Demystifying Lightweight Steel Framing

By Raymond Van Groll and Julia Preston

In 2016, the authors' firm Atkins + Van Groll Consulting Engineers was brought in to work on a new mid-rise retirement residence in Cambridge, Ont. The developer intended to construct an eight-storey concrete structure but was over budget. The team was hired to reduce costs and the building was changed to lightweight steel framing (LSF).

LSF offers a level of precision, efficiency, and cost-savings that is unmatched. However, for some builders, LSF is a mysterious world with complicated requirements and unfamiliar materials. This article provides a map for the lightweight steel world and demystifies the process of building with this versatile, reliable material.

Efficiency advantages

Lightweight steel framing refers to steel studs, joists, beams, trusses, and other members made from cold-formed sheet steel (CFS). The use of LSF is growing across North America and has many advantages. The Canadian Sheet Steel Building Institute (CSSBI) says, "Cold-formed sheet steel is an easy to handle, economical, non-combustible, high quality alternative to more traditional framing materials. Steel framing offers a strong, accurate, dimensionally stable, and durable framing system."

Efficiency is one of LSF's biggest benefits. By maintaining a constant flow of material and manpower, buildings can be completed much more quickly than in other construction methods. In the Cambridge mid-rise project, the authors' firm was able to construct a complete 1672-m^2 (18,000-sf) floor, including walls, every two weeks.

Cost savings

Cost is the other benefit of LSF (or a hybrid system). A 203-mm (8-in.) thick concrete slab weighs 488.24 kg/m^2 (100 psf). The slab contains four layers of rebar, two in the top and two in the bottom.

A composite slab is a composition of lightweight steel decking topped with reinforced concrete. A composite slab weighs on average 268.53 kg/m^2 (55 psf). In Cambridge, the composite slab had a two-hour fire rating and weighed 317 kg/m^2 (65 psf) with the joist system coming in at 244.12 kg/m (50 psf). The slab has one layer of rebar and one layer of mesh.

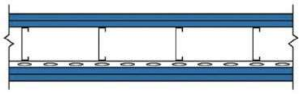
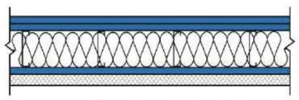
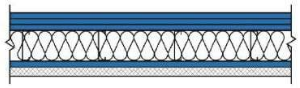
The hybrid system (composite joists or deck on LSF walls) weighs less so it requires buying less concrete. Less material in the LSF system also translates to less labour and cost.

Flooring

Composite and precast are two flooring systems used in LSF. In composite, the LSF deck acts as formwork for the concrete. The concrete bonds with the metal deck, so they work together compositely.

The form of the deck results in small concrete T-beams providing strength and stability. In the retirement mid-rise, the authors' firm used a deep composite deck.

Image courtesy Bailey Metal Products

Fire Rating : 2h				
59* Report: IRC-IR-761; Tests TL-014, TL-017	 Interior Wall With or Without Cavity Insulation	100	ULC U413	2 layers, 15.9mm thick on both sides
N/A	 Exterior Wall With or Without Cavity Insulation	80	ULC U415	2 layers, 15.9mm thick interior side; 1 layer, 12.7mm or 15.9mm gypsum sheathing on exterior side
N/A	 Exterior Wall With or Without Cavity Insulation	100	ULC U414	3 layers, 12.7mm thick interior side; 1 layer, 12.7mm or 15.9mm gypsum sheathing on exterior side

Lightweight steel framing (LSF) wall fire and sound ratings.

In deep deck, there are scallops which form a concrete beam over the top of the load-bearing wall. This beam helps disperse the load.

Load dispersal in composite slab is an important consideration. Composite joists are generally spaced approximately 1 m (4 ft) on centre. With studs at 406 mm (16 in.) on centre and joists at 1 m on centre, the top track must be designed to spread the load.

Pouring and finishing the concrete for a composite slab is done the same way as cast-in-place. Rebar in a composite deck is in tension, therefore less concrete is required. There is one row of shoring.

LSF joist systems, with their minimal concrete, offer a significant amount of open space to run services. One caution, a 457-mm (18-in.) hole does not equal a 457-mm duct. Allow for some wiggle room to put mechanical items between joists.

Precast is a popular flooring choice for its low cost. However, there are some things to watch out for when using precast with LSF.

Precast can create concentrated loads. When placing a rigid piece of concrete on top of a more flexible wall, studs should be spaced very close together to avoid stressing any one point. A common spacing on centre is 203 mm—this is good for managing loads, but not so good for the electrician and plumber.

Precast slabs have a series of holes running down the length of the unit. During construction, when the slabs are exposed to the elements, these holes can fill with water. If building in the winter, this water will freeze and the slab will crack. The holes should be pre-drilled so water can get out of that trapped space.

