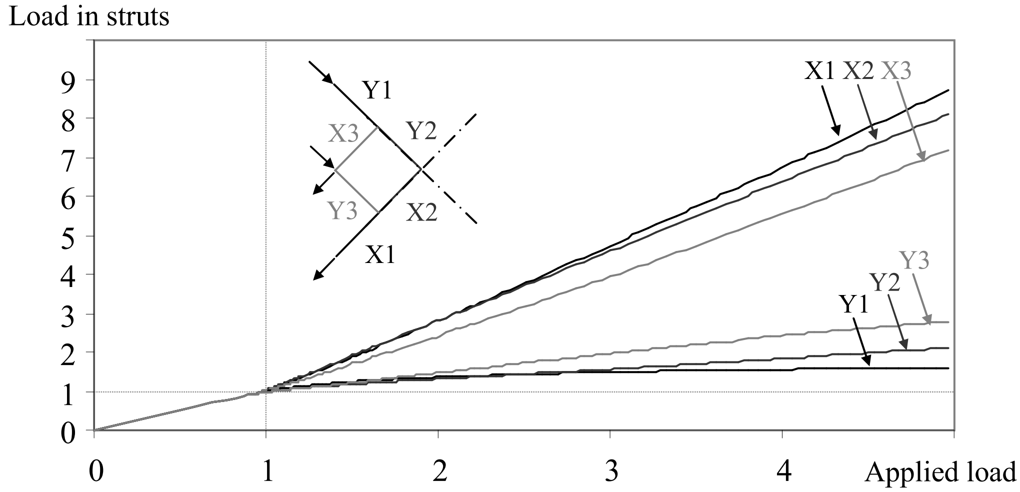


Figure 2 Load distribution for n = 2 truss-lattice, buckling out-of-plane

It was found that the properties of the frame had significant influences on the post-buckling behaviour of a multiple cell shear panel. Figure 1(b) shows the frame in solid lines around the truss-lattice panel. In practice, a panel is usually supported by stiffeners, thus the frame properties may be formulated to represent the stiffeners instead of the simply-supported or clamped boundary conditions. It was seen that the post-buckling path of the panel is relatively insensitive to the axial stiffness of the frame, but highly sensitive to the in-plane bending stiffness. In practice, a stiffener provides support in-between simply-supported and clamped, and it is demonstrated that the torsional rigidity of the frame members can represent a similar continuous boundary condition.

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