Design Issues with Steel-stud-framed Wall Systems

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Date: 1999

Preface and acknowledgments

One problem with buildings is that nobody really speaks for the buildings themselves. The deep pockets in the building industry are the material and product manufacturers who tend to have a relatively narrow focus. For instance the wood industry promotes wood and wood products, the concrete industry favors cementitious products, and the steel industry markets steel and steel products. Advertising and marketing being what they are, especially when market share is at stake and a gain by one material is often made at the expense of another, it follows that the trade and even the technical literature may reflect bias. An objective and comprehensive assessment of how a product performs may be hard to come by.

Cold-formed, light-gauge, steel framing has not been widely used in low-rise housing in the US. One obstacle to its adoption may arise from the fact that the steel industry is essentially a highly industrialized manufacturing industry, which employs metallurgists, engineers, consultants, etc. The industry's strengths with regard to engineered construction may have been a disadvantage with regard to low-rise housing, which is essentially non-engineered. The structural engineers and consultants have done an excellent job on the structural issues. The steel industry has done well on all the things that it knows about; there is an extensive listing of engineering papers, guidelines, tables, pamphlets, etc., in support of steel studs as a structural element. Unfortunately, the building science aspects and the "low-tech" concerns of the small builder and framing sub-contractor seem to have been largely ignored, and only recently has the steel industry started to address these important issues.

The US lags countries like Canada and Australia in the use of cold-formed, light-gauge steel in housing. Moreover, there have been well-documented problems with the performance of steel-framed enclosure wall systems in the cold and wet climates of Canada. It is, therefore, difficult to understand why some of these issues, especially moisture control in the North-eastern states, have yet to be properly addressed. It is largely for these reasons that this report has been prepared for the home building industry in Pennsylvania.

The authors of this report were Robert Bombino and Eric Burnett.

Funding was provided by the following:

· The Commonwealth of Pennsylvania through the Pennsylvania Department of Community and Economic Development (DCED);

- The Pennsylvania Builders Association (PBA);
- The individuals, associations, and corporations that are members of the PHRC;
- The Hankin Endowment.

The main purpose of this report is educational. It is not a comprehensive design guide—the steel industry needs to take the lead in producing one. We welcome questions or other feedback plus advice on what the PHRC can best do to facilitate the affordability and quality of housing within as well as outside Pennsylvania.

E. F. P. Burnett, Director

Executive summary

Cold-formed, light-gauge steel framing is an alternative to wood framing for residential and commercial applications; however, steel framing cannot be used as a simple replacement for wood framing in exterior walls. Because steel and wood have very different material properties, they are not interchangeable in framing systems. A different approach is necessary if steel-stud-framed wall systems are to achieve the desired performance and durability.

Current design guidelines for light-gauge steel framing provide extensive information on structural design, offer marginal recommendations for thermal design, and largely neglect recommendations for moisture control which is of particular importance in colder, wetter climates such as Pennsylvania.

This study was conducted to identify and document the significance of the control of heat, air and moisture for steel-framed exterior wall systems and then to develop and suggest appropriate design strategies.

To develop a strategy to improve the thermal performance of steel-framed wall systems, a parametric analysis was carried out on a variety of above-grade wall systems. The effects of insulation location, and of stud size, spacing, and gauge were evaluated. It was demonstrated that continuous exterior insulating sheathing is needed to provide a thermal break within the wall system. Without this thermal break, the thermal bridging created by the highly conductive steel framing significantly reduces the thermal effectiveness of the insulation within the cavity. In addition, stud size and spacing will have significant effects on the thermal efficiency of a wall system. Unless 2´6 studs are structurally necessary, 2´4 studs should be used. Also, studs should be spaced as far apart as practical. The thickness of the steel (or stud gauge) has little effect on heat transmission, particularly when exterior insulation is used.

To address moisture-related issues, the likelihood of condensate deposition and accumulation during average winter conditions was considered. To maintain interior surfaces warm enough (under normal interior and exterior conditions) to avoid condensation, exterior insulating sheathing is necessary in steel-stud-framed wall systems. To ensure that stud cavity temperatures are maintained above the dewpoint temperature of exfiltrating interior air, a specific proportion of the total thermal insulation has to be placed external to the stud cavity. This proportion will vary depending upon the indoor and outdoor temperatures and the indoor relative humidity.

It is emphasized that thermal and moisture control are interrelated and must be considered simultaneously. To facilitate or check the selection of steel-framed wall systems that meet a target R-value and avoid exfiltration condensation within the stud cavity, a simple graphical aid has been provided for a variety of steel-framed wall systems for various environmental conditions.

The results of this project suggest that cold-formed, light-gauge steel framing is a viable method of constructing exterior enclosure wall systems; however, steel framing cannot be used to simply replace wood framing. At this point, further research and developmental work in collaboration with several industries is still necessary. This work should be used as the basis for further work.

At this time we are reluctant to provide hard and fast recommendations about what to do in specific situations and locations. Instead, we recommend seeking assistance from knowledgeable professionals. We also recommend that any individuals or organizations that select or specify steel-stud framing develop some understanding of the nature and relevance of heat, air and moisture control in steel-stud-framed wall systems.