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Alternative model of composite castella beam for cyclic load

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Abstract. One alternative in the modelization of steel structural elements is the castella steel beam. This study aims to determine the strength and stability of the normal castella beam due to static loading, cyclic loading and know the damage model of the two types of loading. In this research used normal steel beam IWF 200.100.8.5,5; normal profile steel beams modified into castella steel beams and composite castella steel beams, with hexagonal opening forms, 0.6H aperture height, 9 cm opening distance and 60° opening angle. The results of this study indicate that the moment capacity of composite castella beam with cyclic loading increased 475% from castella beam with static loads. While the load capacity on castella beam with static load increased 152% from composite castella beam with cyclic load. The deflection occurring in the composite castella beam with cyclic loading increased 399% from castella beam with static load. The collapse mechanism of the castella beam with static load is the lateral-torsional buckling and web-buckling. While the collapse mechanism on the composite castella beam with cyclic load is cracked on the concrete stuffing. This shows that the model of composite castella beam can be applied to structures built on earthquake-prone areas.

1. Introduction

The rapid growth of development requires engineers to be more innovative in planning the structure of a building. In its development, the steel structure also innovated modeling. one of the favorite models of steel structures is castella steel. In structural development, a combination of several materials is also needed which is often called composite material. One component of a composite structure in the form of a steel beam covered with concrete. With the composite structure, the performance of structures using the composite system will increase in retaining the tensile force as well as press. The structural expert tries to increase the strength of the steel without increasing its own weight, using the beam open method by replacing the IWF beam with the castella beam. The optimum opening web will give optimum castella beam performance. So, when the combination of castella beam and filler concrete will give the optimum model to withstand the cyclic load given.

2. Literature Survey

A study of the mortar covered of castella and gave the result that the measurement of bending ratio of the composite beam was 229% of the castella beam [1]. The collapse pattern of the composite beam is lateral buckling, while the collapse pattern of the castella beam is the lateral torque buckling. With the provision of mortar mix, the castella profile behavior becomes more stable as it is along the beam span of mortar restraints. The use of the beam is inefficient, since it has a larger moment ratio of 1.09%, while more of the value is greater than some of the comparison beams that have equal capacity.



The research has conducted used IWF 200 100 5.5 8 profile which was fabricated into hollow hexagonal castella beams, 0.6 H aperture height, angle variation and opening length, and castella beam with reinforced concrete reinforcement between wings with monotonic loading [1]. The results showed that the opening angle of 60 degrees and the opening length of 9 cm gave optimal results for hexagonal openings. Furthermore the castella beam is reinforced with concrete filler (composite). The result of the composite castella beam increased by about 250% of the normal beam bending stress or 270% of the bending stress of the castella beam, an increase in load capacity of about 270% of the castella beam, and a moment capacity of about 400% of the normal beam and castella beam. The deflection obtained is 6.99 mm. The value of buckling that occurs in the web is very small.

3. Experimental Study

3.1 Research Design.

This research is designed from the beginning, fabrication, testing, analysis, discussion and conclusion phase as following flow diagram:

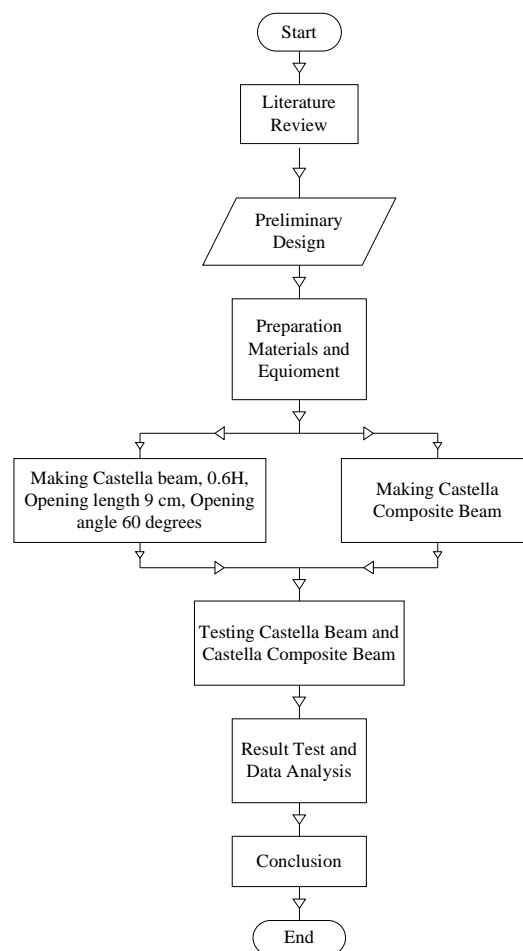


Figure 1. Flowchart Research

3.2 Beam testing.

For specimen, a steel beam that is used is the profile of the IWF 200 x 100 x 8 x 5.5 with hexagon-shaped opening angle. High opening is 0.6 H, clearance distance 9 cm and angle of opening 60 degrees.

