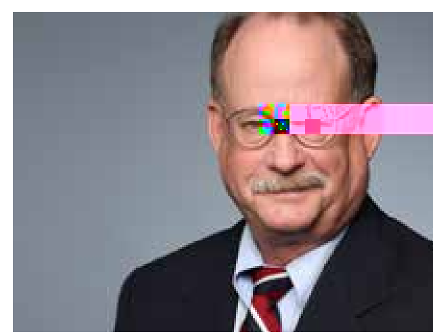
In this third and final article in our series, we continue the discussion about unlisted materials, this time focusing in on considerations beyond those listed in the Commentary to the AISC *Specification*.

UNLISTED MATERIALS – PART 3



Larry Muir (**muir@aisc.org**) ... **Tom Schlafly** (**schlafly@aisc.org**) ...

IN ADDITION TO the considerations listed in the Commentary to the *Specification for Structural Steel Buildings* (ANSI/AISC 360, available as a free download at **www.aisc.org/specifications**) there are other factors that might also be considered when contemplating the use of unlisted materials. We'll discuss them here.

Engineers and contractors often use the term *equivalent* when discussing unlisted materials. The party proposing the substitution will often claim that the proposed material is equivalent to a listed material, or the engineer will ask about the equivalency of two different materials. This sort of thinking misses at least half the issue.

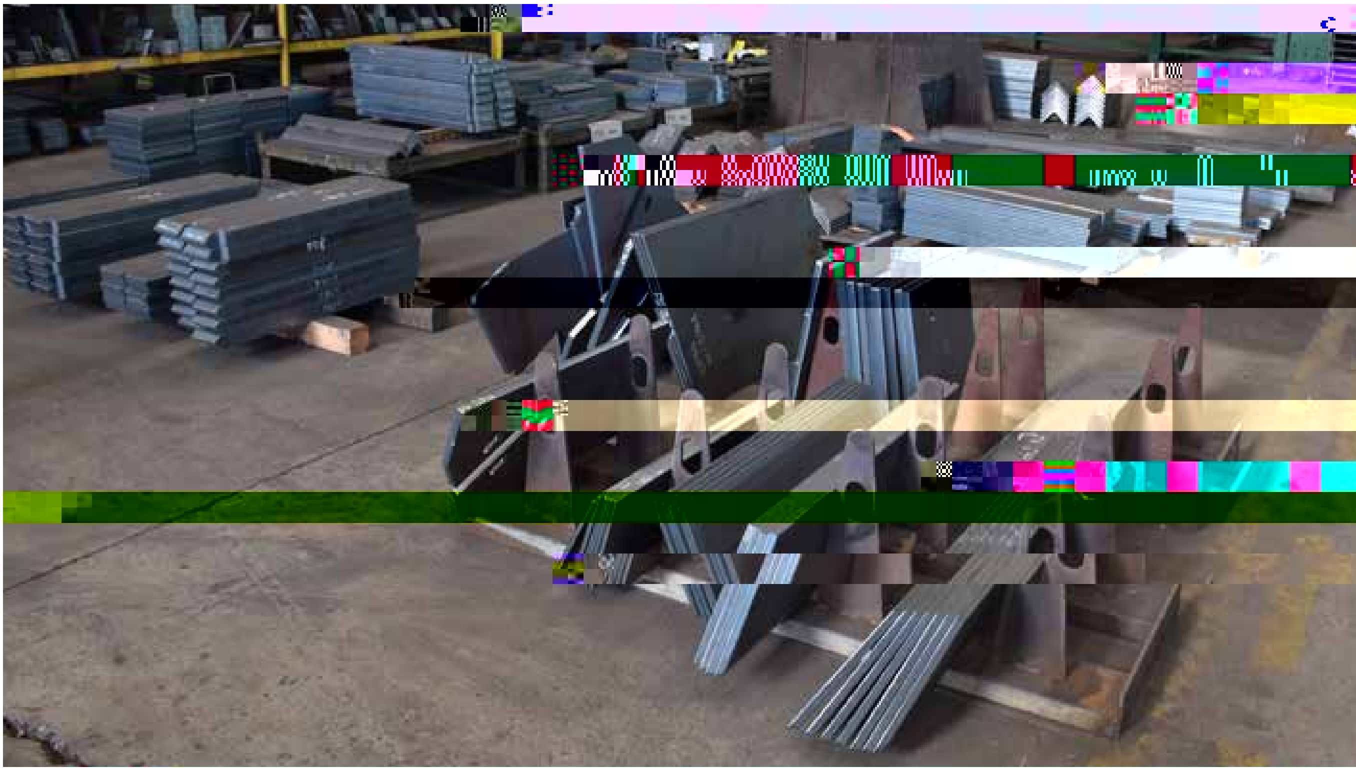
In some instances, it may be possible to specify a more general material in such a way that it becomes equivalent to some other more specific material. In such cases, the material could likely be dual- (or multi-) certified rather than being treated as a substitution. Setting aside this possibility, it is unlikely that two specifications will be wholly equivalent. There will be differences. This means that equivalency must be judged not just considering the material side but also the application side. The two materials are not identical, but can they function in an effectively identical manner in a given application? Both the proposed material and the proposed application must be considered together.

