Newsletter for the
Light Gauge Steel Engineers Association
January 2000

INSIDE

Upcoming Events

BIA/Hawaii Exposition Honolulu, HI *Info.: (808) 847-4666*	Feb 10-14
Hawaii Chapter Meeting *(Installation Dinner for New Chapter Officers)* Honolulu, HI *Info.: (808) 485-1400*	Feb 15
Atlanta/Southeast Chapter Meeting Atlanta, GA *Info.: (615) 242-0023*	Feb 25
LGSEA Europe Chapter *Meetings* *Exhibition* Baden-Baden, GER *Info.: 07225/977 102*	 Mar 16-17 Mar 16
Hawaii Chapter Meeting Honolulu, HI *Info.: (808) 485-1400*	Mar 21
LGSEA Meetings and Seminars Las Vegas, NV *Info.: (615) 279-9251*	Apr 29-30
Association of Wall & Ceiling Contractors (AWCI) *Convention* *Trade Show*	 Apr 29 -May 3 May 1-2

Tests Provide New Insights Into Strength of Metal-to-Metal Screw Connections

by Dr. Roger LaBoube, Ph.D., P.E., University of Missouri/Rolla

Self-drilling screw connection strength equations in the current American Iron and Steel Institute's *Cold-Formed Steel Design Manual* (AISI, 1996) are based on a data base of over 3,500 tests (Pekoz, 1990). Because the test parameters involved are broad, there is much scatter in the data, and the design equations were conservatively developed.

A more recent study conducted at the University of Missouri/Rolla focused on design parameters typically found in residential construction in the United States. Patterns, spacing, and number of screws were varied to determine their effect on connection strength, and test results were used to develop design. *(Note: A full report on the tests, including sample calculations, will be included in an upcoming LGSEA Technical Note.)*

The connection strength study involved testing of 200 single lap connections of normal ductility steel sheets. Three sheet thicknesses were considered. Three self-drilling screw sizes, #8, #10, and #12 were studied. Unique to this research

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Mid-Rise Structures Designed and Built Using Load Bearing Cold-Formed Steel

by Dean H Peyton, PE , Anderson-Peyton Structural Engineers, Seattle, WA

As prime properties for new building construction become more scarce, developers are increasing their unit counts by building taller structures rather than using expensive land area. Multi-family and hotel projects up to 4 or 5 stories tall typically have used light timber frame construction. Beyond those heights, however, light timber framing is not structurally or architecturally allowed by building codes. Traditionally, the next step would be the use of structural steel or concrete construction, materials that also increase the cost of the structure.

The recent completion of a new 8 story Holiday Inn in Federal Way, Washington now presents designers and builders with an alternative that economically bridges the gap between light framed timber and heavy steel or concrete construction. The first of its kind, this 165-unit hotel utilizes (8) stories of axial load bearing light gauge steel studs as the primary load bearing system.

When Westmark Properties Inc., began their quest to develop this prime site in Federal Way, they investigated the economic feasibility of different construction material designs. During this pro-

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Newsletter for the Light Gauge Steel Engineers Association

COFS Subcommittees Meetings in Chicago

The Committee on Framing Standards (COFS) and all five of the subcommittees met at the Hyatt Rosemont in Rosemont, IL on November 4th & 5th, 1999. The COFS hopes to submit the following standards to ANSI's Board of Standard Review during the 2000 calendar year:

1. *General Provisions for the Construction of Cold-Formed Steel Framing*
2. *Design Standard for Cold-Formed Steel Truss Construction*
3. *Base Standard for the Design of Cold-Formed Steel Framing*

BASE STANDARDS: *Chairman Rick Haws, American Building Company*, is currently resolving outstanding negatives on Load Combinations and Design Assumptions. A contractor has been selected to run the engineering analysis and develop the standard language for the first edition of the Base Standard. The first ballot should be out before the May 2000 meetings.

HIGH WIND: *Chairman John Matsen, Matsen-Ford Design Associates, Inc.,* focused his subcommittee's attention around developing a design process for the High Wind Design Standard. His committee is also gathering high wind details and shearwall testing needs anticipating special requirements for High Wind conditions.

HIGH SEISMIC: *Chairman Neal Peterson, Steel Stud Manufacturers Association*. Currently developing a design process for the High Seismic Design Standard. The committee plans on using the newly approved IRC Seismic requirements as a starting point for the standard. The subcommittee continues to gather details, diaphragm and shearwall information to expand upon the current IRC document.

