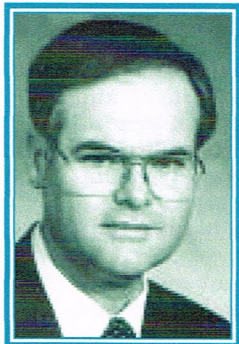


# EFFECTIVE CONTRACT AND SHOP DRAWINGS



*Emile W. J. Troup, is a structural engineer and consultant based in New England. He also currently serves as president of the National Council of Structural Engineers Associations.*

**D**URING THE PAST TWO DECADES, OUTSIDE INTERESTS HAVE INCREASINGLY INFLUENCED CONSTRUCTION CONTRACT DOCUMENTS and the assignment of tasks associated with design, detailing and quality assurance of fabricated structural steel framing for buildings. Insurers and attorneys have been advising structural design professionals to limit their scope of service and issue contract documents that make working relationships with contractors more confrontational and defensive. This is hardly the stuff of “partnering” or “team building”. The term “approve” has been displaced on shop drawings by “reviewed for conformance to the design concept”, whatever that might be.

For their part, since the “fast-track” construction process became popular, owners and developers have come to believe that Rome really was built in a day. Projects that sit on the shelf for two years suddenly must be designed and bid in two or three weeks.

Occasionally, this “schedule driven” mentality allows design professionals insufficient time for preparation of complete contract documents. The contractor bidding process deteriorates into one of speculation rather than a meticulous estimate of the work to be done. Speculative bidding breeds uncertainty and uncertainty increases bid prices. Incomplete design drawings also increase the chance that they will be misinterpreted. Not only is the public perhaps at higher risk, but the fast track project can quickly become plagued with bloated cost and schedule — and greater potential for disputes, claims and litigation. Healthy profits may be realized, but not by those involved at the level of structural design or steel fabrication. Ultimately, one way or another, the owner must understand that there is a premium to be paid for short-circuiting the design process..

The purpose of this paper is to encourage more consistency in the way contract drawings and shop drawings for structural steel are prepared. The author’s recommendations are based primarily upon a series of “round table” discussions, which were held during the past several years among members of steel fabricator, steel detailer and structural engineers associations throughout New England.

## Should pre-qualification of structural fabricators be specified?

**Background.** On most building projects, the Structural Engineer of Record is not involved in the selection of structural fabricators or suppliers. The “low bid” mentality employed by many general contractors and construction managers sometimes results in selection of a structural steel fabricator who may be unable to produce a product of the required quality, on schedule, and in accordance with contract documents. Under this scenario, while valiantly shifting into a rectification mode on behalf of the owner, the SER can witness its profit being eroded while the owner observes the routing of its project goals.

Since the mid-1970s, the American Institute of Steel Construction (AISC) has administered a Quality Certification Program for structural steel fabricators. (A similar program was recently launched by AISC for steel erectors.) Fabricators that are AISC Certified have been evaluated for their capability to perform work of the required quality for projects in various building and bridge categories. The program is recognized by several model code agencies (e.g., BOCA International) as fulfilling the requirement for evaluating a steel fabricator’s procedures as stipulated under provisions for “Special Inspections”, Section 1705 of the National Building Code.

Attempts by the SER to pre-qualify steel fabricators for complex building work are often rebuked by general contractors who convince owners that selection of structural fabricators should be solely by price. Even with nearly 400 domestic AISC certified plants, owners may perceive that pre-qualification will limit competition. Although this may be true in certain regions, owners should be advised that pre-qualification of structural fabricators may reduce certain construction costs, including those for structural tests and inspections.

**Recommendation:** For buildings requiring “Special Inspections”, contract documents should specify that fabricators of any structural material (whether custom or “pre-fabricated”) be pre-qualified. Owners should

loads, showing calculated beam reactions will allow the detailer to more closely match connection capacity to design requirements. And, showing end reactions along with beam and girder sizes on contract documents provides the SER with an intuitive check by “another set of eyes”; a beam that is inadvertently undersized may be detected by an astute fabricator or detailer. Software programs such as RAMSTEEL automatically show design reactions (which can be modified at the SER’s discretion) on the drawing printouts.

