ABSTRACT: Blockhaus systems represent a traditional construction technology, whose strength directly depends on the contact and interaction between timber logs and carpentry connections. Due to the complexity of the phenomena involved in their typical load-carrying behavior (loading perpendicular to the grain, effect of friction, influence of gaps in the joints, creep, etc.), their structural behavior under specific loading/boundary conditions is not completely known. In the paper, the buckling failure of Blockhaus walls under in-plane vertical loads is deeply investigated. Based on sophisticated numerical models, linear modal analyses and nonlinear static incremental simulations are performed to predict their critical buckling load. A detailed parametric study is performed to highlight the effects of openings and load eccentricities. Numerical results are then compared to predictions of analytical models available in literature and results of full-scale buckling experiments.

KEYWORDS: Blockhaus walls, buckling behavior, in-plane vertical loads, numerical simulations, full-scale experiments

1 INTRODUCTION

‘Blockhaus’ systems represent a traditional construction technology where structural resistance is obtained by direct contact between multiple timber surfaces obtained via carvings, notches, and ancient joints [1][2]. Native of forested areas, this technology is frequently used in practice for the construction of log buildings (Figure 1). However, due to the complexity of the phenomena involved (loading perpendicular to the grain, effect of friction, influence of gaps in the joints, creep, etc.), their structural behavior under specific loading/boundary conditions is not completely known, particularly for complex geometries (e.g. wall with openings such as windows and/or doors). The interaction between multiple logs, for example, as well as the restraint effectiveness of carpentry timber joints and the anisotropy of timber, can strongly affect the load-carrying capacity of these structural systems. In the paper, the attention is focused on the structural response of Blockhaus walls under in-plane vertical loads.

2 NUMERICAL APPROACH

To investigate the effects of several parameters on their buckling capacity, sophisticated numerical models are developed using the ABAQUS/Standard software package [3]. The typical numerical model consists of a traditional Blockhouse wall composed by multiple interacting timber logs, described in the form of 3D-8 node solid elements. The main advantage of this advanced numerical modeling approach is given by the realistic description of the interaction between logs, and in particular by surface-to-surface contact pairs able to take into account both the possible sliding and friction effects between multiple logs, and the possible separation between logs when subjected to tensile stresses.

2.1 METHODS OF ANALYSIS

A first simulation phase is focused on the buckling response of Blockhaus walls without openings (Figure 2). Linear elastic modal analyses as well as nonlinear static
incremental simulations are performed on the same numerical models, and in general a good correspondence is found between the corresponding predicted critical buckling loads. At the same time, numerical predictions are compared with critical loads given by analytical approaches existing in literature, to assess their accuracy and applicability to Blockhaus timber walls.

2.2 NUMERICAL PARAMETRIC STUDY

Subsequently, the same numerical study is extended to Blockhaus walls with openings (e.g. only a door, door and window, etc.), to investigate the effects of different geometrical configurations on their typical load-carrying behavior under in-plane vertical loads (Figure 3).

In this case, simulations highlighted that the presence of openings, in conjunction with possible local interactions between adjacent logs, strongly affects the global buckling strength of Blockhaus walls, markedly reducing their collapse load (Figure 4). Consequently, based on the specific geometrical configuration, particular attention should be paid to a correct estimation of the corresponding critical load. Further numerical analyses are then performed on Blockhaus walls under eccentrical vertical loads, and also in this case interesting results are obtained for various amplitudes of assigned eccentricities.

Figure 2: Buckling failure mode of a Blockhaus wall under in-plane vertical load. Wall without openings

Figure 3: Buckling failure mode of a Blockhaus wall under in-plane vertical load. Wall with openings

3 FURTHER DEVELOPMENTS

In conclusion, numerical and analytical predictions are compared to critical loads obtained from full-scale buckling experiments performed on Blockhaus walls under in-plane vertical loads. Based on the results of the numerical study, useful suggestions are provided for an accurate estimation of the critical buckling load of these structural systems.

4 CONCLUSIONS

Buckling failure of Blockhaus under in-plane vertical loads is deeply investigated by means of sophisticated numerical models able to take into account the interaction and contact between multiple timber logs and carpentry joints. As shown, particular geometrical configurations (e.g. door and/or window openings) and load eccentricities can strongly affect the buckling capacity of these structural systems. Based on comparisons between numerical results, analytical predictions and results obtained from full-scale buckling experiments, useful suggestions are provided for a realistic estimation of their critical buckling load.

REFERENCES