

Improvement of Japanese traditional joint by using compressed wooden fastener

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Japanese traditional timber joint is characteristic joint method assembled and fastened by only timber parts them selves on the replace for usage of a nail, bolt and so on.

Recently, it has been more increasingly and widely used because it has good merits for environment system, low energy, and beautiful exterior in view.

Wooden fastener like as Komisen(squared peg), Kusabi(wedge), and wooden nail is well used to fix joint members in traditional joint. Japanese carpenters have used traditionally the hard wood like as maple or oak with high density because wooden fasteners have most important role in strength of joint.

Due to the performance of strength in traditional joint is almost dependent on embedding strength of the border between joint members, stiffness is heavily influenced by contact stress (pre-stress) and gap between joint members. Hence, the shrinkage of joint members has an influence on contact stress contributing to stiffness in the joint. It is a reason why traditional carpenters thought out anti-shrinkage-methods like as hammering around wooden fastener and roasting or frying with a heat before insertion and usage. Wooden fastener with compressed surface and low moisture content must play an important role in prevention of damages originated from shrinkage in the joint.

Ideal concept of this research was hinted and inherited from these traditional carpenter's skills (know-how) in the mechanism using recovery-property of compressed (densified) wood.

Recently, there were some reports about compressed wood for valid usage in low quality wood like as Japanese cedar(*Cryptomeria japonica*, density: 0.38) which is a very plentiful species in Japan. Originally, compressed wood was produced by relatively high temperature and needed to steam or resin treatment for stabilizing and fixation of its size because compressed wood's cells changed from round to flat will spring back by absorbing water molecule.

In this research, it was used this recovery property of compressed wood for preventing of relaxation of contact stress and gap between joint members in Japanese traditional joint.

Compressed wooden fastener produced with relatively low temperature under 130°C and no fixation treatment will automatically spring back and recover its original volume to a certain level, and finally fill up the gap and give contact stress between joint members by cyclic humidity change of surrounding environment as shown in fig.1.

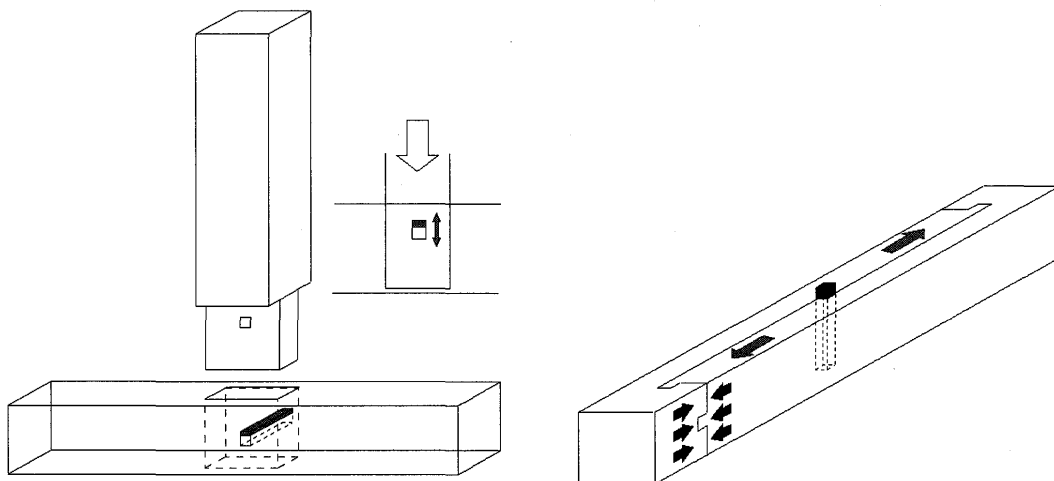


Fig.1. Improvement of contact stress using by recovery of compressed sugi on the Hozo komisen joint(Left) and Kanawa-Tugi joint(Right).

On the view of the capability in komisen material, 70% compressed wood with its high density over 1.1 has good properties in bending strength (250MPa in MOR, 30GPa in MOE) and compressive strength(43MPa).

Therefore, it was focused to study about the change of contact stress by cyclic humidity change, the anti-relaxation effect by recovery of the compressed sugi komisen, and the evaluation of pull-out strength at Hozo-komisen(traditional pegged mortise and tenon) joint inserted by compressed sugi komisen. And, it was focused to study about anti-relaxation effect by recovery of the compressed sugi komisen with contact stress test and creep test in Kanawa-tsugi(traditional beam to beam) Joint.