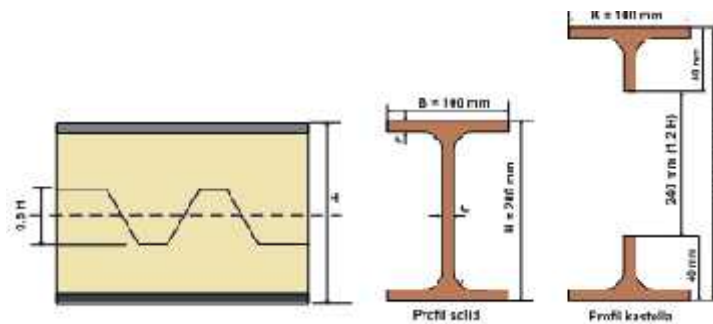


Figure 2. Cross-section of beam

3.3 Testing Framework.

The test framework is designed based on the principle of static load testing and cyclic loading.



Figure 3. Static loading framework



Figure 4. Cyclic loading framework

4. Results and Discussion

Table 1 shows the value of maximum load on castella beam (BC) with 134 kN and the large nominal moment in composite castella beam (CCB) with 149.43 kNm.

Table 1. Capacity of Nominal Moment

No	Beam code	P_n kN	I_x mm^4	M_n kNm
1	BC	134	42110560	31,37
2	CCB	88.25	64458362.54	149,43

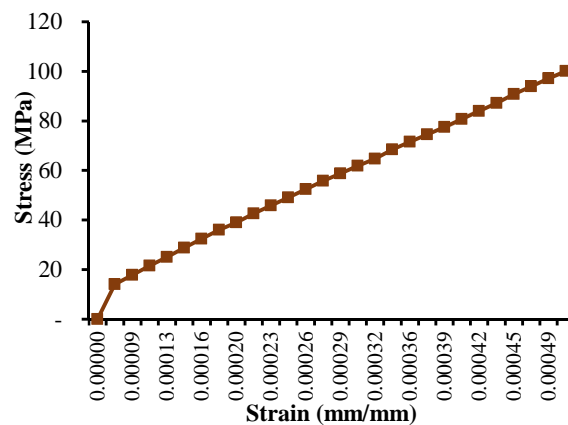


Figure 5. Relationship between strain and stress of castella beam (CB)

From figure 5 shows that castella beam (CB) has a maximum stress of 100.05 MPa and a maximum strain of 0.00050.

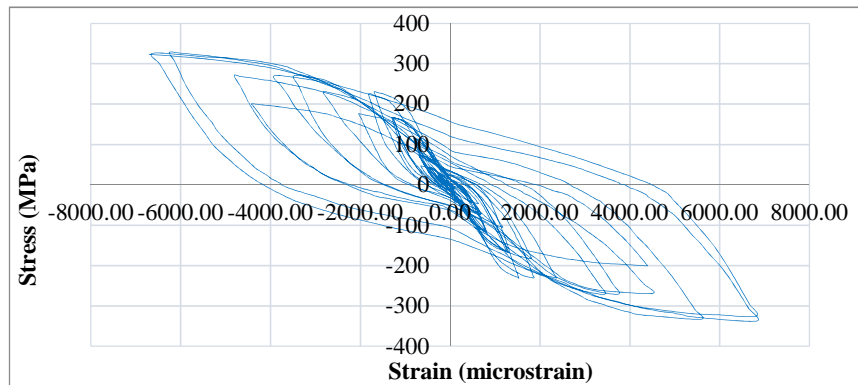


Figure 6. Relationship between strain and stress of composite castella beam (CCB)

From figure 6 shows that the castella composite beam (CCB) has a maximum stress of 337 MPa and maximum strain of 6814 micro strain.