**Recommendation:** Fabricators and detailers involved in structural steel work prefer the opportunity to select and design the common simple shear connections that are presented in the AISC connection design aids. Contract documents should provide selection and design criteria, including all end reactions, and specify in the general notes any connection types that are not acceptable.

**How can the fabricator demonstrate competence of simple shear connection design?**

**Background.** Connections are critical elements of the primary structural system. Without adequate connections the structure’s load paths and integrity of the building are in doubt, regardless of how well the primary members have been designed. If the fabricator is permitted to select simple connection types and is assigned the task of designing these connections, the fabricator should substantiate the competency of this work. A requirement for substantiation should render:

- A more level playing field for bidders;
- A faster “turn-around” time for review of shop drawings by the SER; and
- Another element of quality assurance for adequacy of connection design.

**Recommendation.** The following are examples of documentation that the SER might require when the fabricator is assigned the selection

and/or design of simple shear connections.

- Pre-qualify the steel fabricator, recognizing that pre-qualification is no guarantee of acceptable fabrication on a specific project and attests only to the capability of the fabricator to perform work of the required quality.
- Require a pre-construction meeting and review the typical connection types and design procedures the fabricator proposes to use on the project.
- Require the fabricator to verify the selection and design methods used by submitting sample calculations, tabulating results, or listing technical references (e.g., AISC design aids). Require that all procedures and calculations be maintained in a form that can be readily reviewed.
- Require the detailer to show both connection design loads (they should agree with those shown on contract documents) and connection capacities on shop drawings.

**Should connections in lateral load resisting frames be designed by the SER?**

**Background.** Under today’s “fast track”, budget-sensitive, schedule-driven project environment, the Structural Engineer of Record is often hard-pressed to complete the design of lateral load resisting systems prior to bidding. Since fabricators and detailers are usually under similar constraints and pressures from general contractors, insufficient information in contract documents about moment and bracing connections, including column strengthening (web doublers and stiffeners), often results in unrealistic or nonresponsive bids. In the highly competitive subcontracting marketplace, owners, design professionals and general contractors must anticipate that omission or ambiguity of information at the bid stage may produce justifiable change orders, claims for “extras”, disputes, cost escalations and delays. Thus, this message for owners and architects: Limiting the SER’s scope of services, through financial and/or time constraints, is false economy.

With the adoption of the International Building Code in 2000, and perhaps performance-based seismic design sometime thereafter, many more states will be enforcing seismic design and detailing provisions. For this reason alone, the SER should, with input from prospective fabricators, be selecting and designing connections in lateral load resisting frames.

Especially in the Northeast, perhaps no other single steel detail has caused fabricators and detailers more frustration, time and expense than that of reinforcement (strengthening) of under-designed columns in moment frames. In areas of high seismicity, such as parts of the Western United States, the practice historically has been for the SER to fully design steel moment connections. In areas of the East, however, as seismic provisions have begun to work their way into state and local codes, this task has occasionally been left to the steel fabricator and detailer. In the worst case, information provided to bidders about the costly detailing and fabrication required for column strengthening has been totally lacking. Fabricators cringe when cost estimates must be figured from drawings containing notes at moment connections, such as, “Design connections for the full capacity of the beams” or “Provide doublers and stiffeners where required”.

The need for web doubler plates to strengthen a column web in moment frames is symptomatic of an undersized column. The SER could, of course, benefit all parties by increasing column sizes, where practical, to eliminate doublers and reduce both the cost and time of shop drawing preparation, shop drawing review, fabrication and inspection. It is well-recognized that a “clean” column, heavier by 50 to 100 lbs/ft or more, can be more economical than a lighter column that requires web doublers<sup>2,3,4</sup>. And, a heavier column promotes the “strong column - weak beam” design concept, generally preferred for seismic design. As doublers are eliminated in seismic resisting frames, so is the associated cost of field weld inspection.

As a less desirable alternative, bidders could be given the option of substituting stronger columns to eliminate doublers. However, unless

be fabricated and assembled. Shop drawings generally do not show explicit design calculations by which connections are sized and detailed for structural adequacy. Furthermore, the shop drawing shows information that is normally not reviewed for accuracy by the SER (e.g., detail dimensions for fabrication and erection that are the responsibility of the fabricator).

