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Study on Shear Performance of Cold-formed Steel Composite Wall with New Type of stud

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Abstract. The shear resistance of single oriented-strand board wall and single gypsum board wall can be improved in different degrees by increasing strength of steel. The experimental data of literatures were used, and the test specimens had been simulated and validated by ABAQUS finite element analysis. According to the research, it showed that the compressive bearing capacity of the new stud composite wall was much better than the common stud composite wall, so the establishment and research of all models had been based on the new section stud. The analysis results show that when using new type of stud the shear resistance of the single oriented-strand board wall can be improved efficiently by increasing strength of steel, but the shear resistance of the single gypsum wall can be increased little.

1. Introduction

Cold-formed steel composite wall is the main bearing member in the cold-formed thin-wall steel residential building system. According the research[1,2], the compressive bearing capacity of the new stud composite wall is better than the common stud composite wall due to the vertical compressive bearing capacity of the new section stud is higher than that of the common section stud, which makes it possible for low-rise cold-formed thin-wall steel residential buildings from low to high. Therefore, the research of this paper had been based on the new section stud as shown in Fig2.1. In this paper, ABAQUS is used to validate the finite element analysis model of literature [3,4]. The conclusion can be used as the reference for the theoretical analysis.

2. Establishment of Finite Element Model

In literature[1], the size of studs with C section was 102×50×12×1.0mm.The size of top and bottom tracks with U section was 104×65×1.mm and 104×45×0.75mm respectively. The thickness of single gypsum board was 12mm. In literature[2], the size of studs with C section was 89×44.5×12×1.0mm.The size of top and bottom tracks with U section was all 92×40×1.0mm. The thickness of single orient-strand board was 12mm.The boundary conditions of top and bottom tracks were shown as Fig2.2. The panels were connected to the studs and tracks by screws. In literature, diagram of structure details for combined wall was shown as Fig2.3. Diagram of finite element model for combined wall was shown as Fig2.4.

