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Static and seismic experiment for bolted-welded joint in modularized prefabricated steel structure

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ABSTRACT

This study proposes a type of bolted-welded beam–column joint for modularized prefabricated multi-rise and high-rise steel structures. The components in the same module are welded in the factory, and the modules are quickly assembled using the proposed joint at site. The static performance, hysteretic performance, skeleton curves, ductile performance, energy dissipation capacity, rotation capacity and stiffness degradation patterns of four joints are obtained by model experiment and finite element analyses, and the effect of thicknesses of the chords and web members on the static and seismic performance of the joint as well as the effect of welding quality are investigated. The results show that due to the presence of the bolted connecting parts, the proposed joints maintain relatively good seismic performance including ductile performance, energy dissipation capacity and plastic rotation capacity, and good static bearing capacity after the welding seams fracture, so they can be used in structures of seismic zones. Reducing the thicknesses of the chord and the web members can significantly decrease the load-bearing capacity of the joint; however, this decrease is not proportional to the decrease of the cross-sectional area. In addition, reducing the thicknesses of the chord and web members has no significant impact on the ductile performance and energy dissipation capacity of the joint. Simplified computation formulas for load-bearing capacity of the joint were proposed and the computation results get along well with the experimental results.

1. Introduction

Modularized prefabricated steel structures are consistent with the definition of green buildings that is given in the *Assessment Standard for Green Building* [1], and have an extensive application prospects. The standardized and modularized design and fabrication of members of modularized prefabricated steel structures are realized [2–3]. Steel structures have excellent machinability and are suitable for industrial production; they are lightweight and suitable for transportation, and are suitable to being connected by high-strength bolts, which makes them mostly suitable for prefabricated buildings [4–8].

Beam–column connecting is the core technology of prefabricated steel structures. When designing beam–column joints, it is necessary to fully consider the assemblability on site as well as to ensure the mechanical properties including strength, stiffness and ductility. This study proposes a new type of bolted-welded joint for modularized prefabricated multi-rise and high-rise steel structures. The proposed joint is used to connect two close modules and can facilitate the rapid assembly of modules on site. As shown in Fig. 1, the proposed joint consists of one column base, upper column with a flange, lower column with a flange, one piece of single-angle truss welded to the column base, one piece of single-angle truss bolted to the vertical connecting plate and upper and lower cover plates, two joint cover plates, two joint flitches, and one vertical connecting plate. Each joint cover plate and the corresponding flange form one component that is named as cover plate flange that is welded to the end of the column in the factory. The column base is formed by a short column and two flanges which are welded together in the factory. The vertical connecting plate is welded to the column base at the side of the short column, and on the surface of the upper and lower flanges. The truss beam consists of two pieces of single-angle truss beams. As shown in Fig. 1, one piece of single-angle truss beam is welded onto the column base and the vertical connecting plate in the factory, and as shown in Fig. 2, this welded part is placed in one module; the other piece of single-angle truss beam, which is placed in another module, is bolted to the vertical connecting plate with joint flitch and bolted to the cover plate with the upper and lower chords. The two pieces of single-angle truss beam are spliced by the bolt at the intersection joint of the chord and web members, thus a double-angle truss beam is formed. On the construction site, the two close modules are connected at the beam–column joints using bolts as well as at each intersection joint of web members and chords using bolts, so that the two close modules are merged together with the splicing of the two piece of single-angle truss.

The carried out researches have primarily focused on the basic theory analysis, experimental studies, and design and construction methods for treelike joints, dog bone joints, joints with a cantilever segment, joints with an opening in the web plate, bolted joints with long and circular holes, joints with reinforced haunch or ribbed plates, joints with

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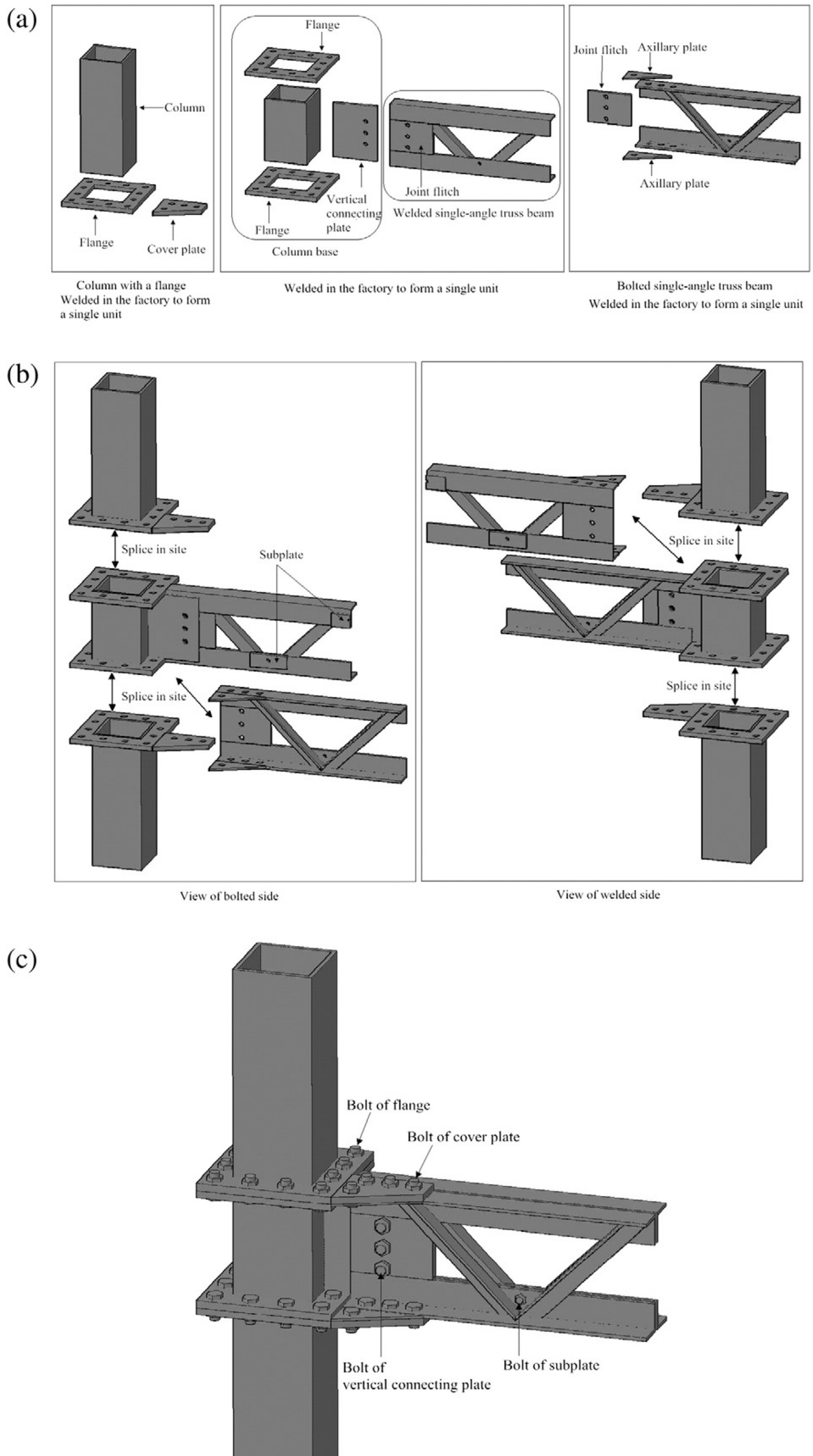

Fig. 1. Structural diagram of the joint. (a) Exploded view of components. (b) Assembly drawing. (c) Assembled joint.