If all connections are selected and shown designed in the contract documents, it should not be necessary to require involvement of another design professional. Likewise, if only simple shear connections are to be selected and designed by the fabricator and detailer (given the excellent AISC design aids available), usually it should not be necessary to require involvement of another design professional.

For other connections not selected and/or designed by the SER, the SER must determine the necessity of requiring the involvement of another design professional. This decision may depend on the existence of a pre-qualification provision in the contract documents. (Pre-qualified fabricators should know their limitations and those of their detailers and should voluntarily retain professional design services when necessary.) The owner must be told that such a requirement will impact bid prices and will likely extend the time needed for bidding and for preparation and review of shop drawings. The owner can ill-afford these schedule-extendors on a fast-track project.

Upon review of shop drawings, if connections designed by a fabricator's design professional meet the criteria and intent of the contract documents (and are in accordance with agreements reached during pre-construction discussions), the connections should be accepted as presented. Therefore, the SER should clearly indicate, in advance, any restrictions or preferences imposed on connection selection or design. In the past, disputes have arisen when the SER rejects competent work, without technical justification, of another design professional who has been retained by the fabricator or detailer.

The national debate among all the affected disciplines over insurability, liability and ethics concerning the design of steel building connections has been ongoing since the 1981 Kansas City Hyatt Regency event. In spite of all the rhetoric, no

one has proposed an allocation of tasks or a national Standard of Care that might be acceptable to both the structural engineering profession and fabricating industry and would be in the best interest of quality assurance and safety of the completed building. In the meantime, the courts — and not the design professionals or the fabricating industry — will continue to decide these issues on a case-by-case basis.

**Recommendation:** It is certainly within the SER's purview, in the bid documents for any project, to require the fabricator to furnish the stamp of a licensed design professional on shop drawings or other connection submittals. In general, however, it should not be necessary if only simple connections are to be selected and designed by the fabricator. In any event, the "playing field will be level" if the bidders know exactly what is required, i.e., if the contract documents are explicit and unambiguous.

### When should the SER consider a fabricator's request for changing a connection?

**Background.** One comment heard from SER's is that fabricators often request a change to a connection that has been designed on the structural plans. This reflects the preference of most fabricators to use the best talents of their shop personnel and equipment. And, it may help explain why there has been a tendency for connection criteria in contract documents to be incomplete. (Why should the SER design a connection if the fabricator will want to change it?)

The SER should consider a request for review of a specified connection that the fabricator believes to be structurally deficient, unsafe for ironworkers, or impractical to erect. Otherwise, when a connection is shown designed on the structural plans, it should be bid and detailed as such, unless an alternate is perceived to benefit other members of the construction team. On any project, the fabricator can, at its own risk, submit a bid based on alternate connections, but, the SER is under no obligation to accept any that the

fabricator proposes. If such a change is accepted during a pre-construction discussion, the fabricator should be prepared to supply supporting calculations (and perhaps compensation) for review by the SER.

Under no circumstances should a steel fabricator or erector modify, without approval from the SER, structural shop drawings that have been reviewed and released for construction.

**Recommendation.** The SER should consider connection changes or alternates proposed by a fabricator, if they are necessary or beneficial to the project.

### What should be the extent of shop drawing review by the SER?

**Background.** Regardless of who ultimately performs the tasks of selecting and designing steel building connections, SER's should note the Council of American Structural Engineers (CASE) July 30, 1994 Position Statement, excerpted here:

"The SER (Structural Engineer of Record), should be responsible for the design of the primary structural system. There may be times when some element of the primary structural system is to be designed and sealed by someone other than the SER.

"Nevertheless, such elements, including connections designed by others, should be reviewed by the SER. He [sic] should review such designs and details, accept or reject them and be responsible for their effects on the primary structural system."

Also noteworthy is an addendum published by the Associated Subcontractors of America, as a commentary to new AGC 650/655 model subcontracts:

"Any design services provided by the Subcontractor or its designer will be reviewed by the architect/ Engineer responsible for the overall project to assure that the design will be acceptable when integrated with the entire work. Contractor, Owner and Architect [and Engineer?] are entitled to rely on the accuracy