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editor's message

by Scott Ward
& SBC Staff

Innovative Framing: A Concept for Today & Tomorrow

"Innovative Framing" is a more fitting term than "advanced framing" for what our industry does each day.

When you hear someone throw out the phrase "advanced framing," what comes to mind? Do you think of 2x4 or 2x6 walls with 24 inch on-center spacing? Do you assume it also means more energy-efficient walls? That's what comes to mind to me, and frankly, many others in the framing business.

Advanced framing, also called optimum value engineering in the past, is a framing system that aims to reduce the amount of lumber used to frame buildings to the bare minimum through a more efficient load path. Coined in the 1960s by the Department of Housing and Urban Development, advanced framing was promoted as a way for builders to reduce costs.[1] Today, the phrase has also been co-opted into the push for more green/energy efficient buildings.

The problem is roof trusses don't seem to enter into the conversation when you talk about advanced framing, as in the 1960's roof trusses were already a big part of the advanced framing movement. There's also no mention of modern-day wall panels, no mention of raised heel roof trusses, no mention of floor trusses and no mention of the versatility of connections between the floor, wall and roof systems. Those are significant limitations of the term "advanced framing," particularly for our industry.

From now on we are going to use a new term of our own: "innovative framing." That is what our industry is providing to the marketplace: structural innovations to help architectural designs go from artistic lines on a page to a physical home, office or commercial building.

That's why, as of this issue of ***SBC,*** we want to change the assumptions surrounding advanced framing, and maybe even alter the way we talk about framing in the marketplace. From now on we are going to use a new term of our own: "innovative framing." Because in reality, that is what our industry is providing to the marketplace: structural innovations to help architectural designs go from artistic lines on a page to a physical home, office or commercial building.

Take a close look at what we do today. We provide value engineering in virtually every product we sell today. As we look to the future, our products, and all the tools and materials that make our products possible, are the best way to meet the demand for efficiencies in structural performance, material use, labor and cost.

Innovative framing is encouraged by the building code, which mandates, "a complete load path that meets all requirements for the transfer of all loads from their point of origin through the load-resisting elements to the foundation."[2] In order to provide this load path, the building code assumes conventional framing, but also

at a glance

- ❑ The problem with advanced framing is there's no mention of modern-day wall panels, raised heel roof trusses, floor trusses or the versatility of connections between the floor, wall and roof systems.
- ❑ Our products, and all the tools and materials that make our products possible, are the best way to meet the demand for efficiencies in structural performance, material use, labor and cost.
- ❑ As we look to the future, we know we can talk knowledgably about innovative framing because we have a sure-fire way to back up our approach: the SBC Research Institute (SBCRI).

[1] http://www.buildingscience.com/documents/insights/bsi-030-advanced-framing

[2] *IRC* R301.1 Application. Buildings and structures, and all parts thereof, shall be constructed to safely support all loads, including dead loads, live loads, roof loads, flood loads, snow loads, wind loads and seismic loads as prescribed by this code. The construction of buildings and structures in accordance with the provisions of this code shall result in a system that provides a complete load path that meets all requirements for the transfer of all loads from their point of origin through the load-resisting elements to the foundation. Buildings and structures constructed as prescribed by this code are deemed to comply with the requirements of this section. See also *IRC* R301.1.2.

Continued on page 6

Editor's Message

Continued from page 5

states, "when a building of otherwise conventional construction contains structural elements...these elements shall be designed in accordance with accepted engineering practice."[3]

In other words, the building code clearly gives us the flexibility to find a better way to frame a building. We do this as a matter of course by reducing material usage to save cost and/or make production and installation easier. The process we use to design and manufacture a structural component lends itself well to finding an innovative framing solution that meets or exceeds our customers' expectations. In fact, we have to do this on every job; otherwise, our customers look elsewhere.

Further, our industry is set up to facilitate innovative framing by bringing together material suppliers, building designers, builders and framers. We are driving innovation through communication and collaboration, allowing everyone in the chain to reap the benefits of the tools and capabilities we have to design a building where the complete load path required by the code can be constructed in the most efficient and cost-effective way.

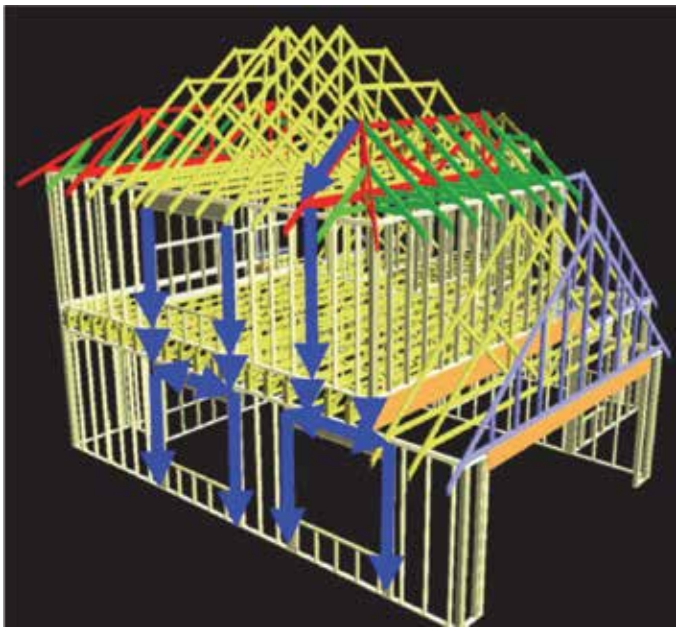
As we look to the future, we know we can talk knowledgably about innovative framing because we have a sure-fire way to back up our approach: the SBC Research Institute (SBCRI). SBCRI was originally built to address questions surrounding load paths because structural framing and load paths exist in three dimensions. When you think about it, it's really difficult to effectively innovate framing if you have to guess or estimate three-dimensional performance.

The fact we can build a two-story house inside SBCRI, apply loads in any way we want, and accurately measure the flow of that load throughout the entire system, gives our industry an incredible advantage. Through the testing we have conducted thus far, SBCA members have more information and knowledge about load path performance than almost anyone involved in building construction.

Because of the investment SBCA members made in constructing SBCRI, we have the ability to tackle the recurring problems that have plagued us in the past (many of which still do), including ply-ply connections, top chord bearing capacities, bracing and web buckling. However, we have recently come to realize we've only scratched the surface of what is possible through the capabilities and know-how we now possess in our industry's state-of-the-art facility. SBCRI's greatest potential is yet to be realized; it will lead our industry into the world of three-dimensional innovation.

SBCRI's system-testing approach allows us to see structural perfor-

[3] *IRC* R301.1.3 Engineered design. When a building of otherwise conventional construction contains structural elements exceeding the limits of Section R301 or otherwise not conforming to this code, these elements shall be designed in accordance with accepted engineering practice. The extent of such design need only demonstrate compliance of nonconventional elements with other applicable provisions and shall be compatible with the performance of the conventional framed system. Engineered design in accordance with the International Building Code is permitted for all buildings and structures, and parts thereof, included in the scope of this code.



mance from a "real building" point of view. So it's not as hard to develop innovative framing concepts when you can frame a load path system in SBCRI, hook up all the monitoring equipment and watch how the loads move through an actual building in real time. One way to think about it is to consider the two pictures above and all they imply for load path innovation and your component designs.

This is why "innovative framing" is a much more apt term for what our industry does each day with the tools we have at our disposal. The exciting part is we have a long way to go to reach our full innovative framing potential. To get an interesting perspective of how a framer thinks about this issue, read George Hull's column on page 8. If you want a further perspective on some possibilities in innovative framing, read this month's TQ&A on page 10.

It may sound funny, but I think "advanced" sounds like a thing of the past. Today, and more importantly, tomorrow, are ruled by innovation. That's why we've always naturally adopted the slogan components are the "future of framing." SBC

framer viewpoint

by George Hull, NFC Chair

A Framer's Perspective on Innovative Framing

By standardizing details and training framers, NFC can help make innovative framing the prevailing approach.

Using material efficiently is the cornerstone of what your industry is now calling innovative framing (read Scott Ward's Editor's Message on p. 5 for a thorough definition of this concept). Buildings are getting increasingly more complex and customers want spans unachievable through traditional span tables. It takes a creative approach to using material to meet our customer's needs, while still providing good quality structures.

The implementation of innovative framing is complex, but by standardizing details and training framers, building officials, components manufacturers and engineers, innovative framing is steadily becoming the new standard in framing. Innovative framing makes better use of raw material by using triangulation, but also takes advantage of structural system effects.

I worked on a job recently, Broadstone Oaklawn Dallas, where the customer wanted to achieve a contemporary look by having cantilever wings coming off a tower. Using stick framing, this structure would have been nearly impossible to construct. As you can see in the picture on the left, by using a girder truss to project the wings, we were able to build the structure our customer desired. However, as a framer I have to point out this innovative approach to framing isn't a good fit for every job.