GENERAL PROVISIONS: *Chairman Don Allen, BLB Consulting*. Currently resolving outstanding negatives on the first ballot of the *General Provisions for the Construction of Cold-Formed Steel Framing*. As several negatives were found persuasive, the subcommittee has formed small task groups to resolve the issues and plans to re-ballot before the next meeting.

TRUSS: *Chairman John Carpenter, Alpine Engineered Products*, currently resolving outstanding negatives on the first ballot of the *Design Standard for Cold-Formed Steel Truss Construction*. As several negatives were found persuasive, the subcommittee has formed small task groups to resolve the issues and intends to re-ballot in mid December. ■

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Screw Connection Tests

Continued from page 1

was the study of the influence of the number of screws, geometric pattern formed by the screws, and the spacing of the screws. The number of screws in a connection varied from 1 to 12 and formed 27 different geometric patterns. Two different screw spacings were investigated, 2d and 3d, "d" being the outer diameter of the screw threads. For the purposes of this article, only 3d spacing is discussed. Screw size determined the minimum spacings. For longitudinal and transverse spacing of screws, Section E3.1 of *Specification for the Design of Cold-Formed Steel Structural Members* (AISI, 1996) was referenced. The effect of stripped screws on connection strength was also studied.

The study also focused on bearing failure as the failure mode. Currently the American Iron and Steel Institute (AISI, 1996) specifies a minimum of 3d spacing. In the full report of this study, 2d spacing was the lower bound because screw heads interfered with each other at spacings less than this. Edge distances as specified by the *Cold-Formed Steel Design Manual* (AISI, 1996) were maintained (1.5d transversely and 3d longitudinally).

Table 1: **Typical Results for Four Screw Patterns**

Pattern	Connection Strength (lbs)	Connection Strength per screw (lbs)	Group Effect
4A-1	1506	377	0.72
4A-2	1524	381	0.72
4B-1	1559	390	0.74
4B-2	1563	391	0.74
4C	1492	373	0.71
4D	1663	416	0.79
4E	1583	396	0.75

Notes: 1) 33 mil sheets, #8 screw, 3d spacing between screws.
2) "4C" indicates 4 screws, type C connection - refer to Figure 1.

GENERAL RESULTS

When fracture occurred, it almost always occurred in the sheet that had the screw threads exposed, rather than the sheet against the screw head. When there were several rows of screws, fracture occurred through the row closest to the jaws of the testing machine.

Bearing failures and tilting with bearing were the desired failure mode. Typically, for larger number of screws, the sheet would fracture. Strength per screw was calculated based on the failure load.

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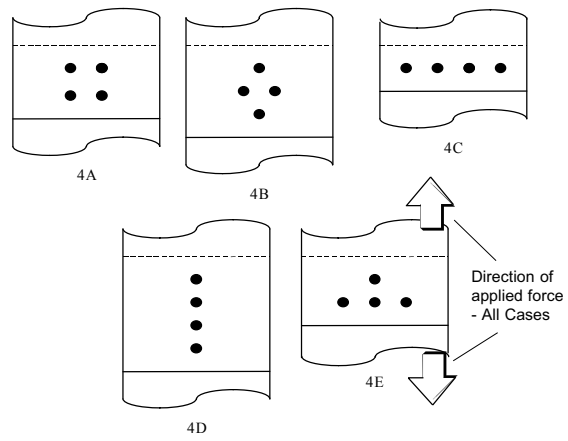
Figure 1: **Screw Patterns for Four Screws**



NASFA Finishes a Strong First Year

by Don Moody, President, NASFA

Strengthened by the high level support of many organizations including the Light Gauge Steel Engineers Association (LGSEA) and National Association of Home Builders (NAHB), the North American Steel Framing Alliance (NASFA) has made significant inroads in its first year toward the increasing use of light gauge steel framing products in new residential construction. This comes at a time when lumber prices remain high and builders are more apt to consider using alternative building materials. Results from the recently completed 1998 NAHB Research Center's *Builder Practices Survey* are showing us positive trends for the use of steel framing in residential construction. The year 2000 will find us continuing our energetic pursuit of strategies and tactics outlined in NASFA's five-year business plan, which provides the context for all of our activities.

As of September 30, NASFA has 45 member companies. The NASFA staff grew to nine (9) full time employees with another 14 shared with the Steel Recycling Institute (SRI), who serve as NASFA regional managers and database administrators located throughout the US.