Photo courtesy Concord Development Company

LSF offers a precise, efficient, and economical building method.

Since precast is pre-tensioned, the slabs are cambered. Topping is required to ensure the floor is flat. The authors recommend at least 38 mm (1.5 in.) for the topping. Precast has a weight of 29 kg (65 lb) per square foot. Even with additional topping, this flooring weighs and costs less than cast-in-place.

The last thing to watch out for with precast is weight. When slabs are being placed, they are often set on the wall and then slid into position. This technique allows the lifting apparatus to be removed. Walls must be braced very well to avoid shifting or bending during this process.

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Photos courtesy Atkins + Van Groll

This image shows a deep composite deck on LSF. In deep deck, scallops form a concrete beam over the top of the load bearing wall, which helps to disperse the load.

Light gauge steel trusses at Lakeside Park Place, a condominium development in Kingsville, Ont.

Walls

Walls in LSF are almost always prefabricated. The top and bottom of each wall needs to be compressed in a jig, which is hard to do outside of a plant. Prefabrication allows for a high level of precision. When walls arrive onsite, they can be erected quickly without specialized labour.

LSF lends itself to building modularly. The walls, floors, and roofs are all pre-engineered units that click together and go up like Lego blocks. This allows for faster construction speeds, lower costs, and higher quality. By putting the blocks on top of each other in different configurations, one can achieve distinctly different buildings using the same module. However, while regularity is nice, it is not a requirement.

Options in LSF include specialty panels, such as curved walls or exterior walls with the cladding already applied. In the Cambridge project, the authors' firm used a faux brick finish on the lower exterior to fit in with the existing architecture of the historic

Roofs

Roofing options in LSF include light gauge steel (LGS) trusses (either symmetrical U-shaped or non-symmetrical), composite deck, joists, and standard C-joists. The easiest option is to build the roof using the same method as the floors. This allows one to use the same crew and same materials that are already onsite.

In one project the authors' team worked on in New York, the building had a flat roof with a cantilever. The engineer had designed the cantilever with structural steel. However, they were able to construct the cantilever out of light gauge by extending the member back over top of the roof. This simple solution saved hundreds of thousands of dollars.

LSF allows one to achieve the residential peaked roof look on a larger scale. Steel standard C-joists can be used just like wood. The big difference with LSF trusses is spacing. In the wood world, trusses run at 0.6 m (2 ft) on centre. In the light gauge world, trusses are set at 1 m on centre. Then on top of the trusses, a metal deck is installed and, plywood if a shingled roof is desired.

Bracing

For lateral stability in LSF, there are four methods: cores, X-braces, shear walls, and moment frames.

The lateral stability in a concrete core takes most of the load and this is the authors' preferred choice. Stair cores can be cast-in-place, using the same method as a concrete building. Matching stairs throughout the building increases efficiency, as forms can be moved back and forth.

Steel manufacturers have begun incorporating forms, including rebar, on decking and studs. These units can come as a package to the site and further increase efficiency.

X-bracing can be done with either flatstock or hollow structural section (HSS) frames and rods. X-braces must be in tension. It can sometimes be challenging to get flatstock tight enough. HSS frames are preferable as they offer a real piece of structure. HSS rods inside the assembly can be tightened to ensure stability.

Shear walls can also be made with reinforced concrete block.

Moment frames are ideal for spaces that cannot have fit in with the existing architecture of the historic neighbourhood. For the upper floors, they selected smooth stucco. The entire outside of the building was enclosed with pre-finished panels. Any articulation architects can design can be done with LSF.

Moment frames are ideal for spaces that cannot have walls or X-braces. These rigid frames are not technically LSF and are instead made of structural steel. However, are used frequently in mid-rise construction because they offer a high level of flexibility.

Henley on the Hudson, high-end condominiums in Weehawken, New Jersey, use deep deck and LSF. Specialty curved panels are prefabricated and include insulation and exterior finish.

Fire and sound

Fire and sound transmission class (STC) ratings are often the biggest stumbling block to LSF. The fire and the STC rating come from two different sources. As well, there may be slight variations in the assemblies between the sound and fire tests. Matching the assembly to the rating is sometimes the hardest thing to do.

The starting point is the Underwriters Laboratories (UL)/Underwriters Laboratories of Canada (ULC) listing. UL is a U.S. association, however, almost all UL fire ratings can be used in Canada. Ensure the UL listing for the assembly is labelled CAN/ULC-S101, *Fire Endurance Tests of Building Construction and Materials*. ULC (the Canadian version) also has its own listings.

ULs and ULCs are owned by the manufacturer. Often, when a manufacturer is named, the listing is specific to their products.