The general contractor (GC) needs to look at both labor and transportation costs to see if using innovative framing adds value to a project. Typically, using components reduces labor costs, so it's beneficial to use them in areas where labor costs are high. However, the distance between the component manufacturer and the job also plays a factor. If the job is very far from the component manufacturer, then the transportation costs can outweigh the savings. By evaluating an individual project's needs, the GC can determine if using innovative framing is right for a particular job.

I know some component manufacturers wonder why innovating framing isn't universally adopted more easily. From my personal experience, innovative framing was initially challenging to implement. Stick framing has worked well for a long time, and framers (just like everyone else) can be reluctant to change. The traditional and prescribed methods are simple to follow and have been taught and passed down for generations. So moving away from conventional framing toward trusses, wall panels and other framing components is a difficult process at first.

Yet once the new methods are learned, and framers experience the ease of installation and discover how all the parts of the framing fit together well, I've seen them quickly become comfortable with the techniques. When that happens, innovative framing becomes the new standard of framing because it's quicker and safer to frame.

By learning innovative framing techniques, my company has been able to bid on projects we otherwise would not have been able to do. Having a diverse portfolio is

at a glance

- ❑ It takes a creative approach to using material to meet customer's needs, while still providing good quality structures.
- ❑ Once innovative framing methods are learned, and framers experience the ease of installation, and discover how all the parts of the framing fit together well, they quickly become comfortable with the techniques.
- ❑ Framers must be involved in creating industry standard details, because we are the ones most familiar with actual building construction.

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important because it allows framers to be open to more jobs, which was critical to survive the most recent economic recession.

Some framers are hesitant to pursue innovative framing because of challenges they have faced in the field with building officials and general contractors. If these individuals aren't familiar with innovative framing techniques, they may not readily accept them and require the framers to re-frame parts of the structure. By developing industry standard details through the National Framers Council (NFC), we are helping to ensure innovative framing is more widely accepted in the framing industry. Standard details will also provide quality control techniques framers can use to ensure the proper load path is created and the structure can resist loads as designed. This will also lead to greater acceptance of innovative framing techniques.

I would argue framers must be involved in creating these details, because we are the ones most familiar with actual building construction. By working closely with engineers to develop details, and then sharing the standard details with the rest of the industry, the NFC will help establish standards and techniques for innovative framing.

Change is challenging, but through training and collaboration among framers, building officials, component manufacturers and engineers, the construction industry will embrace innovative framing because of the immense value it brings to our customers. By making better use of materials, and by using industry standard details, we will ensure we are making the best use of our natural resources while resisting loads as intended.

The change from traditional framing to innovative framing will not occur overnight, but through the help of the NFC, our focus is to effectively train innovative framing techniques and quality assurance so our overall industry sees innovative framing as the new standard. SBC

George Hull is President of Hull Associates, LLC in Arlington, TX. He brings more than 35 years of framing experience as the first Chairman of the National Framers Council. For more information about NFC, visit framerscouncil.org.

FRAMESAFE

The NFC recently completed its FrameSAFE Orientation Checklist to assist members in providing a comprehensive safety overview for new employees on a jobsite. NFC members will receive free access to a printable pdf of this checklist as part of their membership.

To learn more about FrameSAFE & the Orientation Checklist, visit
framerscouncil.org/certification

by Keith Hershey

Innovative Framing Requires Collaboration

If getting innovative framing into the market was easy, everyone would be doing it.

Innovative framing is about being more efficient in resisting loads and the path they follow through the framing structure, while allowing greater flexibility within that framework to accomplish secondary goals (read Scott Ward's Editor's Message on p. 5 for a thorough definition of this concept). In other words, innovative framing can seek to accomplish almost anything: more load carrying capacity, less framing material, greater energy efficiency through reducing thermal bridging, using less connectors and/or reducing framing labor costs.

Even with all these benefits, innovative framing faces resistance. Prescriptive codes don't directly promote innovative framing. And in many cases, creative engineering ideas are overlooked due to the difficulty of getting the idea into the market. Our customers don't understand how it works, building inspectors aren't accepting of methods outside of the "normal code provisions" they see every day, the component manufacturer's (CM) equipment is not set up to assemble the product, and the market is unwilling to embrace change and abandon traditional framing methods.

Let's face it, if getting innovative framing into the market was easy, everyone would be doing it. As manufacturers, we are the last cog in the wheel of framing implementation. This leaves us having to convince the framer (read George Hull's column on p. 8 for a framer's perspective on innovative framing), who has to convince the general contractor or developer, who in turn has to convince the architect or engineer, who needs to be convinced and be willing to present the innovative framing concepts to the building department for approval.

Many times when you try to bypass these steps, you get hung up with a building inspector who is inspecting based on prescriptive codes because the modified plans never made it through the system. This is not the best way to build a strong working relationship with a building department, which then affects the framer, general contractor and design professional, all of whom then blame your innovative framing solutions for the problems they are having on the project.

Question

Is it possible the reason for this problem is that the whole process is backwards?

Answer

Typically, we try to change a project after the architect or engineer has designed the building, so we are too late to make substantive changes. In most cases, the building designers haven't thought about the project for months. They've already jumped through the hoops of permitting and plan review process, and the project is now at the building material supply stage of the process. Just like us, when the homeowner decides he wants to switch the flat living room ceiling to a vault after all the trusses have been sent, everyone on the project wants to know who will pay for the labor and materials to make this change.

When we look at truss and wall panel production operations, we continually look for ways to streamline our operations. These same concepts need to be brought to bear with our engineering processes when we are looking to implement innovative framing techniques. As truss designers, we are working with highly sophisticated

at a glance

- Even with its many benefits, innovative framing faces resistance. Prescriptive codes don't directly promote innovative framing, and markets are slow to adopt for many reasons.
- The earlier in the process CMs can get in front of building designers, the greater their ability to influence the use of innovative framing techniques to design buildable structural framing.
- In order to get innovative framing ideas into the market effectively, you need to have your ducks in a row prior to approaching the building designer.

software, which helps us see problems that may or may not have been addressed by the architect or engineer. It's in our best interest, and the interests of everyone involved in the process, to solve those problems, or at least alert everyone. We also have the responsibility to make all of the components we design buildable, both in our shop and in the field.

Given this reality, the earlier in the process we can get in front of the building designer, the greater our ability to influence the use of innovative framing techniques to design buildable structural framing. Bringing architects and engineers and our designers closer together allows the synergies of the two different steps in the building design processes to incorporate innovative solutions.

Developing details that can be incorporated in the building plans, or preapproved by the architect or engineer, allows for flexibility in the component designs. This concept is even independent of innovative framing concepts, and applies to things like stacking trusses over the 24" o.c. wall studs or removing window and door headers as was done in the project covered in the "Going Beyond Green" article (see ***SBC Magazine***, May 2012, at sbcmag.info/archives).

When we unilaterally change from standard construction details, many times we change the load path or design capacities anticipated by the building designer, which can cause unintended downstream building design issues. If new ideas and resulting details are reviewed with the building designers during the building planning and design phases, they can become part of the plans and specs, and then be more easily reviewed and approved prior to breaking ground on the project.

My point is, in order to get innovative framing ideas into the market effectively, you need to have your ducks in a row prior to approaching the building designer. A phrase I hear all the time is, "don't give me problems, give me solutions." If you want to increase the stud spacing in a job, look at all of the issues: how am I going to support the trusses, what happens to the shear wall design, do my ledger attachments still work, do I need to change the grade of the stud to handle the axial load and how does it affect the connections from wall to wall? If you leave these issues to the building designer to handle, your chance of success and making that sale decreases significantly.

Innovative framing should be adopted in the market because it can efficiently address load path issues while also enabling building designers to accomplish the additional secondary goals I started out discussing. However, to get there we as an industry need to be committed to making the adoption process as easy as possible, one job and one conversation at a time. SBC

To pose a question for this column, email technicalqa@sbcmag.info.

Seismic Design Coefficients

How they are determined for light-frame components

Part 2

by Daniel Lawless, MSCE, Structures & Kirk Grundahl, P.E.

