Structural Properties of Steel-glulam Composite Column^{*1}

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ABSTRACT

A new green home designed to save money while at the same time saving the environment with some of the finest green features available in the market. Composite column composed of structural steel and structural glued laminated timber is a very Eco-friendly building product for design building because that use recycled or second hand. For compare to compressive strength of structural glued laminated timber (glulam), structural steel, and composite column (steel-glulam), tested compressive strength of each specimen. 1) structural glued laminated timber : Theoretical compressive strength is 151.6 kN similar to elastic limits. 2) structural steel (H type) : Theoretical compressive strength is 148.2 kN little under the elastic limits. 3) structural steel (D type) : Theoretical compressive strength is 147.3 kN upper than the elastic limits. 4) composite column : Actual elastic limits are about 600 kN. Result in, composite column improve compressive strength of Structural steel column and provide structural stability of the building.

Keywords : structural steel, structural glued laminated timber (glulam), composite column

1. INTRODUCTION

In the last decade, the wood-framed housing has grown and expanded into new markets in Korea. The fact remains that most of architects use steel structure for design building because they are familiar with steel structure. Steel structure is widely accepted in industrial and commercial construction. Increasing long-span and multi-story building require mechanical properties greater than criteria. Also, due to concerns about the environment, now is the time to make “Green-House” eco-friendly and reduce carbon footprint. Many studies are on

saving the building Energy to cope with FCCC (Framework convention on Climate Change). Structural steel and Structural glued laminated timber can be a very Eco friendly building product for new homes or extensions, even more so when we use recycled or second hand. Most Korean architects have low credibility of the lumber because they consider that lumber is not a structural product. For expanding wood-framed housing market, should make a new system to correct the flaws. Upper than 4 story buildings need to performance verification of structural properties defined the construction standard for light wood framed structure on KS F 9002.

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Table 1. Allowable stress of glulam 10S-34B grade (Unit : N/mm²)

F _b	F _c	F _t	F _v	F _{c⊥}	E
11	9.5	8	2	3.5	8,000

Many studies looking for high capacity hybrid materials to get developed building design. Yang (2006) mentioned new adhesive system of composite column composed of structural steel and structural glued laminated timber. We expect that composite column (steel-glulam) provide high mechanical properties for long-span and multi-story building design. In this study, composite column compare to compare to compressive strength of structural steel, structural glued laminated timber (glulam) and composite column.

2. MATERIALS and METHODS

2.1. Structural Glulam

Korean Larch was used to manufacture glulam in accordance with KS F 3021. Structural glulam was produced using the 10S-34B grade and all the laminations were selected to have the same machine stress grade which was E11 or greater. Table 1. Shows allowable stress of glulam specified in KS F 3021. During manufacture, resorcinol resin adhesive was applied at the rate of 250 g/m² and at the pressure of 7~10 kg/cm². Size of cross section is 150 × 150 mm and length is 3,000 mm.

The theoretical formula used to calculate the compressive strength of structural glued laminated timber (glulam). Design value of compressive strength should considered stability factor, specified strength in compression parallel to grain and cross-sectional area. Calculated design compressive strength of the structural glued laminated timber is 151,560 N.

Table 2. Strength of structural steel SS400 grade (Unit : N/mm²)

F _y	F _t	E
235	400	206,000

Table 3. Strength of structural steel SPSR400 grade (Unit : N/mm²)

F _y	F _t	E
235	400	206,000

2.2. Structural Steel

2.2.1. H Type

According to KS D 3503, structural steel was produced using the SS400 grade. Table 2. Shows strength of Structural steel specified in KS D 3503. Web and flange of Structural steel (H type) are 6.5 mm and 9 mm. Size of cross section is 125 × 125 mm and length is 3,000 mm. Cross-sectional area is 3,031 mm². Compressive strength for design should consider slenderness variables and specified strength in compression parallel to grain. Calculated design value compressive strength of the structural steel (H type) is 148,243 N.

2.2.2. □ Type

According to KS D 3568, structural steel was produced using the SPSR400 grade. Table 3. shows strength of Structural steel specified in KS D 3503. Size of cross section is 80 × 80 mm and length is 3,000 mm. Thickness of Structural steel (□ type) is 3.2 mm. Cross-sectional area is 956.7 mm². Calculated design value compressive strength of the structural steel (□ type) is 136,007 N.