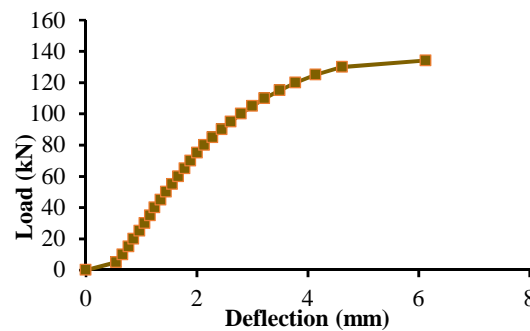


Figure 7. Relationship between deflection and load of castella beam (CB)

From figure 7 shows that the castella beam (CB) reaches a maximum load of 134.15 kN with a maximum deflection of 6.12 mm.

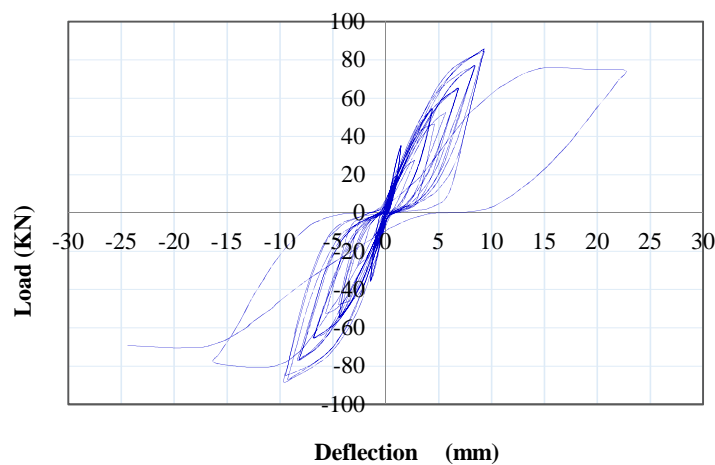


Figure 8. Relationship between deflection and load of composite castella beam (CCB)

From figure 8 shows that the composite castella beam (CB) has a maximum load of 88.25 kN with a maximum deflection of 24.4 mm.

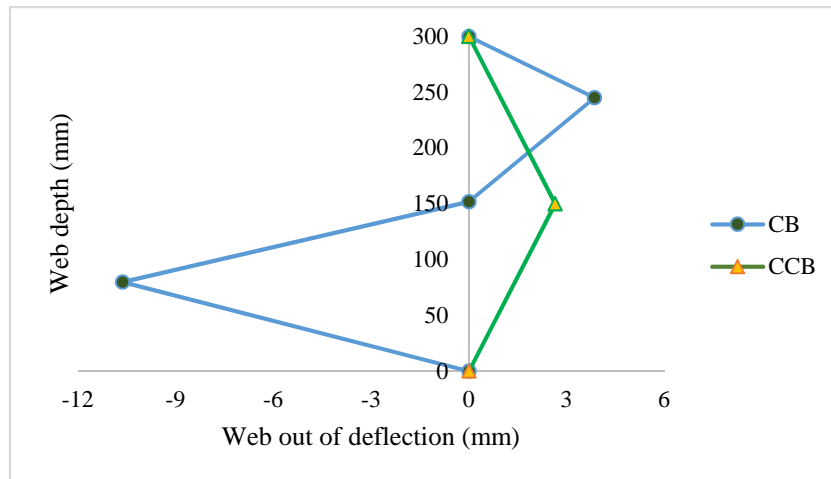


Figure 9. Relationship between web out deflection and web depth

From figure 9 shows that the castella beam (CB) buckling on upper web by 3.85 mm and buckling on lower web by 10.63 mm while the composite castella beam (CCB) buckling on web by 2.65 mm. Table 2 shows that the castella beam (CB) has a failure of lateral torsional buckling on the flange and web, while the composite castella beam (CCB) is cracked on the filler concrete.

Table 2. Failure of beam

Beam code	Damage location	Type of beam failure
BC	Flange and Web,	Lateral Torsional Buckling, Web Buckling Mechanism.
CCB	Concrete filler	Crack

5. Conclusion

Castella composite beams with cyclic loading increased moment capacity by 475% of the beam castella with static loading and a deflection by 399% of the beam castella with static loading. Failure of the castella beam lies on the flange and wings that have lateral torsional buckling and castella composite beam have cracked on the filler concrete. These results indicate that the alternative model of castella composite beam can be used as an earthquake resistant structure.

Reference

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