In other instances, a single material can satisfy multiple ASTM specifications. Such materials are sometimes supplied as dual- or multi-certified materials, and multiple ASTM specifications will be listed. The most common condition seen in building construction is some combination of A36 with ASTM specifications for approved steels with a yield strength of 50 ksi. This is possible because ASTM A36 does not provide a limit on the maximum yield strength. For most building applications, the greater strength is not a concern. In some cases, such as in the AISC *Seismic Provisions for Structural Steel Buildings* (ANSI/AISC 341, **www.aisc.org/specifications**), the material over-strength is explicitly accounted for (i.e., in the values for R_y and R_t).

There are, however, applications for which greater yield strength could be detrimental to the design intent. These applications generally fall outside the scope of the *Specification*. In such cases, the specifier must either specify a limit on maximum yield strength or adjust the design to accommodate readily available materials. It should be noted that obtaining ASTM A36 material with a yield strength near 36 ksi can be exceedingly difficult.

The *Seismic Provisions* treats material selection differently than the *Specification*. Section A3.1 states: "The structural steel used in the SFRS described in Chapters E, F, G and H shall meet one of the following ASTM Specifications…" and provides a list of permitted materials. The permitted materials have been selected to be consistent with tested seismic systems and to reflect desirable seismic performance characteristics (e.g., ductility or limited maximum yield strength) consistent with the requirements of the *Seismic Provisions*.

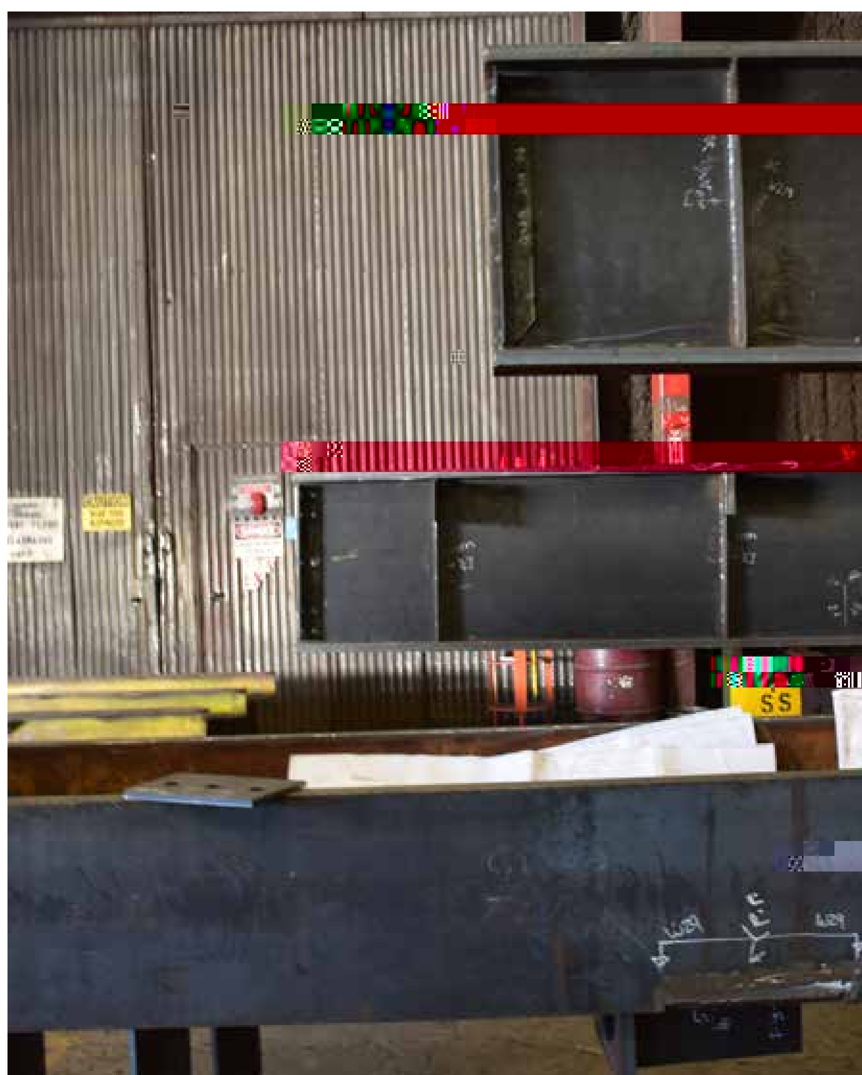
Even if other materials were not explicitly prohibited, their use in the seismic force-resisting system (SFRS) could be difficult due to lack of expected material strengths