2.3. Composite Members

Structural glulam was used to manufacture

Table 4. Size of composite columns selected for strength

Kind of specimen	Sizes of structural steel (depth $\times$ width $\times$ length)	Sizes of specimen (depth $\times$ width $\times$ length)
H-section steel column with glulam cover for compressive tests	125 $\times$ 125 $\times$ 3,000 mm	250 $\times$ 250 $\times$ 3,000 mm
$\square$ -section steel column with glulam cover for compressive tests	80 $\times$ 80 $\times$ 3,000 mm	200 $\times$ 200 $\times$ 3,000 mm

Fig. 1. (a) steel H column covered by glulam and (b) steel $\square$ -column covered by glulam.

composite member as a cover on structural steel. Steel H and $\square$ -section steel tube act as a structural frame. Resorcinol resin adhesive applied to glue steel and glulam. Section of the composite members are arranged in Fig. 1. Table 4 demonstrates the size of structural materials selected for strength and fire tests.

2.4. Strength Tests

5 specimens for each member used to evaluate the mechanical properties of composite columns. Using the LVDT, displacement of

Fig. 2. Compressive test for glulam, structural steel and composite column.

composite members measured during the compression test. For measure deformation of column, LVDT set up 180 mm from bottom edge. Using an elasticity line join 2,720 mm span. The compressive test parallel to the grain were performed by a Universal-type testing machine. The specimen is supported near the butt and tip, and a load is applied at the ground line by the moving head of the mechanical testing machine. The average loading speed is 9.80 N/mm² per minute. All deflection curves were obtained from the compressive test, and then the ultimate compressive strengths parallel to the grain were calculated from the ultimate load.

Fig. 3. Compressive strength of glulam.

Fig. 4. Failure mode of glulam.

3. RESULTS and DISCUSSION

3.1. Compressive Strength of Structural Glued Laminated Timber

Fig. 3 shows the compressive strengths of structural glued laminated timber (glulam). Theoretical design compressive strength, 151.6 kN, similar to elasticity limits of actual compressive test. Elasticity limits of actual compressive test is 135.8 kN. Stress-strain diagram separated three section. Slope of the last section is lower than other sections.

Fig. 4 is major two failure mode of structural glued laminated timber. One is that high strength finger - joint member digs into low strength finger-joint on the face layer of structural glued laminated timber. The other major failure mode is that column failed from bending through

Fig. 5. Compressive strength of structural steel (H type).

Fig. 6. Compressive strength of structural steel (□ type).

buckling.

3.2. Compressive Strength of Structural Steel

Theoretical design compressive strength of Structural steel (H type) is 148.2 kN. It is lower than elasticity limits of actual compressive test. According to Fig. 5, almost section include elasticity section and reach the maximum load after the elasticity section. Elasticity limits of actual compressive test is 151.9 kN.

Fig. 6. Shows compressive strength of struc-

Fig. 7. Failure model of structural steel (H type, □ type).

tural steel (□ type) and theoretical design compressive strength of structural steel (□ type) is 147.3 kN. Also, theoretical design compressive strength of structural steel (□ type) is lower than elasticity limits of actual compressive strength of structural steel like a structural steel (H type). Measured elasticity limits of actual compressive strength test is 113.7 kN lower than elasticity limits of structural steel (H type).

Structural steel (H type) failed by buckling on Perpendicular to web. Structural steel (□ type) failed by buckling on parallel to flange. Fig. 7 shows failure model of structural steel (H type) and structural steel (□ type).

3.3. Compressive Strength of Composite Column

Fig. 8 indicates the compressive strengths of composite columns. Composite columns not shows failure mode. As shown Fig. 8, composite columns (steel-glulam) have limit of elasticity around 600 kN. It considered to calculate compressive strength of composite column. In Fig. 8, elasticity limits of composite column is higher than other members. Compressive strength of composite members were much higher than steel columns in spite of that the initial stiffness was lower than glulam columns.

Fig. 8. Compressive strength of composite members.

4. CONCLUSION

Structural steel and Structural glued laminated timber can be a very Eco friendly building product for new homes or extensions, even more so when we use recycled or second hand. Structural glulam cover improved the stiffness and strength of structural steel columns under compressive loads. For compare to compressive strength, tested structural glued laminated timber, structural steel (H type), structural steel (□ type) and composite column (steel-glulam).

1) Structural glued laminated timber : Theoretical compressive strength is 151.6 kN similar to elastic limits (135.8 kN).

2) Structural steel (H type) : Theoretical compressive strength is 148.2 kN little under the elastic limits (151.9 kN).

3) Structural steel (□ type) : theoretical compressive strength is 147.3 kN upper than the elastic limits (113.7 kN).

4) Composite column : Measured elastic limits is about 600 kN. Compressive strength of composite members were much higher than steel columns in spite of that the initial stiffness was lower than structural glued laminated timber column. Also, the results expected that composite column improve design compressive strength of Structural steel column and provide structural stability of the building.

ACKNOWLEDGEMENT

This work was supported by ‘Forest Science & Technology Projects (2007)’ funded by the Korea Forest Service, Republic of Korea.

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