In Part I of this article (see April 2014 at sbcmag.info/archives) the proprietary and non-consensus-standard-based means of assigning seismic design parameters to alternative sheathing products given in ICC-ES AC130, *Acceptance Criteria for Prefabricated Wood Shear Panels,** was reviewed. We made the following observations regarding AC130:

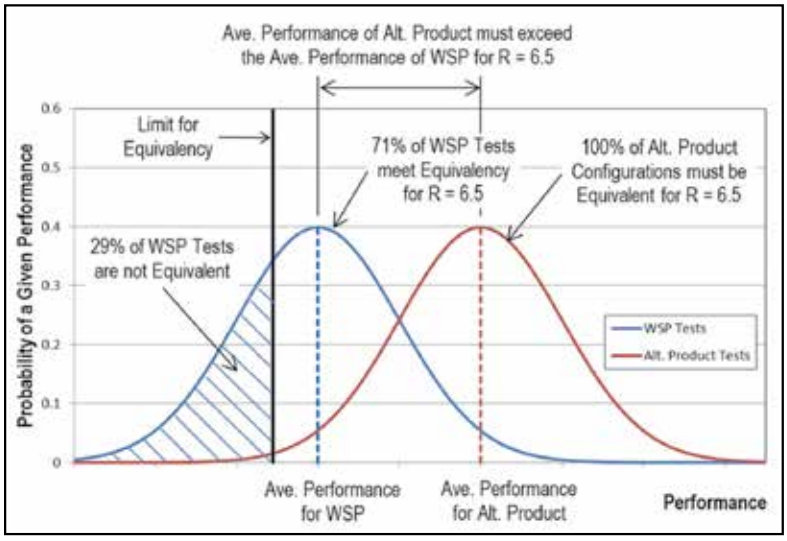

Figure 1. Illustration of AC130 Equivalency Methodology

- Alternative products are not allowed to have the same range of performance as wood structural panel (WSP) shear walls.
- The WSP shear walls that fail to meet the equivalency parameters can use an R factor of 6.5, while alternative systems that fail to meet the equivalency parameters are required to use an R factor of 2.0.
- Checks on the overstrength and the ductility of the wall assembly are performed independently of each other. Since the R factor results from a combination of the overstrength and the ductility of a system[1], checking these two factors separately neglects their interaction and can result in systems with less ductility and more overstrength being inappropriately penalized.
- The drift limit of 2.8% of the wall height can result in systems with good ductility and high initial stiffness being penalized.

The consequence of the inherent problems in AC130 is that newly-developed alternative products may fail to meet the AC130 equivalency parameters and be considered not equivalent even when they have equivalent to or better performance than WSP shear walls.

As illustrated in Figure 1, the average performance of each configuration for an alternative product must be greater than the AC130 limits. In contrast, only a portion of the WSP shear wall configurations are actually greater than the AC130 limits.

* ICC-ES Acceptance Criteria are proprietary documents. ICC-ES policy states that "5.1 Acceptance criteria are established by the committee to provide a basis for issuing ICC-ES evaluation reports on products and systems under codes referenced in Section 2.0 of the Rules of Procedure for Evaluation Reports. They also clarify conditions of acceptance for products and systems specifically regulated by the codes. Acceptance criteria may involve a product, material, method of construction, or service. Consideration of any acceptance criteria must be in conjunction with a current and valid application for an ICC-ES evaluation report, an existing ICC-ES evaluation report, or as otherwise determined by the Evaluation Committee only. All approved criteria are available for sale at www.icc-es.org/Criteria/index.cfm. Also ICC-ES AC322 Appendix A Acceptance Criteria for Prefabricated, Cold-Formed, Steel Lateral- Force-Resisting-Vertical Assemblies. www.icc-es.org/Criteria_Development/1212-alt/AC322.pdf

In short, alternative products are not allowed to have the same range of performance as WSP shear walls. If WSP shear walls that fail to meet the equivalency parameters can use an R factor of 6.5, while alternative systems that fail to meet the equivalency parameters are required to use an R factor of 2, the ability of alternative products to compete in the marketplace is inappropriately constrained. Currently, all roads to a competitive market are perceived to require equivalency to WSPs and the use of a proprietary and non-consensus-standard-based method called an "AC" (i.e., AC130, AC322, AC440, etc.) created by ICC-ES, a private, non-profit business. As a consequence, the reality is they control all seismic design innovation.

This is great for the "in" products, like WSP, because it gives them a clear competitive advantage. A better methodology for determining seismic design coefficients (SDCs, or also known as Seismic Design Parameters) that can provide more accurate comparisons between different systems is necessary.

SBCA has used its extensive amount of ASTM E2126 test data to develop an energy-based methodology that can provide more meaningful comparisons for testing and defining SDC equivalency. The goal of this work was to provide a rational method for determining the R factor based upon empirical test data. The basis for this methodology is Section 12.2.1 of ASCE 7, which states:

> Seismic force–resisting systems that are not contained in Table 12.2-1 are permitted if analytical and test data are submitted that establish the dynamic characteristics and demonstrate the lateral force resistance and energy dissipation capacity to be equivalent to the structural systems listed in Table 12.2-1 for equivalent response modification coefficient, R, system overstrength coefficient, Ω_0, and deflection amplification factor, C_d, values.

SBCA has applied the "Equal Energy Method" found in literature to light frame wood shear wall tests conducted in accordance with ASTM E2126 to compare the energy dissipation capacity of different assemblies[2,3].

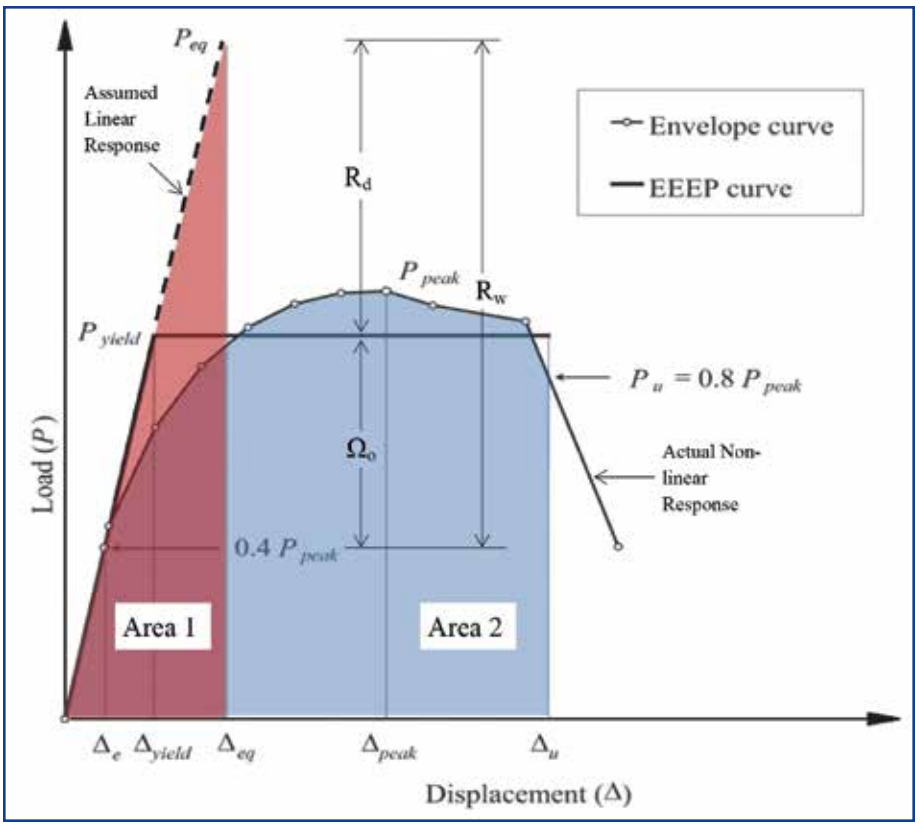

Figure 2. Inelastic Force Deformation Curve Showing Seismic Performance Factors

The Equal Energy Method

The equivalent lateral force procedure for seismic design contained in ASCE 7 assumes an idealized linear-elastic behavior of the structure. This is done because the idealization simplifies the engineering equations used for seismic design. However, structural elements or buildings seldom remain linear-elastic until failure. Most real structures have a non-linear, inelastic response to seismic loads. See Figure 2 for an assumed linear response compared to the actual non-linear response of a real building. The terms and symbols used in Figure 2 follow the definitions given in ASTM E2126.

As seen in Figure 2, a linear response would result in much greater seismic loads on the structure. The purpose of the R factor is to reduce the seismic loads to a level that is consistent with the non-linear response of an actual building. This reduction is possible due to the energy dissipated by a building's non-linear, inelastic behavior and the building's structural overstrength. Hence, the R factor can be divided into two components: a ductility reduction factor, R_d, and a structural overstrength factor, Ω_0.