LGSEA and Code Officials Seminars

While having new material identification standards (LGSEA Newsletter, October 1996) and a Prescriptive Method are great advantages, they are no help to builders or designers if building departments don't know about them or how to

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TECHNICAL EXCHANGE

The Light Gauge Steel Engineers Association needs you and your experience. Please mail or fax your opinions, questions, and design details that are relevant to the cold-formed steel industry (fax to Dean Peyton at (253) 941-9939). Upon editorial review, your submission may be printed in the Technical Exchange Section of this Newsletter.

Design of Eccentrically Loaded Fastener Groups

By John Lyons, P.E., Walter P. Moore & Associates/Atlanta

Whenever load is not transmitted directly through the center of a fastener group, a connection is said to be eccentric. The most common examples of this type of connection in cold formed steel construction are clip angles, joist end clips, and stud clip connections consisting of a short piece of stud. In addition to the direct shear load from the connected member, eccentrically loaded connections must resist secondary shear forces which arise from torque developed within the connection itself as illustrated in Fig. 1. Although these connections are often specified, determining their capacity can be time consuming.

There are two methods of analyzing eccentric connections. The "ultimate strength" method is most accurate. Unfortunately, this is an iterative method and requires that the load-displacement charateristics of a fastener be known. This information is not readily available for light steel framing connectors. The "elastic" or "vector" method assumes that shear in each fastener is proportional to the distance from the center of gravity of the connector group. The elastic method yields a direct solution, and is slightly conservative as compared to the ultimate strength method.

Analyzing an eccentric connection involves the following steps:

1. Determine the direct shears per fastener.

2. Compute the torque acting on the connector group and determine the torsional shears in the individual connectors required to resist the torque.

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Fig. 1

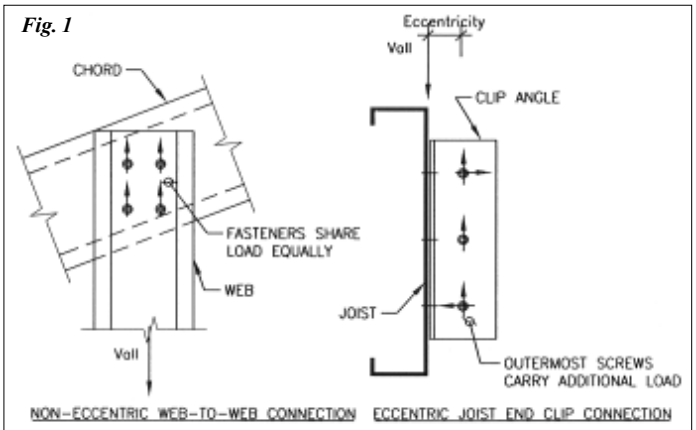
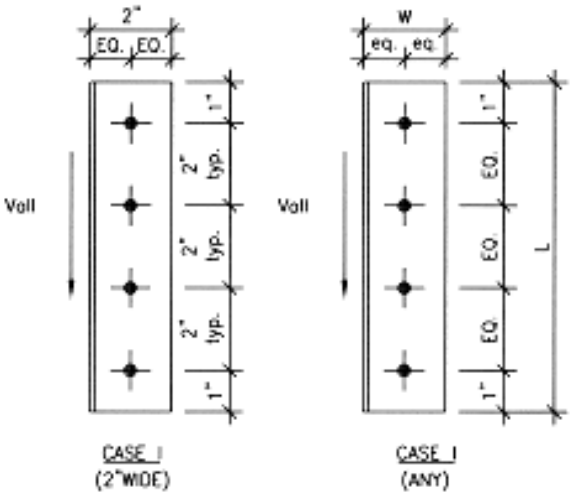