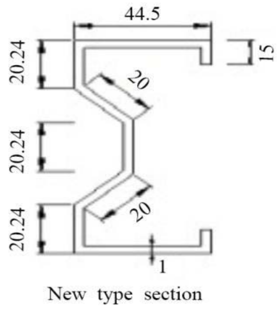

Fig 2.1. New type section

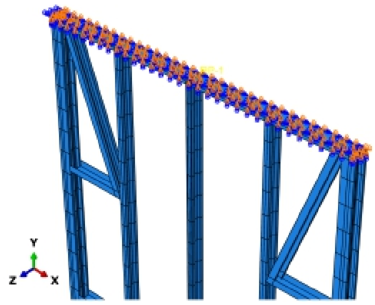

Fig 2.2. Boundary conditions of top and bottom tracks

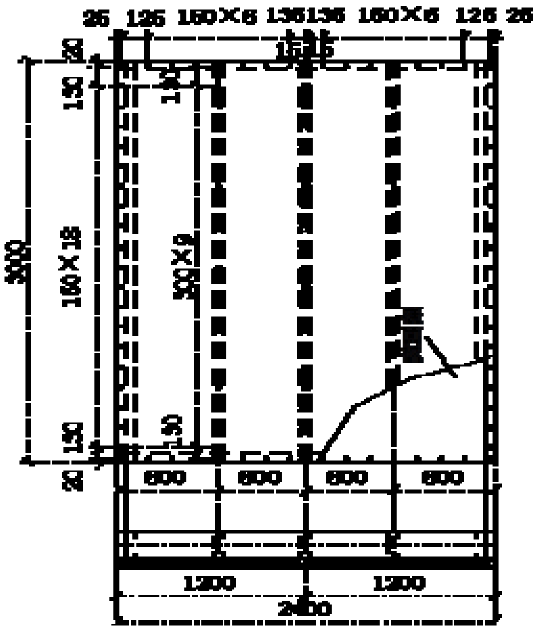

Fig 2.3. Diagram of structure details for combined wall

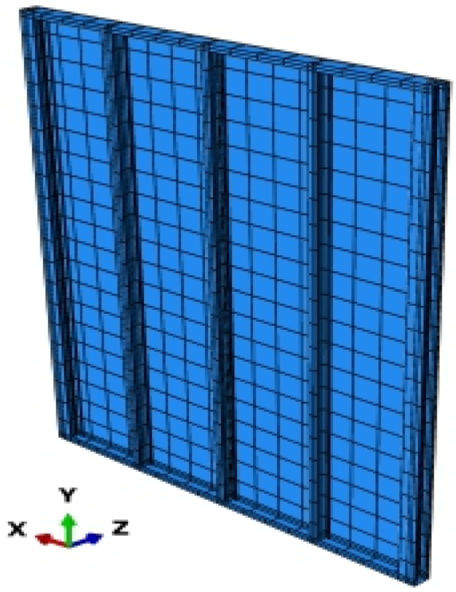

Fig 2.4. Diagram of finite element model for combined wall

3. Verification of the finite element modeling

The cold-formed steel shear wall models had been tested and verified as shown below. The test results were used to verify the correctness of the finite element models, which had the single orient-strand board wall and the single gypsum board wall.

The finite element and test results[1] of the single gypsum wall were shown in Table 3.1. The finite element and test failure modes were shown as Fig3.1 and Fig3.2.

Table 3.1 Comparison between test results for gypsum board wall and finite element analysis results

	Yield load （kN）	Yield displacement （mm）	Peak load （kN）	Peak displacement （mm）
Experimental	9.89	21.17	11.90	45.88
Numerical	10.03	18.62	11.92	39.89
Relative error (%)	1.42	12.05	0.17	13.06

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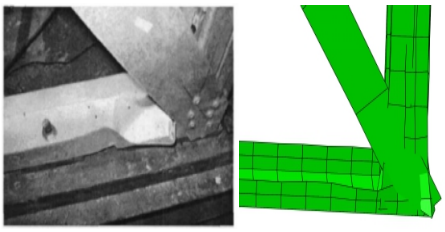

Fig 3.1. Crushing failure of the bottom track

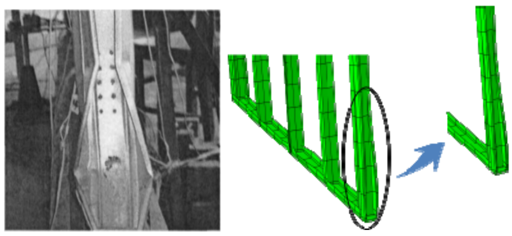

Fig 3.2. Distortion damage of the stud at edge

The finite element and test results[1] of the single orient-strand board wall were shown in Table 3.2. According to the cloud picture of the sheathing and the skeleton of the wall, which had been shown in Fig3.3 and Fig3.4, the stud of wall and wall panel had uniform lateral displacement. The displacement increased gradually from bottom to top, middle stud torsion deformation phenomenon was very serious. Stress in the chords and flange of bottom track were much larger than others in wall frame. The stress area of the wall panel was concentrated in the middle of the slab and distributed in the direction of 45 degrees.

Table 3.2 Comparison between test results for oriented strand board wall and finite element analysis results

	Yield load（kN）	Yield displacement（mm）	Peak Load（kN）	Peak displacement (mm）
Experimental	21.50	23.95	26.84	51.21
Numerical	21.71	23.00	26.43	50.52
Relative error (%)	0.98	3.97	1.53	1.35