Definition of the EEEP Curve

The equivalent energy elastic-plastic (EEEP) curve (see Figure 2) is defined by Section 3.2.5 of ASTM E2126 as an ideal elastic-plastic curve circumscribing an area equal to the area enclosed by the envelope curve between the origin, the ultimate displacement, and the displacement axis. In ASTM E2126, the yield point of the load-deflection curve (Δ_{yield}, P_{yield}) is permitted to be determined using the EEEP curve for specimens with nonlinear ductile elastic response. The elastic portion of the EEEP curve contains the origin and has a slope equal to the elastic shear stiffness, K_e. The elastic shear stiffness is calculated as:

$$K_e = \frac{0.4P_{peak}}{\Delta_e}$$

where Δ_e = displacement of the top edge of the specimen at $0.4P_{peak}$ in inches and P_{peak} = maximum absolute load resisted by the specimen in the given envelope in pounds. The plastic portion is a horizontal line equal to P_{yield} determined by the following equation:

$$P_{yield} = \left(\Delta_u - \sqrt{\Delta_u^2 - \frac{2A}{K_e}}\right) K_e$$

If $\Delta_u < \frac{2A}{K_e}$, it is permitted to assume $P_{yield} = 0.85P_{peak}$

where:

P_{yield} = yield load, lbf

A = the area under envelope curve from zero to ultimate displacement (Δ_u) of the specimen, lbf•in

Δ_u = the displacement at the point on the envelope curve corresponding to the last data point with the absolute load equal or greater than $|0.8\ P_{peak}|$, in

Continued on page 14

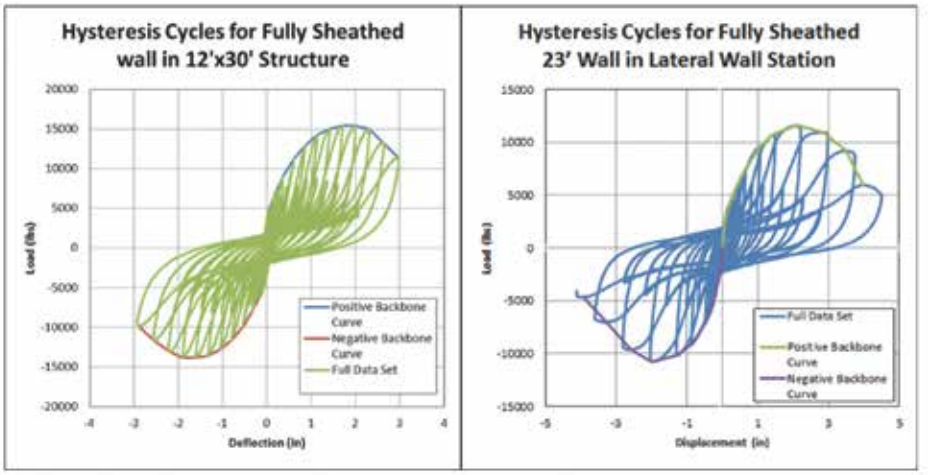

Figure 3. ASTM E2126 Cyclic Test Data of a Shear Wall as Part of a Real Building

Seismic Design Coefficients

Continued from page 13

The ductility reduction factor, R_d, accounts for the reduction in seismic forces due to the energy dissipation resulting from inelastic behavior. The area under the load-displacement curve can be used to measure the energy dissipated by the structure as it is forced to move (deflect) by the ASTM E2126 test cyclic loading protocol.

In an ASTM E2126 test, this produces hysteresis loops as shown in Figure 3.

A backbone (or envelope) curve, as shown in Figure 4, is obtained from the hysteresis cycles by connecting the point of maximum load from each loop.

Using the area under the load-displacement curve as a measure of the energy dissipated by the structure is a key concept of the "Equal Energy Method" for determining seismic design coefficient equivalency in accordance with ASCE 7, Chapter 12.

The assumption made by the "Equal Energy Method" is the energy dissipated by the linear load-deformation curve assumed in ASCE 7 (shown by the red shading in Figure 2 on page 13) is equal to the energy dissipated by the actual non-linear load deformation curve of the structure (shown by the blue shading in Figure 2 on page 13).

By equating the area under each curve, the formula for calculating the ductility reduction factor can be derived as $R_d = \sqrt{2\mu - 1}$, where μ = the ductility ratio as defined in Section 3.2.1 of ASTM E2126, which states:

> Ductility ratio, cyclic (D), n—the ratio of the ultimate displacement (Δ_u) and the yield displacement (Δ_{yield}) of a specimen observed in cyclic test.

Since the structure deforms inelastically under seismic forces, it must by definition, reach its yield strength. Thus, the yield strength of the structure is used in seismic design as shown in Figure 2. This replaces the allowable stress design concepts that are more common for wood design (i.e., ultimate strength divided by a factor of safety). As seen in Figure 2, the ratio of the yield strength, P_{yield}, to the design strength, $0.4P_{peak}$, of the structure is defined as the structural overstrength factor, Ω_0.

The structural overstrength factor, Ω_0, in Figure 2 is equal to 2.5 (P_{peak} / $0.4P_{peak}$ = 2.5). For light frame structures, the structural overstrength factor is typically in the range of 2.5 to 3.5.[1]

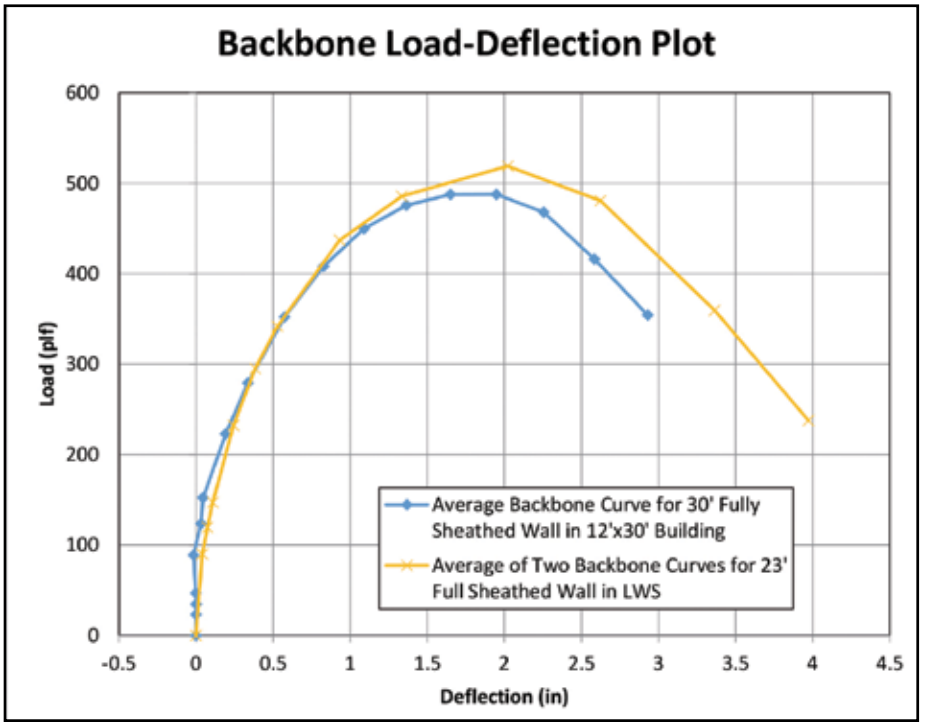

Figure 4: E.g. of "Actual Non-linear Response" shown in Fig. 2 (Obtained from ASTM E2126 Cyclic Test of a Real Building)

Derivation of the Ductility Reduction Factor, R_d

Define ductility, μ, as:

$$\mu \equiv \frac{\Delta_u}{\Delta_{yield}}$$

Using similar triangles and the relationships shown in Figure 2 on page 13:

$$\frac{P_{eq}}{\Delta_{eq}} = \frac{P_{yield}}{\Delta_{yield}}$$

Rearranging the above equation:

$$R_d \equiv \frac{P_{eq}}{P_{yield}} = \frac{\Delta_{eq}}{\Delta_{yield}}$$

Equating the areas under the linear and non-linear load-deflection curves:

$$Area\ 1 = Area\ 2$$

$$\frac{1}{2}P_{eq}\Delta_{eq} = P_{yield}\left(\Delta_u - \Delta_{yield}\right) + \frac{1}{2}P_{yield}\Delta_{yield}$$

$$\frac{1}{2}P_{eq}\Delta_{eq} = P_{yield}\left(\Delta_u - \frac{1}{2}\Delta_{yield}\right)$$

$$\frac{1}{2}P_{eq}\Delta_{eq} = \frac{1}{2}P_{yield}\Delta_{yield}\left(2\frac{\Delta_u}{\Delta_{yield}} - 1\right)$$

$$\frac{P_{eq}\Delta_{eq}}{P_{yield}\Delta_{yield}} = \left(2\frac{\Delta_u}{\Delta_{yield}} - 1\right)$$

$$R_d{}^2 = (2\mu - 1)$$

$$R_d = \sqrt{2\mu - 1}$$

Continued on page 18

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Seismic Design Coefficients

Continued from page 14

As seen in Figure 2, the R factor, R_w, is the product of the ductility reduction factor, R_d, and the structural overstrength factor, Ω_0:

$$R_w = \Omega_0 \cdot R_d = \Omega_0\sqrt{2\mu - 1}$$

The R_w factor, determined using the above equation, reduces the earthquake forces to an allowable stress level. The commentary to ASCE 7 provides the following discussion of the difference between R and R_w:

> Past design practices (the SEAOC and UBC requirements prior to 1997) for earthquake loads produce loads intended for use with allowable stress design methods. Such procedures generally appear very similar to this standard, but a coefficient R_w was used in place of the response modification factor R. R_w was always larger than R, generally by a factor of about 1.4; thus the loads produced were smaller, much as allowable stresses are smaller that nominal strengths.