Some UL/ULC listings are specific to bearing walls, while others can be used for both bearing and non-load bearing.

Fire ratings include a diagram of the assembly. However, looking at the picture is not sufficient to understand the rating. Each image includes a legend

Do not be daunted by the fire ratings. The most important thing is to read the text and read it carefully.

The best source for fire and sound ratings is the Steel Framing Alliance's (SFA's) "A Guide to Fire and Acoustical Data for Cold-formed Steel Floor, Wall and Roof Assemblies." This free document brings together all the information in one place.

Beyond UL/ULC and STC, it is worthwhile to consider an assembly's impact insulation class (IIC) rating. This rating applies to sound transmitted through a floor and ceiling. IIC is not required in Canada yet, but it will be included in future building codes. The *International Building Code* (*IBC*) requires condominiums, apartments, hotel rooms, or other residential units be designed for an IIC of 50 or higher.

There are several ways to find fire ratings for particular materials: UL/ULC listings, provincial building codes, or the national code. For example, precast does not have a UL/ULC listing. Instead, its fire rating is included in the *National Building Code* (*NBC*).

If there are questions about ratings and how they apply to a specific project, manufacturers have understand the rating. Each image includes a legend providing detailed descriptions of requirements to achieve the fire rating. Reading the descriptions is essential. For example, a diagram may show two layers of drywall, but that may not be the requirement. An assembly labelled for interior may also be approved for exterior. Generic studs may be allowed, or they may be specific to a particular manufacturer. All these permutations are detailed in the text of the listing.

apply to a specific project, manufacturers have technical service staff who will be able to assist on that.

Progressive collapse

Beyond sound and fire, another safety consideration is progressive collapse. In buildings using natural gas and are more than four stories, the structure may have to be designed to prevent progressive collapse. This requirement comes not from the building

Photo courtesy A-LINX

The Seasons Retirement Residence in Cambridge, Ont.

code, but from some gas company. (Note not all gas companies have this regulation.)

Concrete buildings are considered already designed for progressive collapse, so they are exempt. However, in wood and light gauge, it is important to ensure that if one wall blows out, the whole building does not collapse in a catastrophic manner. In LSF, this usually means adding extra rebar to strengthen certain sections.

Steps for building with LSF

When working with LSF, the authors' firm follows a tried and true process that sees them through the design and construction phases to successful project completion.

At the site plan stage when working out the size and shape of the building, bring the engineer on board to work with the architect. The engineer will do a preliminary layout, including the thicknesses of walls, distance of spans and how the building will stack. This is also a good time to do a preliminary lateral stability analysis.

As one moves toward applying for a building permit, the engineer of record should do a complete structural layout. This should include the size of the walls, minimum thickness of walls, and all the loading required for the building. All the lateral forces must be accounted for at this stage.

A shop drawing review is required to proceed to construction. The engineer will do a layout of the building and work out the final thicknesses or gauges

The future of LSF

In any building, the function should drive the design. That may mean lightweight steel framing is the ideal choice. Or it may not be.

LSF can be used in combination with other building methods to achieve the desired architecture. A light gauge building does not have to be 100 per cent light gauge. If it makes more sense for the building to have concrete columns, steel beams, and a composite deck then it should be designed that way.

LSF works well for mid-rise (up to 12 stories), but beyond that other systems are better choices. People often think if one part of a building is modular, the whole building should be modular. That is not the case. LSF offers a high level of flexibility and integrates well with other systems, so the desired function and architecture can be achieved.

For the authors, LSF represents a new stage of engineering and construction. They often compare LSF to cars. Since Henry Ford, cars have been built on assembly lines and roll off fully assembled, not in pieces that must be put together elsewhere. This is where the construction industry is going as well, and LSF is the vehicle that is driving people there.

Raymond Van Groll is a managing partner at Atkins + Van Groll Consulting Engineers. With more than 30 years of experience, Van Groll specializes in mid-rise structural buildings and light gauge steel construction. He assisted in the development of Canadian Sheet Steel Building Institute's (CSSBI's) Lightweight Steel Framing Design Manual. His notable projects include Chelster Hall Estate in Oakville, Ont., Verve Retirement Homes, Seasons Retirement Homes, the Louis Vuitton Flagship Store in Toronto, the J.W. Marriott Red Leaves Hotel in Muskoka, Ont.,

building and work out the final thicknesses of gauges of the material. All this needs to be confirmed by a specialty engineer.

Loading will be confirmed and the base building engineer will do a cursory review of the panel drawings. Panel drawings are prepared by a specialty LGS engineer. With a final letter covering the design from the LGS engineer, fabrication—and construction—can go ahead.

Field review includes periodic checks and an analysis of independent inspections or any tests. It is valuable to have an independent inspector check the thicknesses of all the material.

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