Fig. 2

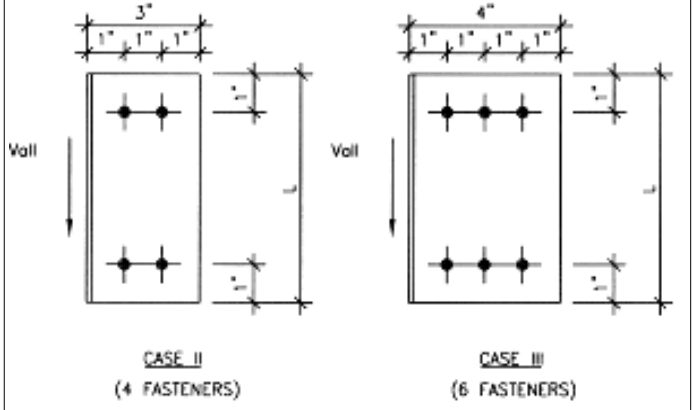


CASE I – CLIP ANGLE WITH SINGLE COLUMN OF FASTENERS

No. of Fasteners	Coefficient C	
	Case I (2" Wide)	Case I – (Any)
3	2.40 (6" Long)	$1/\sqrt{(9W^2/16L^2)+1/9}$
4	3.42 (8" Long)	$1/\sqrt{(9W^2/25L^2)+1/16}$
5	4.47 (10" Long)	$1/\sqrt{(W^2/4L^2)+1/25}$

Vall = C x Ras, where Vall = Goup capacity
C = Connection Coefficient, Ras = Allow. load per fastener

Fig. 3



CASE II and III – CLIP ANGLES WITH TWO ROWS OF FASTENERS

Clip Length L	Coefficient C	
	Case II (3" Wide)	Case III (4" Wide)
3"	0.80	2.11
4"	2.00	2.39
5"	2.52	3.04
6"	2.92	3.60
7"	3.05	4.06
8"	3.37	4.30

Vall = C x Ras, where Vall = Goup capacity
C = Connection Coefficient, Ras = Allow. load per fastener

Fastener Groups

Cont'd from page 4

3. Identify the most highly loaded "critical" fastener and algebraically combine the direct and torsional shears to determine the largest fastener shear in the connector group.

These computations can be time consuming if done by hand, but there is an easier way to check these connections. For a given loading direction and fastener pattern, the critical fastener will always carry the same fraction of the total applied load. For these types of connections, such as a joist end clip, a connection coefficient C can be defined which is the inverse of the fraction of the total load taken by the critical fastener. This coefficient C can be thought of as the number of effective fasteners in an eccentrically loaded connection. Values of C are given in figures 2 and 3 *(page 4)*. Note that this method can be used with any type of connector including screws, bolts, powder driven fasteners, and pneumatic pins.

Example:

Given: 2"x 2"x 68 mil joist end clip, 8" long.
Fastener - (4) #10 screws into 43 mil header.
Allowable fastener shear

Find: Capacity of eccentrically loaded fastener group, Vall.

Solution: Vall = C x Ras
C = 3.42 (figure 2)
Ras = 263# (AISI Specification: allowable fastener shear for #10 in 43 mil)

Vall = 3.42 x 263 = 899 # ■

Screw Connection Tests

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A connection with one screw had a higher strength than the strength per screw for a multiple screw connection with the same screw and steel sheet size. To quantify this effect, a "Group Effect" was created that normalized connection strength with respect to single screw strength. This "Group Effect" is the strength per screw, in a multiple screw connection, divided by the connection strength for a tested single screw connection. If all screws in a connection acted and contributed equally, the "Group Effect" would be 1.0.

Figure 2 **Effect of Number of Screws on Connection Strength**

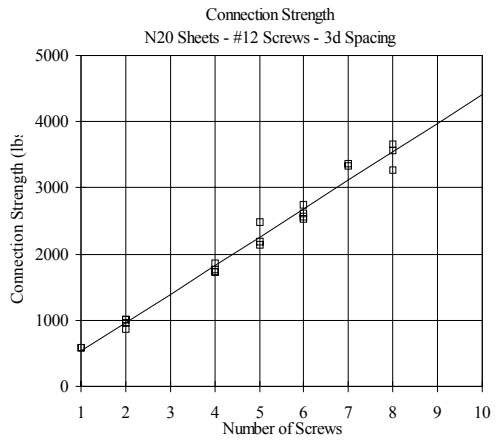
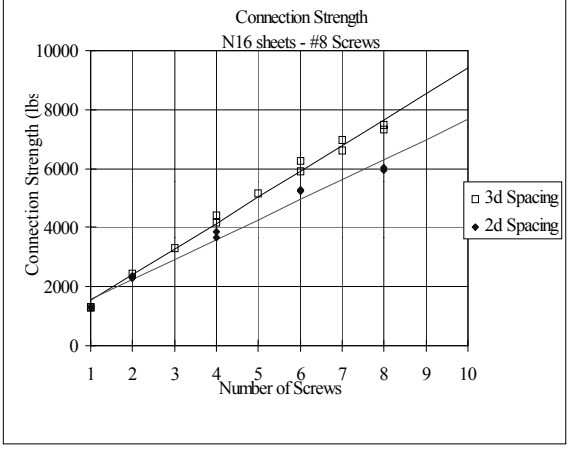


Figure 3 **Effect of Screw Spacing on Connection Strength**



EFFECT OF PATTERN

A total of 27 different geometric screw patterns were tested. Figure 1 shows the patterns for four screw connections. As indicated by the "Group Effect" in Table 1, varying the screw pattern did not significantly vary the strength of the connection.