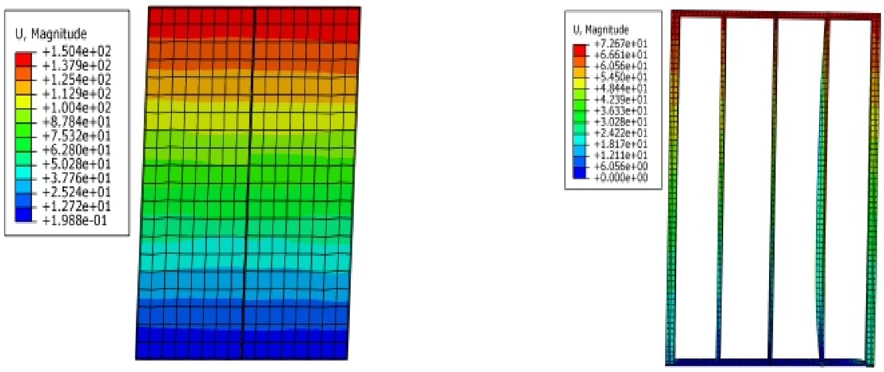

Fig 3.3. Load-displacement nephogram of the wallboard and frame

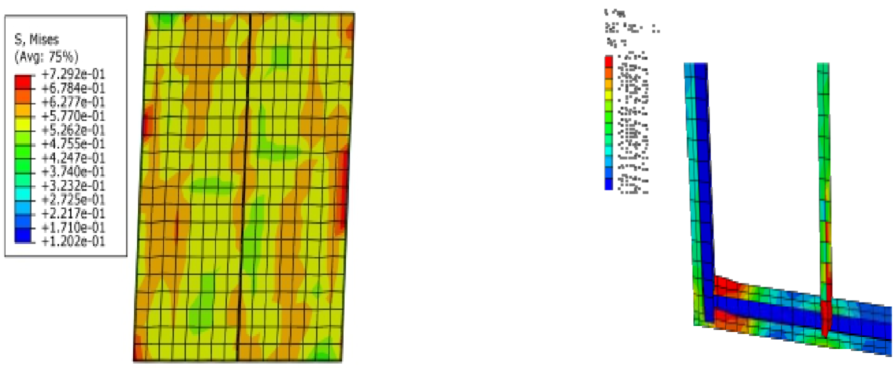

Fig 3.4. (a) Equivalent stress nephogram of the wall panel (b)Stress nephogram of the chord

Finally, it showed that the finite element model can be used to simulate fact condition of cold-formed steel composite wall with the single orient-strand board and gypsum board, in terms of yield load, yield displacement, peak load, peak displacement and failure modes.

4. Shear performance of different wall panels in different steel strength

In this section, the shear resistance of single oriented-strand board wall and gypsum board wall had been studied by changing the strength of steel. The results of each index were shown in Table 4.1

Table. 4.1 The result of finite element analysis for walls with different strength of steel

Label of walls	Yield load （kN）	Yield displacement （mm）	Peak load （kN）	peak displacement （mm）	Ultimate load （kN）	Ultimate displacement （mm）
WSG-F1	7.14	17.14	8.55	43.03	7.27	66.10
WSG-F2	7.25	18.10	8.68	46.53	7.38	65.19
WSG-F3	7.26	18.18	8.69	47.23	7.39	60.69
WSO-F1	16.40	15.02	19.73	27.52	16.77	38.65
WSO-F2	20.53	22.61	24.99	41.38	21.24	71.73
WSO-F3	24.48	27.91	29.59	45.23	25.15	46.02

W-wall；S-single；O-oriented strand board；G-gypsum wall board； F1、F2、F3-steel strength of 235MPa、345MPa and 550MPa；

As Table.4 shown above, the shear resistance of the single gypsum board wall with steel strength of 345MPa, 550MPa can be more increased 1.52%, 1.64% than steel strength of 235MPa only. The shear resistance of the single oriented-strand board wall with steel strength of 345MPa, 550MPa can be increased 26.66%, 49.97% than steel strength of 235MPa respectively. The failure modes of two kinds of walls were different. Gypsum board was a kind of brittle material. The net section of gypsum wall board was snapped at edges that had screws. The steel framing had not yield at this time，the shear resistance of single gypsum board wall had little impact by increasing strength of steel. The toughness of oriented-strand board was better than gypsum board. When the orient-strand board wall suffered shear from the self-tapping screws, it did not immediately occur brittle fracture, but the screws in sheathing had a small amount of slip[5]. And it can drive frame to resistance horizontal shear force together, so the shear resistance of single oriented-strand board wall can be improved efficiently by increasing strength of steel[6].

5.Conclusion

In this study, the shear resistance of the single oriented-strand board wall can be improved efficiently by increasing strength of steel when using new type of stud. The shear resistance of the single gypsum wall can be increased little by increasing strength of steel.

Acknowledgments

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