For use in the load combinations given in ASCE 7, the calculated R_w factor must be multiplied by a factor of 0.7 (1/1.4≈0.7).[4]

$$R = 0.7R_w$$

This reduction produces an R factor that reduces forces to a strength level, instead of an allowable stress level, and allows a direct comparison to the R factors in Table 12.2.1 of ASCE 7.

Comparison to AC130 Database & SBCRI Test Data

Using the available ASTM E2126 data, SBCA has calculated the ductility and equal energy R factor for the 48 WSP shear wall tests contained in the AC130 database[5]. In addition, SBCRI has conducted cyclic tests on 12 shear walls in a 12'x30' building and 34 shear walls in a calibrated single element test station.

The single element test station was designed to produce results similar to the tests in the 12'x30' building. This is important to note, since a shear wall itself cannot actually have a set of SDCs. The seismic design parameters (R, Ω_0, C_d) can only really apply to the overall building structure.

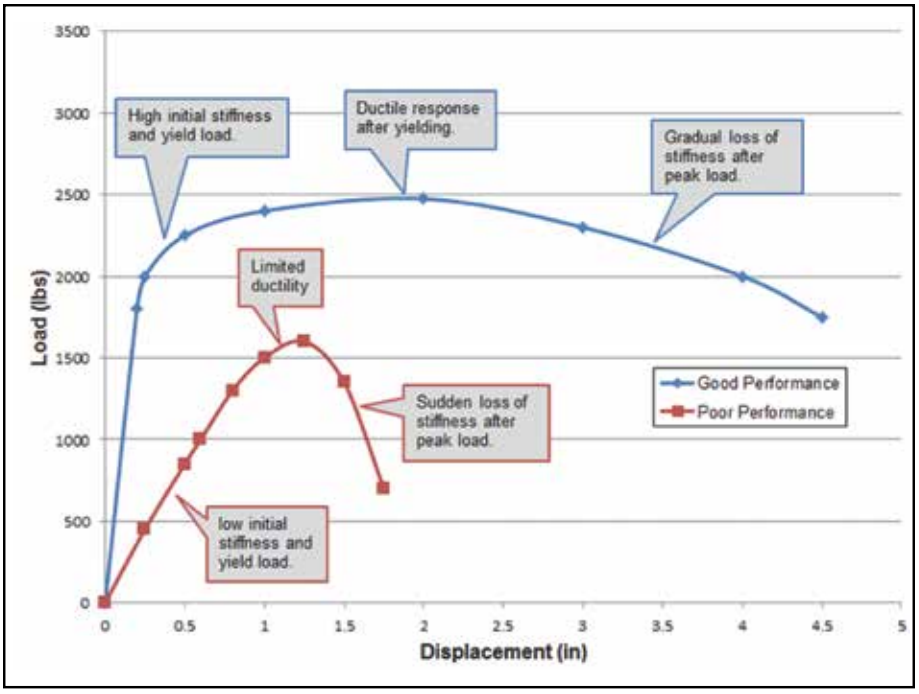

Figure 5: Comparison of the Load-Deflection Plots for Two Seismic Force Resisting Elements

This is because in a real structure, the stiffest portion of the structure is going to take the entire load until it yields and then there will be a progressive sharing of load and progressive yielding. To say that an individual element has a set of SDCs that can be relied upon during a seismic event is challenging since the limit state for earthquake design is based upon system performance, not individual element performance. SDCs then become engineering estimates of performance characteristics to aid in appropriately placing structural elements to resist seismic loads. An ideal element for resisting seismic loads is one that:

1. Has very high initial stiffness and a high yield load (this prevents permanent damage from occurring under small seismic events).
2. Has a very ductile response after yielding occurs (this dissipates a significant amount of energy during a large earthquake).
3. Has a gradual loss of stiffness after the peak load (less likelihood of collapse than if there is a sudden loss of stiffness).

See Figure 5 comparing two elements with different seismic performances.

The SBCRI lateral wall station uses a parallel chord truss to load a shear wall, similar to the way a roof diaphragm would load a shear wall in an actual structure. By comparing the results from identical shear wall configurations (see Figure 6 for an example), it was determined the lateral wall station provides a very similar result to that of the 12'x30' building.

Figure 7 shows the plot of the R factor versus the ductility of the walls. As expected, the R factor increases as the ductility of the shear wall increases. Comparing the trend in Figure 7 to the one in Figure 8, there is no increase in the R factor as the AC130 ductility parameter increases. This is why the equal energy method provides a better approach with respect to evaluating SDCs and comparative equivalency. The quadratic relationship developed between the R factor and the ductility ratio is very consistent with the understanding that highly ductile systems are more earthquake resistant.

The plot in Figure 7 shows the ductility of WSP shear walls can vary significantly. The variability in the shear wall ductility

Figure 6. 12'x30' Building vs. Lateral Wall Station w/ Truss Test Setup for Fully-Sheathed WSP Shear Wall

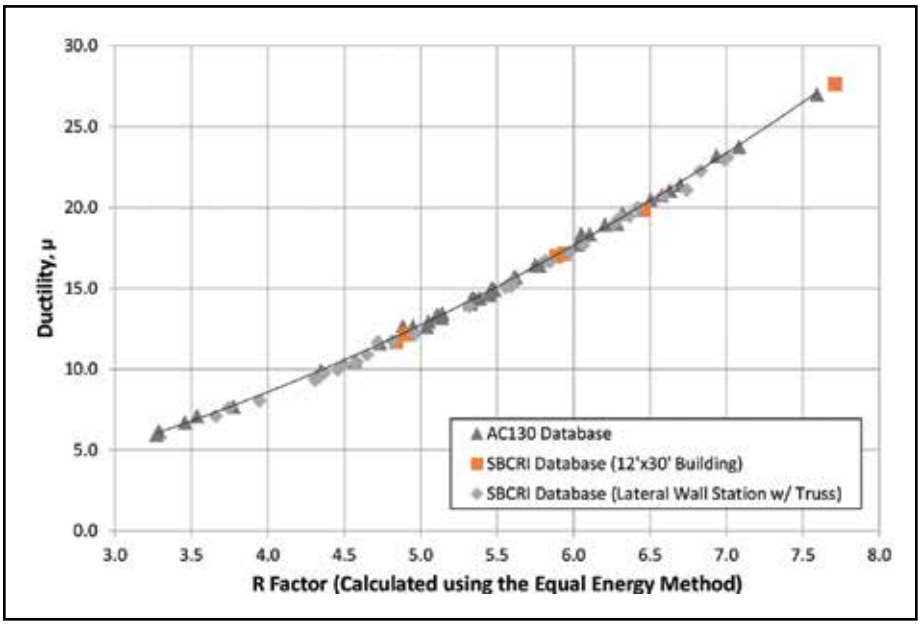

Figure 7: Plot of R factor vs. Ductility for AC130 and SBCRI Database Tests

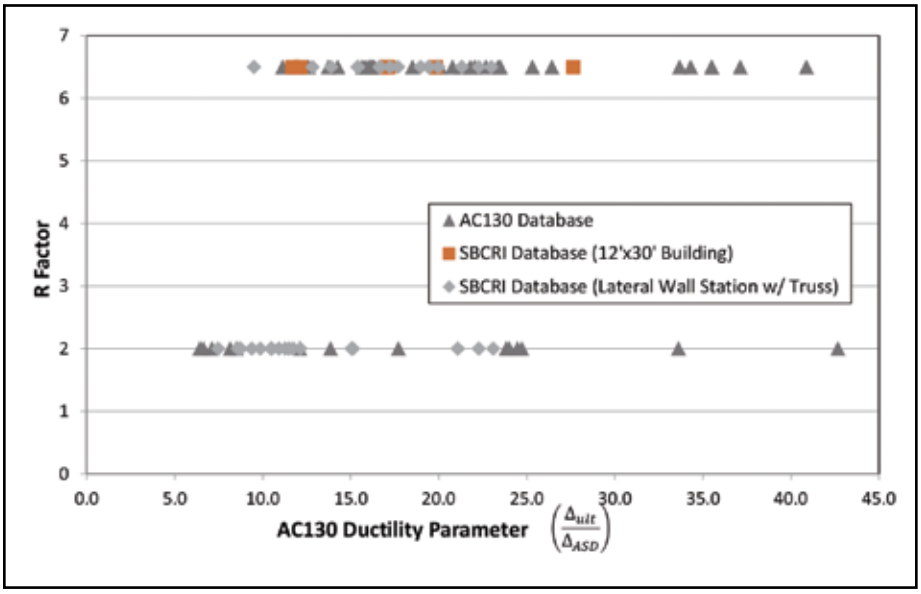

Figure 8: Plot of Benchmark Data used for AC130

results in a wide variety of R factors for walls sheathed with WSPs. The calculated R factor for the AC130 database tests ranges from 3.3 to 7.6, while the calculated R factor for the SBCRI database tests ranges from 3.7 to 7.7. However, all of the AC130 database shear walls have a code-defined R factor of 6.5 per ASCE 7. This doesn't make good engineering common sense.