EFFECT OF NUMBER OF SCREWS

For all tests performed, the strength per screw in a connection diminished as the number of screws increased. Figure 2 shows a typical relationship between the connection strength and the number of screws.

EFFECT OF SCREW SPACING

A sample of the test results are given by Figure 3, where the effect of 2d spacing is compared to 3d spacing.

DESIGN EQUATION

A design equation was sought that would allow calculation of a connection strength based on a single-screw strength equation. The general form of the equation is shown in Equation (4-1).

$$P = nP_1R \qquad (4\text{-}1)$$

where:
n = number of screws in a connection
P_1 = strength for a single screw connection
R = reduction factor that accounts for the "Group Effect"

The equation for P_1 is given by equation (4-2).

$$P_1 = F_u td\left(2.013\frac{t}{d} + 1.56\right) \qquad (4\text{-}2)$$

where:

F_u = ultimate tensile strength of steel sheets being joined
t = thickness of sheets being joined
d = nominal screw diameter

The R factor was derived based on all of the "Group Effect" data for test specimens having a center-to-center spacing of 3d or greater.

DESIGN MODEL LIMITATIONS

The design models are limited by the following parameters:

1) 0.030 inch ≤ t ≤ 0.053inch
2) 0.165 inch ≤ d ≤ 0.215 inch
3) s ≥ 3d
4) 47 ksi ≤ F_u ≤ 70 ksi
5) $1.19 \le \frac{F_u}{F_y} \le 1.62$ ■

❑

NASFA

from page 2

interpret the information. Beginning earlier this year, NASFA and the LGSEA developed a seminar program expressly intended to reach this important audience and provide them with basic understanding of light gauge steel design and construction methods.

Since the LGSEA first began presenting these seminars last May, it has been presented to nearly 1,000 building inspectors and plan checkers from more than 40 jurisdictions in more than a dozen states. The 2000 schedule is equally aggressive, with plans to increase by one-third the total number of building inspectors exposed to this information.

Follow up contact is made with the jurisdictions where the seminar has been presented encouraging the recognition of prescriptive standards and the International Residential Code, when it is available for adoption (see NewsBriefs section).

LGSEA members play a key role in implementing this seminar program by serving as seminar presenters and helping identify jurisdictions where this information would be most useful.

NAHB: A Powerful Ally

NASFA also has enjoyed tremendous support from a powerful ally, the NAHB, who has opened many doors for us this year. With more than 200,000 members, of which over 70,000 are builder members, NAHB support of NASFA's efforts has been monumental in propelling us forward.

During NAHB's Fall Board Meetings held in Nashville last September, a resolution was passed that directly supports the use of alternative building materials including steel, and intends to ask the U.S. Congress to appropriate specific funds for further research and development of these construction products and how they are used.

1998 Market Trends

As reported by the NAHB Research Center's *Builder Practices Survey*, total shipments of light gauge steel used in residential construction (for all site built housing) grew in 1998 by 43.68% over 1997. The size of the overall homebuilding market grew by 12.66% due to increases in the number of units built in both the single- and multi-family segments, and to increased average square footage in the single-family segment. The biggest gains in market share were in wall studs and floor joists - wall studs (primarily non-loadbearing) gained 61.15 percent.

To break this into the two market segments of site built construction, single- and multi-family housing, we found total shipments of light gauge steel framing grew by more than 52% for single-family, and 13.22% for multi-family, over 1997 respectively.

Gains by framing application (walls, floors, roofs) appeared in walls studs and floor joists. Combined steel interior and exterior wall studs accounted for 61.13% of total 1998 single-family steel framing shipments, showing a significant 84% growth over 1997. For multi-family, combined steel wall applications accounted for 75.75% of total 1998 steel framing shipments, but realized no significant growth in shipments over 1997. Steel floor joists realized a 25.27% gain over 1997 shipments for single-family homes, and a more modest 9.86% gain for multi-family homes.