established to be consistent with the *Seismic Provisions*. The lack of values for R_y and R_t effectively excludes the use of unlisted materials for yielding elements and makes correct implementation of some provisions virtually impossible.

known, extra precautions such as tensile tests and chemical composition tests by independent laboratories of a sample of the product may be justified. It is the engineer who must both specify the tests to be conducted and evaluate the results.

There are, of course, other reasons an engineer may want to consider a material substitution. It may be that some material is especially well suited to the design of the project. For example, ASTM A992 and ASTM A1085 both existed as ASTM specifications prior to being approved under the *Specification*, and some



to understand that the specification associated with the proposed material may be more general than the originally specified material or the approved materials. When you specify an approved material, parameters are likely specified that make the material especially useful as structural components in a building.

When a substitution is made, it may be necessary to impose additional project-specific requirements beyond what is included in the standard specification. For example, ASTM A500 includes tolerances on outside dimensions, wall thickness, straightness, squareness, twist and other parameters. When a similar HSS is specified to be fabricated from plate, the specifier should carefully consider which of these parameters, if any, need to be controlled, and take measures to do so. In some instances, tolerances from other standards like AWS D1.1 may be applicable, but it should be kept in mind that these tolerances are often tied to the intended use—i.e., whether it is a column or a beam, which may not always be obvious in the wh57do

tors or suppliers often decide what will be provided when the contract documents are not clear, and use of the products is confirmed through the approval process. This process, though not ideal, often proved sufficient.

When considering the use of unlisted material, the specification should be carefully examined to ensure that all pertinent properties are addressed. Very general specifications should be avoided or supplemented with project-specific requirements.

The use of unlisted materials can impact multiple members of the project team, sometimes in unexpected ways. These effects must be considered.

As described above, evaluating unlisted materials is not always simple. Significant engineering time and effort may need to be dedicated to evaluating the proposed material. In some instances, experts may have to be brought in, as structural engineers often do not possess specialized knowledge of metallurgy or welding that may be required in the evaluation. The project budget and schedule must accommodate these factors. If it is decided that additional requirements must be enforced, then the affected parties must work together to determine what is necessary, what is possible and what is practical.

If toughness is a design consideration but the toughness of the proposed material is uncertain, the engineer may want to impose minimum toughness requirements and impose toughness testing—but this will be to no avail if the material specified simply cannot meet the specified requirements.

If a large quantity of bent plate is required but the material specified proves to be susceptible to cracking when formed using typical shop practices, who is responsible for the costs associated with retooling, retraining and re-fabrication?

If the proposed material has a straightness tolerance significantly larger than that of the approved materials but the project specification requires a tighter straightness tolerance, how is this to be achieved? Will the mill supply straighter members than is typical? If so, how will this be done and will there be any detrimental effects to other material properties? Will the members be straightened by the fabricator and if so how—via heat straightening or cold straightening? If the material is damaged using typical shop straightening processes, who is responsible for the repair or replacement of the material?

These are the sorts of issues that may have to be addressed by the project team. The team should be prepared to address them, preferably in a proactive manner. It is often much more difficult and expensive to fix a problem than to prevent the problem from occurring in the first place.

As stated near the beginning of this article, the *Specification* is commonly referenced by other codes and used at the discretion of engineers for applications outside its stated scope. It is important to understand, however, that there are limitations to its applicability. Comparing the AISC provisions to those of other codes and information provided in guides and texts can sometimes provide the engineer with additional insight.

0´ 8