Final Thoughts

The concept of dividing the R factor into overstrength and ductility components, and using the equal energy method to calculate the ductility reduction factor, is not new. The equal energy method has been published in literature since 1961. In 1998, APA–The Engineered Wood Association published a preliminary report[6] on cyclic shear wall testing that used the equal energy method to calculate the overstrength and ductility components of the R factor as shown in Figure 9 on page 20.

The current building codes do not contain a definitive mathematical methodology to establish the R factor, or any of the SDCs for a building system or the building components that make up that system.

Instead, seismic design literature frequently states SDCs currently adopted by the building code are largely based on observations of past seismic performance and committee judgment.[1,7,8,9,10] In other words, they are engineering judgments with the goal to simplify ASCE 7 Table 12.2-2 at a time when computers were not as readily available to provide more precise solutions.

Today, computational capabilities allow scientific principles, or equal energy mathematics in this case, to easily be used when better answers are desired. This provides a means of assigning SDCs based on the actual tested performance of a system.

The unfortunate aspect of today's situation is more sophisticated solutions are confronted by simplifying assumptions

Continued on page 20

Calculated R factors (R_o-overstrength and R_d-ductility) from wood structural panel shear wall tests[a]

Test No.	F_{yls} (lb)	Δ_{yls} (in.)	F_{sls} (lb)	Δ_{sls} (in.)	$R_o = \frac{F_{sls}}{F_{yls}}$	$R_{d\text{-}L} = \mu = \frac{\Delta_{sls}}{\Delta_{yls}}$	$R_{d\text{-}S} = (2\mu\text{-}1)^{0.5}$
1A	6,950	0.51	10,150	2.00	1.5	3.9	2.6
2B	7,900	0.47	10,900	1.99	1.4	4.2	2.7
3A	8,250	0.47	10,600	1.74	1.3	3.7	2.5
4A	6,200	0.34	8,300	1.16	1.3	3.4	2.4
5A	5,700	0.35	8,750	1.82	1.5	5.2	3.1
6A	7,700	0.51	10,300	2.02	1.3	4.0	2.6
7A	6,150	0.35	8,700	1.16	1.4	3.3	2.4
8A	5,100	0.36	7,700	2.06	1.5	5.7	3.2
BLS.1A	6,050	0.55	11,100	2.33	1.8	4.2	2.7
BLS.1B	7,150	0.76	10,900	2.32	1.5	3.1	2.3
BLS.2A	8,550	0.62	12,400	1.80	1.5	2.9	2.2

[a]Based on average bilinear load-displacement relationship determined from Figures A1-A8 and B1-B3. For description of wall test specimens, see Tables 1 and B1.

Figure 9: Equal Energy Method Calculations from APA Research Report 158[6].

Seismic Design Coefficients

Continued from page 19

like AC130/AC322 Appendix A so they can fit into an ASCE 7 Table 12.2-2 tradition.

Hence, SBCA's goal is to use its knowledge and better data analysis to understand real structural wall panel performance and provide credible comparative equivalency results with known boundary conditions that fully conform to the traditions of ASCE 7 Table 12.2-2.

Using currently available literature, and its extensive amount of industry test data, SBCA has developed an energy based methodology that provides a more rigorous means of testing and defining SDCs.

Introducing a mathematical model like the method described in this article for determining the R factor into the building code should be done, but this will likely take a significant amount of time given the politics involved in the code development process, and all the vested interests that exist in preserving the status quo. Innovation causes competition, and competition reduces profits for traditionalists, groups like ICC-ES, etc. and codified products like WSPs.

The equal energy method provides a more precise means of assigning seismic design coefficients which, in turn, allows for a more rational means of new product development and innovation to take place in an efficient and cost effective manner. SBCA's method has been under development since September of 2011, and we have taken every precaution to ensure the analysis and conclusions are correct.

This work can easily be seen as disruptive to the status quo. That said, SBCA believes it is in the SBC industry's, the engineering community's, and the general public's best interest to publish its innovations in order for the body of engineering knowledge to increase. Transparent communication allows everyone to make their own judgments and to provide comments and feedback that may result in corrections and/or further innovations.

The ultimate goal of this work is to help all industries be best served with transparent, free and unfettered competition as the rule of engineering and trade. **SBC**

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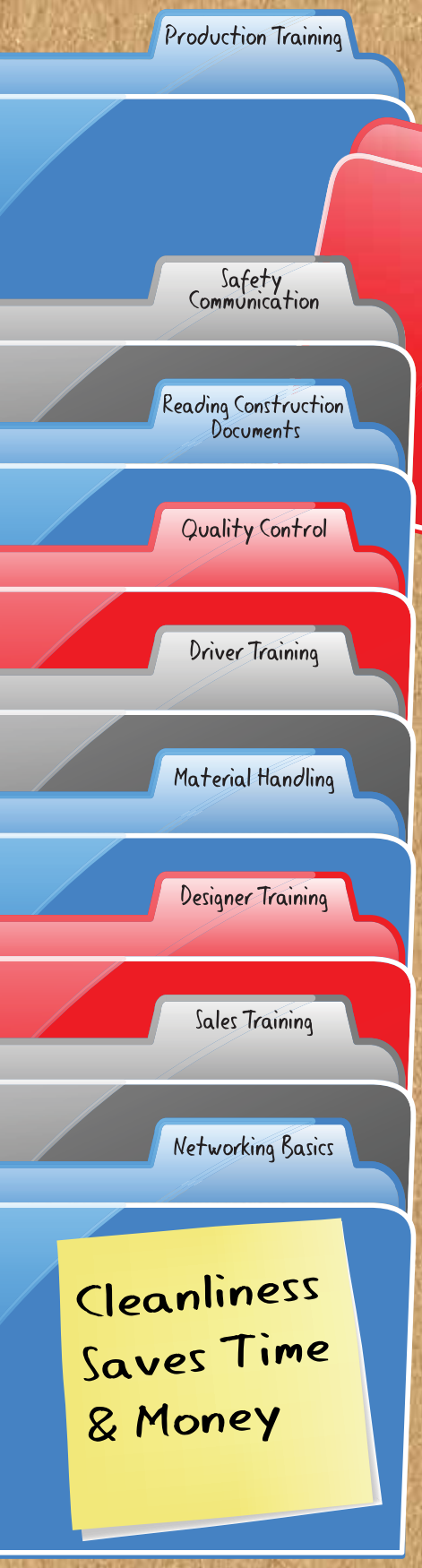
TOP 10 Employee Training Tools

by Sean D. Shields & Ben Hershey



Cleaning. It's not sexy, and when a component manufacturer (CM) is cranking out trusses, it's difficult to switch focus and make sweeping and picking up scraps a priority. However, a few simple housekeeping steps can help bolster a CM's bottom line, and that is sexy. This article will look at some of the most common areas of the production facility where cleaning can have a big impact and explore easy steps to make it part of a CM company's culture.

Housekeeping includes collecting and properly disposing of sawdust; keeping cords off the floor or organized properly, cleaning up during and after each shift; picking up scrap lumber and organizing usable end pieces; and making sure plates that fall on the floor are reused or recycled. Every one of these areas has an effect on production from ensuring employee safety and efficiency to reducing material shrink and liability.

The last article (see May 2014 at sbcmag.info/archives) addressed production training for new employees. Beyond the basic skills training they need in order to successfully continue learning on the job, it's a good idea to include training in proper housekeeping as part of their orientation. Specific areas where housekeeping training can be useful include collecting wood dust around saws; recovering reusable material around the gantry table and production area; keeping banding, finishing and maintenance areas free from debris and tripping hazards; and ensuring delivery vehicles are clean and well-organized.

Sawdust Collection

Thorough housekeeping is important in all areas where sawdust is produced, including component saws, linear saws and other cutoff saws. This is an area where OSHA has paid particular attention over the past few years following a few high-profile combustible dust explosions with several fatalities.[1] If OSHA shows up to conduct a facility inspection, it is almost a given they will inspect for sawdust.