SteelXpert© Software

NASFA has undertaken a large-scale project that will develop a sophisticated software program to do steel framing takeoffs and estimates.

Based on the *Prescriptive Method*, and containing the newly revised standard details and standard stud designators (the Right STUF), SteelXpert© automates member selection, estimates, bills of materials, and other tasks associated with steel frame construction. SteelXpert© also helps the user determine quantities of all other materials involved in framing the house, including wood, fasteners, bracing, etc. And it calculates time and cost estimates for framing labor.

Software of this nature is a major step toward enabling the practical use of steel framing. It helps to eliminate confusion and reduce burdens associated with steel framing for builders and framers who are unfamiliar with it. This also begins to put the use of steel framing on a more even footing with wood framing, for

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Mid-Rise Project *from page 1*

cess, *Anderson-Peyton Engineers* specifically designed this structure three times: 1) as a concrete floor, column, and bearing wall system, 2) as a structural steel frame system, and 3) as a cold formed steel bearing wall system. Each design was put out to bid and the cold-formed building proved to be the more cost effective solution. According to Mike Degelder of *Degelder Construction* Inc., the structural system including steel studs, metal deck, and concrete topping was completed for approximately $12.00 /SF.

Structural description:

The roof and floors were constructed with 5-1/2" normal weight concrete working in composite action with a cold formed metal deck providing unshored spans of 12'-6" from unit party wall to unity party wall. *(Note that hotel projects typically require unit room sizes which economize this floor system.)* At some isolated locations increase spans were required, and achieved, by adding reinforcement to the concrete slab. The concentration of bearing wall loads are minimized (for hotel projects) by a uniform distribution to an increased number of wall locations. Loads are spread out and distributed to the foundation like a snow shoe on snow. The party walls at the first floor carry approximately 12,000 PLF. These are significant loads for a light framed system regardless of efforts to keep loads as uniformly distributed as possible. Given the first floor height was 14'-0", 68 mil (14 gauge) studs were used at conventional light framed spacing to carry the load. The metal deck was directly applied to the top of the bearing walls and fastened with screws. The studs were coordinated to align with the metal deck flutes and directly transfer gravity loads to the studs below. As framing progressed up the building the thickness of the studs progressively decreased to 54 mil (16 gauge) and to 33 mil (18 gauge). A significant structural concern was the stability of the bearing studs against lateral torsion buckling. Given that (8) stories of open framed bearing studs were carrying building dead weights prior to placement of sheathing it was critically important to address stud bracing. An appropriate number of rows of channel bracing were placed within the centerline stud punchouts, and accumulative load anchorage was provided.

The lateral loads are carried through a minimized amount of full height concrete shearwalls at each end of the structure. These walls provide a relatively stiff full height, stacking, concrete shearwall system. It is interesting to note that cold-formed steel studs will lighten the overall dead weight of the building given their large strength to weight ratio. The lighter building weight will reduce seismic loads and design requirements. This project was designed within seismic zone 3 and seismic loads govern the longitudinal direction, however, wind loads govern the transverse direction.

The construction schedule for the structural framing was found to be very favorable at a rate of one floor per week. The Contractor found it economical to shop fabricate the panels in Vancouver, British Columbia and trucked them to the site. There is very little if any welding involved with the construction of this project. All track to stud, metal deck to wall track, wall bracing, and beam connections were made with self drilling light gauge screws. Building shrinkage or settlement was also a concern. Shop fabrication allowed the wall studs to be seated hydraulically into their top and bottom wall tracks providing a tight fit and therefore minimizing tolerance gaps. Additionally, wall tracks were specifically sized during fabrication for tight fit seating (bearing) of studs webs to track webs.

With the success of this project, and the trend toward more mid-rise projects, cold-formed steel is now proven to be an effective competitor for this growing segment of the construction industry. ■

NASFA *from page 6*

which dozens of products of this nature exist. SteelXpert© will enable virtually any framing contractor, builder, or supplier to identify, specify, quantify and order steel framing, all in accordance with the *Prescriptive Method*.

In summary, NASFA has been extremely busy not only with the normal business of setting up a new trade association (by-laws, articles of incorporation, membership structure and recruitment, staffing, accounting and controls, office relocation and set-up, etc.) but also starting the many fundamental market-enabling projects necessary to raise the awareness of steel framing and accelerate its use in the homebuilding industry. ■

Light Gauge Steel Engineers Association

LGSEA

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