ABSTRACT: This paper presents the results of an experimental study on the compressive behavior of longitudinally cracked wood columns retrofitted using self-tapping screws, which were driven through the crack to improve the structural integrity of the cracked columns. Full-scale compression tests were conducted to investigate the failure mode and maximum load carrying capacity of intact and cracked wood columns with different retrofitting provisions. As the first part of the experimental study, seven columns were tested up to failure. The test results indicated that self-tapping screws are almost equally effective with FRP sheets in terms of the recovery of the load carrying capacity of longitudinally cracked columns. Considering retrofitting using self-tapping screw is much faster than that using FRP sheets, this new technique can have a very broad application in retrofitting historical timber buildings.

KEYWORDS: Self-tapping screws, Wood columns, Longitudinally cracked

1 INTRODUCTION

Wood members of historical timber structures may experience significant damages and crack during their service life due to fungal decay, moisture changes and/or external loadings. These damages and cracks may significantly affect the compressive behavior of wood columns and impair their load carrying capacity especially when the reduced stability capacity (due to loss of structural integrity) dominates. Retrofitting of such members is necessary and urgent to preserve the social and cultural values of the historical timber structures.

Many techniques have been developed for retrofitting of cracked wood members, including replacement of local damaged material, injection of resin or other materials to fill the cracks, use of steel jackets or cages, and use of FRP cloth material wrapping [1-8]. However, the material replacement and resin injection techniques are rather empirical and difficult to quantify the amount of recovery that can be yielded from the retrofitting; metallic confinement has compatibility problems and may cause second source of damage if the metal parts get rusted; and FRP materials may reduce the fire resistance of the so-strengthened members.

Self-tapping screws used as reinforcement of wood material in perpendicular to grain direction have been studied widely [9-14]. It was found that the reinforced specimens exhibited a much more ductile failure mode than the unreinforced specimens. Compared to the aforementioned retrofitting techniques, self-tapping screws do not require pre-drilling and therefore is more convenient from the perspective of construction. However, the application of self-tapping screws in reinforcing cracked wood columns has not been studied. This paper presents the results of a study on the compressive behavior of longitudinally cracked wood columns retrofitted by self-tapping screws. Material property tests and full-scale compression tests were conducted to investigate the failure modes and recovery in the load carrying capacity of longitudinally cracked wood columns. Self-tapping screws were applied perpendicular to the cracks to improve the structural integrity of the cracked columns. Different combinations of column geometries, crack dimensions, and diameters and spacings of self-tapping screws were considered in the tests. Previously obtained test results of similar wood columns reinforced by fiber reinforcing polymer sheets were also considered to discuss the effectiveness of the two retrofitting techniques.
2 SPECIMEN PREPARATION AND TEST SETUP

Full-scale wood square columns were tested under compression load. The tests considered two frequently used cross-sectional sizes and lengths in Chinese historical timber structures. The column specimens were made of same batch of Douglas Fir lumber. To consider the rather randomly formed longitudinal cracks in wood columns of real timber structures, the column specimens were manually made to crack in a way that they were slotted throughout the member with a prescribed width (6 mm) and length. The cracks were filled using glue and wood straps of same quality.

Figure 1: Test setup

Seven wood column specimens were produced for this preliminary testing program. Douglas fir lumber (Pseudotsuga menziesii var. menziesii) was used for the columns. The specimens were sized into a square cross-section of 200×200 mm² and 1800 mm in length. To consider the rather randomly formed longitudinal cracks in timber columns of real timber structures and adapt them to laboratory testing conditions, one artificial crack was produced along the longitudinal axis of each specimen at the middle of the cross-section. The crack was achieved by slotting the columns at the prescribed position with a width of 6 mm and a length of 1500 mm. The corners of the slots were chamfered to avoid stress concentration. The corners of the cross section of the FRP retrofitted column were chamfered for ease of wrapping sheets and the cracks were filled using glue and wood straps of same quality. The specimens were loaded concentrically by a hydraulic testing machine with a capacity of 1960 kN. The loading rate was set constantly at 0.3~0.5 kN/s till member failure. The specimens were placed vertically and simply supported along one principal axis of their cross-section, unless otherwisely specified, with the displacement in the other principal axis restricted. Six strain gauges were attached along the four sides of the midheight cross-section of the columns (four were used for the controlled columns). Before testing, each specimen was measured for the moisture content using a digital moisture meter. The test setup is shown schematically in Figure 1.

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REFERENCES