If a CM has a mechanical dust collection system already installed, the operation is ahead of the game. If a CM doesn't have an automated system, it's a good idea to take five minutes every four hours to sweep up accumulated sawdust and properly dispose of it in a covered container located away from areas where open flame or sparks may occur. Even if a CM does have a collection system, it's important to periodically ensure it is working properly and sawdust isn't collecting near intake areas.

Why is proper sawdust management so important? Safety is the primary reason. When sawdust builds up on a concrete floor it can get slippery, and when an employee is around any type of saw the last thing a CM wants is to have a slip and fall occur. Further, dust is combustible and while the chance of ignition or explosion is extremely small, it's a risk easily avoided. Sawdust buildup can also gum up mov-

[1] https://www.osha.gov/dsg/combustibledust

ing parts, causing them to bind, and can cause electrical switches to short, all leading to production-stopping equipment maintenance.

A CM should consider having a supervisor do regular checks of sawdust accumulation in high accumulation areas and train employees on proper collection and disposal. Shop vacuums, brooms and compressed air (if the psi is set low enough) can be effective tools in this process, as long as they are used correctly. Sweeping too forcefully, or using compressed air at too high a psi setting, can have the opposite effect desired because it can send fine sawdust particles into the air, which can collect over time in harder to reach areas than the floor and counters. If employees aren't collecting sawdust properly, that's a perfect opportunity for a supervisor to grab a broom, model the desired approach and give some quick on the job training.

Start with blowing off and/or sweeping high and hard to reach surfaces, get as much material to the ground as possible. Then sweep using short brush strokes, or vacuum up the dust, and collect sawdust in covered containers so that if the container is bumped or jostled it doesn't introduce fine sawdust particles back into the air to recollect in hard to reach areas.

SBCA has created a combustible dust housekeeping program that gives CMs a good sense for what OSHA inspectors are looking for in the event of an inspection. It also includes an employee training module with industry best-practices on proper dust collection. Knowing what OSHA is looking for and mitigating potential infractions will help avoid the thousands of dollars in citations and fines other component manufacturers have been hit with over the past few years. In addition, proper sawdust cleanup can reduce the risk of injury and prevent unnecessary equipment maintenance.

Gantry Tables/Production Area

Housekeeping in the production area is vital to eliminate the possibility of slips and tripping hazards. It can also be effective at minimizing material shrink, which can affect the bottom line. While CMs know they won't use 100 percent of their material inventory, increasing usage from 95 to 96 percent in a plant can represent significant cost savings. The areas under the gantry and assembly tables are common places overlooked during cleaning. These are areas where a lot of material can become a trip hazard, or simply go to waste because, when left there, it isn't used for a valuable purpose.

While challenging, instilling in employees the habit of taking five or ten minutes at the end of each weekly shift can make a big difference. Consider strategically locating collection bins for assemblers to easily dispose of paper, metal plates and wood scrap. It is surprising how much of the plates and wood can be sorted through and reused. Keeping areas around assembly tables clean can also help prevent maintenance issues, particularly with the prevalent use of computerized equipment.

Again, properly cleaning sawdust out of crevices and keeping debris away from moving parts will help to protect the investment made in equipment. Keeping these areas clean can also promote efficiency by removing potential obstacles to smooth material throughput. In turn, improving material flow will have a direct impact on labor costs. The shorter the distance material needs to move, the less employees have to touch it, the lower the production costs.

Banding, Finishing & Maintenance

Tripping hazards can also be a significant source of potential injury in banding areas. Loose scrap banding that isn't recycled or disposed of properly can be one of the leading causes of cuts during the material handling process. While cuts aren't always serious, the labor stoppage time caused by even minor injuries like these can cause bottlenecks in the production process and add to overall costs. Keep a broom, magnet and collection bin in this area to make collecting scrap a snap.

Given the nature of the production and shipping process, it's easy for refuse to quickly collect in finishing areas. One good practice to consider is having a trash bin attached to each forklift. If the forklift operator sees something as they move material, they can pick it up and place in the bin. It's not uncommon for an operator to have to get out of a forklift to adjust something anyway, so there is little reason not to.

Continued on page 24

The best way to have an effective housekeeping program is to invest time in showing employees what is desired and having the management team model it.

Top 10 Training Tools

Continued from page 23

Another benefit is this keeps tripping hazards and potential punctures to tires to a minimum.

Keeping maintenance areas clean and organized can also have a big impact on the bottom line. For one, given the types of materials stored in maintenance areas, this area can easily become a fire hazard if allowed to become unkept. Two, imagine how much time can be lost if the tool area is not tidy and no one can find the right sized wrench. Three, during repairs, if the work areas aren't kept clean, it can be difficult to quickly find a convenient place to fix a part. Worse yet, employees can easily misplace replacement parts if everything is haphazardly stored in this area, leading to reordering repair parts that are actually in stock but can't be located when they are needed. Beyond the cost of the part, the additional production delay as an employee retrieves or waits for another part to arrive can significantly increase costs.

Delivery Trucks

A clean cab is important for many reasons. Besides a CM's sales staff, their truck drivers are the people who represent their company to their customers. Making a good impression on the jobsite is an integral part of ensuring a happy customer. Having a driver show up to the jobsite in a clean, well-organized truck sends a clear message to the customer about how a CM chooses to run the business.

In addition, trucks can carry considerably more than just the finished product, they can also transport jobsite equipment like strapping, hangers, connectors, installation tools and protective equipment. Having these items stored and well organized ensures time isn't lost during delivery while the driver tries to find something they need. Not only does the lost time look bad, a disorganized truck can have many of the same problems associated with an unkept maintenance area: inventory can be misplaced and unnecessarily reordered; it can cause tripping hazards for drivers climbing in and out of the cab and/or on and off of the trailer; and having loose refuse or materials in the cab of the truck can increase the risk of an accident if something were to shift and impact the driver's ability to steer, shift or work the accelerator and gas pedals.

Given all this, it's not a bad idea to have each driver spend five minutes at the end of the day clearing refuse out of the cab, sweeping out dirt and mud, and storing equipment back in its proper place. Label trailer storage bins and, if there is room behind the seats, install storage boxes for organizing tools and materials. Besides the time savings and good impression, putting a focus on keeping the vehicle clean and tidy will likely spill over to all other facets of vehicle maintenance, reducing the risk of unforeseen mechanical failures, or worse, accidents.

Housekeeping Made Simple

The best way to have an effective housekeeping program is to invest time in showing employees what is desired and having the management team model it. It's vital that a CM's management shows they care and are invested in keeping a clean facility; periodically walking through the production floor and picking up refuse, pushing a broom to collect a pile of sawdust, or recoiling and storing a loose hose. All of these actions can go a long way in illustrating what a CM wants employees to do.

When the production teams see their employer cares about cleanliness and order, they will also care. Another thing to consider is making housekeeping a part of a safety bonus or productivity bonus program. One idea is to measure material shrink, and when there are improvements through proper housekeeping, consider contributing a percentage of the savings toward the productivity bonus.

As another example, if a targeted waste lumber cleanup and reuse policy is implemented, track its effect on the percentage of lumber material used. If there is a marked improvement, set aside a portion of the increased margin towards an incentive program to encourage continued success. The same can be true for eliminating minor injuries associated with trips and slips. These types of injuries don't typically lead to worker's comp claims, but they do contribute to lost labor hours or a decrease in worker effectiveness or efficiency, depending on the injury. Track minor injuries like these and consider implementing a small reward program for consecutive days without an injury that could have been avoided with better housekeeping.

Beyond modeling behavior and incentives, good housekeeping occurs when it is easy to do. Having plenty of brooms throughout the plant and in the cabs of delivery trucks, locating several collection bins throughout the production area, and providing tools like magnets and step ladders will make cleaning tasks easier for everyone. **SBC**

Ben Hershey is a Lean Management & Manufacturing Expert with 4Ward Consulting Group. The topic of Safety Communication will be covered in the September/October issue.

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Do You Need a Swiss Army Knife?

Effectively Evaluating Your Equipment Needs

by Sean D. Shields

You don't want a Swiss Army knife when a good sharp blade is all you need, and vice versa. That's the consensus of Rod Wasserman (Wasserman & Associates), Jay Halteman (Wood Truss Systems) and Steve Shrader (Hundegger USA). In May (see "Manual Labor," May 2014 at sbcmag.info/archives), these three industry equipment experts shared how cracking open the owner's manuals of your existing equipment and focusing on retraining may be the most effective short-term strategy for maximizing your current production capacity. This month we asked them, "What should a component manufacturer consider when developing a long-term production capacity strategy?" Not surprisingly, their answers were complex, but boil down to the following: know your need, get input from multiple sources, and evaluate all your equipment options before pulling the trigger.

Know Your Need

"Buying equipment can't be about what you want," said Wasserman. "Given the significant capital investment equipment now represents, you should only purchase what you truly need." Okay, so how do you know what you truly need?