In result, it was verified that compressed sugi komisen has the anti-relaxation effect on contact stress between joint members in Hozo-komisen joint and Kanawa-tsugi joint. And, compressed sugi komisen improved strength of Hozo-komisen joint after long term cyclic humidity changes as shown in fig.2.

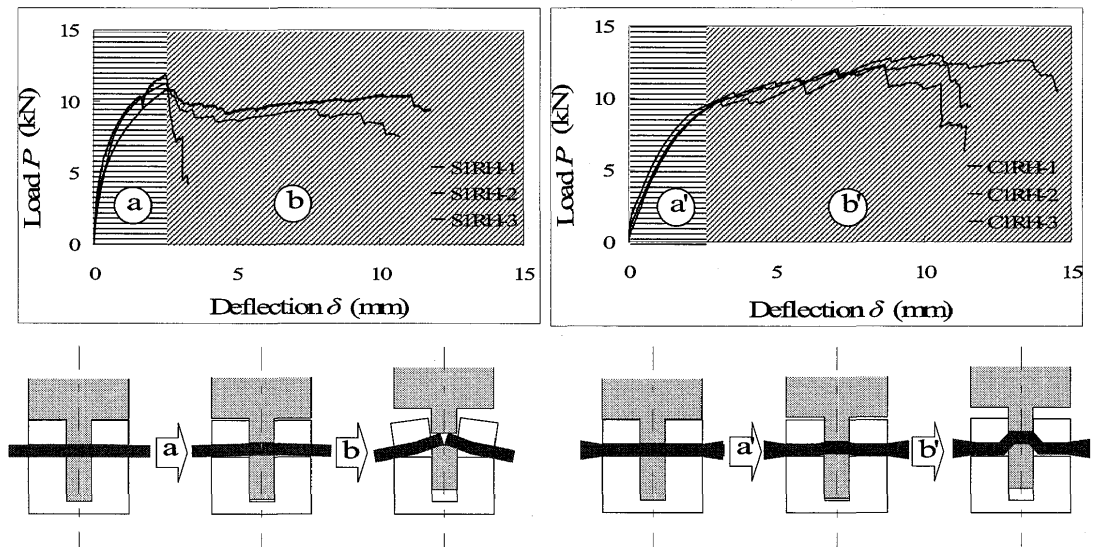


Fig.2. Load vs. Deflection in pull-out strength of Hozo-komisen joint after controlling of 2 years cyclic humidity changes (Left: compressed komisen joint, Right: normal shirakashi joint).

The creep of Kanawa-tsugi joint inserted by compressed sugi komisen didn't accept any influence by cyclic humidity change in all cycles, however shirakashi komisen joint had been getting more increased from 2nd cycle as shown in fig.3

Finally, it was concluded that compressed wood have a good performance as types of key or wedge fastener received big cross-direction stress due to its anti-stress-relaxation in company with recovery property, however normal hard wood even high density wood give birth to the serious relaxation of stress in radial and tangential direction.

Compressed wood fastener, on view of valid usage in low quality wood and improvement for high-performance of joint, can be expected its practical application and adaptation in the role as fasten material.

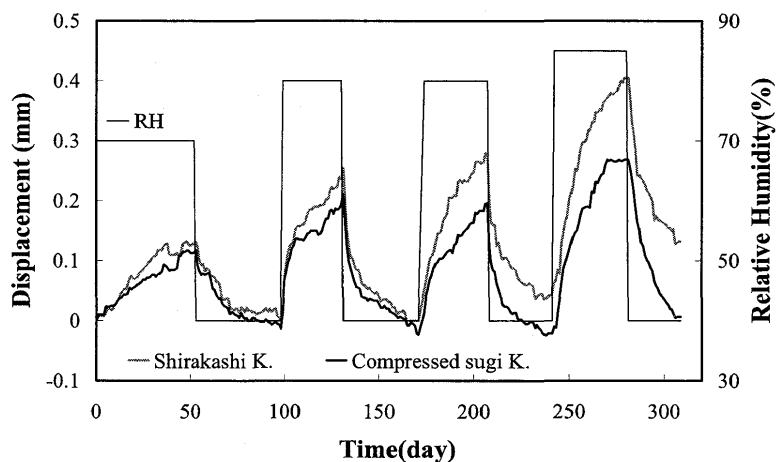


Fig.3. Schedule vs. deformation by cyclic humidity change for the time progress in Kanawa-tsugi Joint.