"First you need to know who you are, and possibly who you want to be," advised Halteman. What he's getting at is do you primarily produce long span trusses for agricultural post frame buildings or a large volume of standardized components for production home builders? Would you rather be producing components for large multi-family projects or for single-family custom home builders? Have you considered producing components for light commercial applications?

Shrader agreed. "The more you know and understand about your core business and the makeup of the market you want to compete in, the better your ability to evaluate your production needs for the future," he said. All three experts were quick to point out your business and your market don't have to be what they currently are. "If you are confident there is greater sustained growth potential in an area beyond what you currently do, then your evaluation process needs to be focused on what you have to do differently to get there," said Halteman.

You also have to look at your unique situation. What are your current strengths and weaknesses, and what are the greatest threats you face in the market? Going back to the idea of putting your expertise on a pedestal (see "Finding Your Niche," April 2014 at sbcmag.info/archives), are there ways you can tailor your products and services to meet your customers' needs in a way no one else can? Positively differentiating yourself from your competition is one of the best solutions for sustained success.

"When you are evaluating, don't just think about how can I do more of the same," said Shrader. "Really think about whether doing things a little differently may make your whole operation easier, faster and more cost effective."

In the end, knowing who and where you want to be in the future is essential in determining what you need from your equipment. The next step is gathering input from your employee teams, those who know your processes the best and can help you identify and quantify your strengths, weaknesses and opportunities for enhancement.

Gather Internal Input

"I would start with your sales and design department," said Wasserman. "They are the best situated to tell you about your current market and where the greatest potential for improvement exists." This group of individuals should help you identify what you currently sell that works well and what you sell that creates either unnecessary headaches or has the potential to lose the company money.

Continued on page 28

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Equipment Needs • Continued from page 26

"Your sales force can tell you immediately what makes them really frustrated," said Halteman. "Most times, their frustration is directly related to situations where your customers' needs and expectations aren't being met." All three agreed it's vital to explore those frustrations. Those conversations can raise simple questions about your operations no one's asked before and discovering an existing strength or a possible opportunity previously hidden from view.

Beyond this group, you want to gather your production leadership together to help you analyze your current manufacturing process. They can help you identify inefficiencies, pinpoint real and potential bottlenecks, and brainstorm the many ways those obstacles to throughput could be addressed. "In the end, this team is about helping you deduce if equipment can either solve your current problems or help you achieve future goals," said Shrader. Yet, these employees need to be challenged to keep it simple and forthright, because equipment may not be the answer at all.

Through these conversations, your employee teams may determine different or additional equipment is necessary to meet your current customers' needs, or the potential demands of the market segment where you want your business to grow in the future. "Having their buy-in on the front end will have a dramatic impact on their investment in maximizing its use once it's purchased and installed," said Halteman.

Gather External Input

After evaluating your needs internally, the experts agreed it's a good idea to seek outside opinions. "You can get great advice from component manufacturers you don't compete with," said Wasserman. "Ask the original equipment manufacturers (OEM) for references outside your trade area." If you find yourself interested in purchasing a particular piece of equipment, it makes sense to talk to other manufacturers who already have experience installing and using it.

Of course, attending the BCMC show in Charlotte, NC in October is a great place to meet other CMs and discuss production strategies. After all, building a community is the main purpose of BCMC, and between the OEM vendors on the show floor and all the CMs in attendance, it's the best opportunity to learn directly from others what they do and how they do it while simultaneously developing long-lasting relationships.

Beyond the annual BCMC, SBCA has three Open Quarterly Meetings (OQM) throughout the year that give CMs an opportunity to connect with peers across the country. By participating in these meetings, your new network of friends can give you valuable insight into innovative ways to structure your production and material handling processes. "It's hard to put a price tag on the value of being able to pick up the phone and ask someone you trust how they would handle a problem you are struggling with," said Halteman.

While a phone call or face-to-face conversation at an SBCA event can give you valuable information, nothing is more effective than a plant tour. A fellow CM can talk about what they do, they can even send you diagrams and photos, but they simply can't do justice to the real thing. "I've walked through truss plants on three continents and there aren't enough words to describe how different they all are," said Shrader. "You have to walk through their production line, and see the material flowing through the facility, to truly understand what they're doing."

"The best part about plant tours is the ability to point to various aspects of the business you wouldn't think to ask about over the phone," said Wasserman. "You see something someone else is doing and wonder, why?" Many times, answering the "why" question leads to both CMs learning something new.

Evaluate All Your Options

In the end, this approach to evaluation should enable you to articulate what you need, and more importantly, why you need it. You should have a good handle on the labor percentage you are aiming for, the extent to which you want your employees touching material as it flows through the production line, and to what degree you are willing and able to reorganize your facility layout to incorporate new equipment. Further, whether it's an automated component saw, roller gantry table, laser projector, component conveying and stacking equipment, or any combination of machinery you require to meet your identified production needs, you should have clear expectations on what you want to get from the equipment you buy.

That brings us back to the original premise: you don't want a Swiss Army knife when a good sharp blade is all you need, and vice versa. Halteman advises CMs to ask themselves, "Do I need everything this particular piece of equipment can do?" You're going to pay for all of those features, even if you don't need them. Sometimes a simple problem only requires a simple solution. On the other hand, if you're trying to do more to differentiate yourself in the market or meet an additional customer need, equipment that improves your versatility and capabilities may be exactly what you need.

Knowing where a new piece of equipment will fit into your production process and how it will affect throughput is another factor to consider. "If your current saw is causing a bottleneck, will a new, faster saw truly improve things, or will it simply shift the bottleneck farther down the line?" asks Shrader. He gave an example of a lumber mill that purchased a new high-end planer that could plane boards at twice the speed of their previous planer. On paper, their throughput capacity should have doubled. Instead, they ended up having to shut the mill down for several shifts because their drying kiln couldn't keep up. You need to have the ability to rebalance your workflow with the new equipment in order to realize a favorable return on investment (ROI).

Conclusion

Speaking of ROI, the three experts agree the recent housing downturn has ensured everyone is more in tune with the importance of this concept. They also agree the days of simply throwing new equipment at a problem don't work anymore. "The playing field has changed," said Wasserman. "You need to be more surgical in your response."

In the final article in this series, we will talk with this industry's OEMs and get their perspectives on ROI. We will also explore the pros and cons of brand uniformity, changes in equipment life-cycles and the opportunities for CMs to be a better consumer and influence the equipment produced by the OEMs. SBC

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Two years have passed since we covered Integra Steel Truss ("Men of Steel," August 2012). At that time, they were just starting out, leasing a portion of a warehouse to produce their first big job with a handful of part-time employees. Today, they lease the entirety of that original warehouse, have opened a second facility, grew their workforce to over 20 full-time employees and expanded their workload tenfold. "Thanks to the incredible work of our dedicated staff, we've been fortunate to ride this wave of economic expansion," said Integra President Jon Moore.

With the help of building information modeling (BIM), Integra has found success landing several large clients. The 3D model pictured below is of a recent project,

an army reserve training center in Windsor, CO, with 130' trusses. Split into three parts, the 73' span truss sections each weighed 800 pounds. "The CFSBCSI was instrumental in helping us show the builder how to brace these huge trusses properly, and they even ended up framing the roof system on the ground and hoisting it into place in sections," said Moore (see photo at left). SBC

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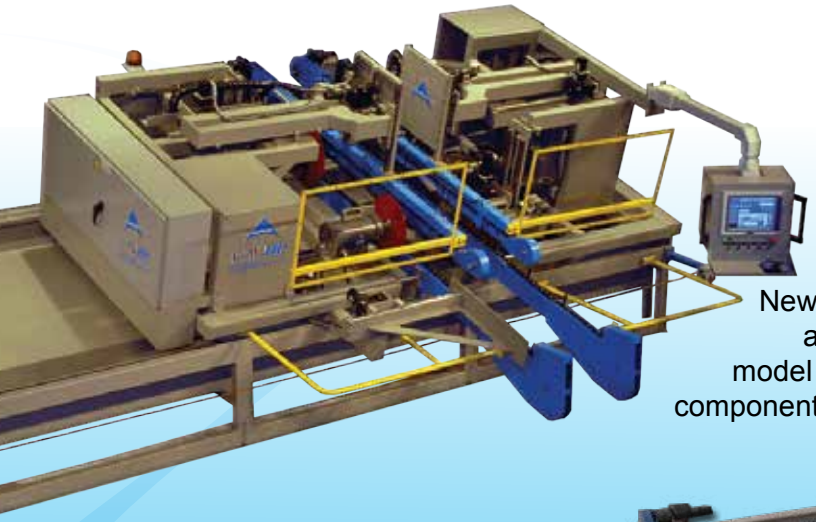

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