Metal Stairs And Railings:

Will The Responsible Designer Please Step Forward?

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During the past decade, problems with contract documents have increased for miscellaneous metal fabricators bidding stairs and railings in much the same way as these problems have escalated for structural fabricators. Specifically, increased design responsibility has been foisted on miscellaneous metal fabricators while at the same time contract documents—upon which estimates are based—have become less intelligible.

Concurrently, building codes have expanded safety provisions and modified loads for stairs and railings, while federal and state agencies have developed regulations to provide disabled Americans with greater access and safety. Thus, at a time when Contract Documents should be including more guidance for system selection and detailing, fabricators are increasingly bidding under more speculation, greater financial risk and a higher degree of responsibility for adequacy of design. As a result, some professionals are concerned that reduced oversight or involvement by the Architect or Structural Engineer of Record (AR or SER) might be exposing the public to greater risk.

In late 1992, the Structural Steel Fabricators of New England (SSFNE) expressed this concern in an open letter published in the newsletter of the Boston Society of Architects (BSA). Response to that letter led to the formation of an ad hoc Metal Stair and Railing Task Group to air issues and seek improvements to a process which was clearly becoming more confrontational. The Task Group included architects, miscellaneous metal fabricators and representatives from the Boston Association of Structural Engineers (BASE). During 1992 and 1993, the Group met bimonthly and developed a Guideline for Contract Documents governing metal stair and railing work bid under a *DESIGN-FABRICATE* scenario, i.e., a scenario in which some or all of the design effort is assigned to the fabricator. The Task Group sponsored several workshops, feedback from which helped to refine the Guideline.

Figure 1: The 850-flight emergency stair system in the World Trade Center performed admirably after the building was bombed in 1993.

Concern for Safety

Metal stairs and railing components do not have a history of structural failure due to design flaws. The few problems known to the writers mostly involve gradual weakening of components due to inadequate maintenance in a corrosive environment, or to inadequate attachment of stair systems to other elements of the building. Rarely, there have been dramatic failures of guardrails in stadium-type structures subjected to excessive or dynamic loading by a crowd of unmanageable spectators.

Other than for evacuation drills, many fire stairs (or "egress" stairs), like sprinkler systems, are never required to perform their safety function during the life of a building. However, when the rare disaster strikes in mid- or high-rise buildings, e.g., the major earthquake,

uncontrolled fire, or bomb blast, the welfare of many hundreds or even thousands of vacating people is at risk, even if the structural frame itself remains intact.

The performance of egress stairs after the 1993 World Trade Center bombing in New York City is a case in point. The 850-flight emergency metal stair system (Figure 1), built in 1962, was subjected to the maximum load it may ever experience as thousands of occupants evacuated from the 110-plus story building. The system, in compliance with all codes and regulations at the time, performed admirably and as intended under these extreme conditions.

Current Practice of Stair and Railing Design

Obvious as it may seem that a project's Architect of Record (AR), along with the structural consultant, should be responsible for the process of custom stair and railing design, current practice differs. The Structural Engineer of Record (SER) is usually not involved in the initial stages of stair design. Traditionally, by definition, stairs are not considered part of the primary structure, so the SER is typically not retained for structural design and review of stair systems. Indeed, the National Practice Guidelines of the Council of American Structural Engineers (Second Edition, 1994) defines stairs as "secondary structural elements", the design of which is in the category of Special (additional) Services, "which may or may not be foreseen at the beginning of design stages and are not normally included as Basic Services..." provided by the SER. This current practice within the construction industry, often excluding the SER from involvement in stair design, creates problems for the architect and ultimately the fabricator and owner. Consider the following.

- Fire stairs are typically drawn by a junior staff member in the architect's office using office standard details that may or may not get reviewed with respect to recent code revisions, current practice, or local codes and specifications.
- Architects frequently require the fabricator to provide an engineer's stamp on the shop drawings. Fabricators are often reluctant to comply, thus slowing down the review process. The cost of this engineer's stamp is included in the fabricator's price. Thus, initially avoiding the fee for structural review of stair shop drawings by the SER is not a savings to the owner.
- The public bid process (and the realities of the private marketplace) discourages pre-qualification of miscellaneous metal fabricators. Project design professionals may lose a valuable partner in the quest for code-compliant and acceptable stairs.
- The architect's specifications and performance criteria often are in conflict with typical, proven shop details.
- The architect may neglect to coordinate rail mounting with adjacent material such as back-up for wall-mounted railings.
- The fabricator may believe that the stair railing, as shown, is not structurally adequate and is thus in a dilemma as to whether to bid per the Contract Documents and subsequently request a change order, or bid the documents with railings that are believed to be properly sized and risk losing the job.

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Reality of Current Practice

The reality of today's design and construction practice is the *DEMAND OF SCHEDULE*. Many projects are fast-paced with unreasonably strict deadlines, and the fax machine and computer have only increased the client's demand for speed. This leads to quickly drawn details providing minimal or insufficient information for bidding, lack of thorough review, and condensed bid, fabrication and erection schedules. Contrarily, with the abundance of compliance issues in today's environment, all parties need to have the complete and correct information in the Contract Documents, presented concisely and efficiently.

Primary Structural Systems and Sub-Systems

All projects are composed of a primary structural system. In new construction this framing system is the design responsibility of the SER. In renovation work the current SER may also have responsibilities for the existing framing system if it is being upgraded or if new construction (loading) is being is imposed.

All projects are also composed of structural sub-systems, defined here as those sub-systems that are usually attached to and supported by the primary structural system, and the design of which requires structural calculations to be performed. These sub-systems may be numerous and include elevators, stairs, cladding support systems, equipment framing sys-

tems, etc. Sometime during the process, especially in regions of seismic risk, a qualified, licensed design professional (not necessarily the SER) should be involved in either the design or review of structural sub-systems.

Stairs are commonly considered as sub-systems and are usually specified under the category of Miscellaneous Metals or other technical sections of the project specification. These sub-systems are usually treated as separate and distinct from the primary structural system. They are rarely covered as framing systems on the structural plans and often are not adequately reviewed by a licensed design professional. However, as separate entities in the contract involving discrete subcontractors or suppliers, special attention must be paid by the prime design professionals to ensure that proper engineering of these systems is achieved.

The most logical solution is for the AR to include, in the scope of work, the SER's involvement in either the initial design or review of the final design, to the extent necessary to assure code compliance and public safety of important structural sub-systems such as stairs and railings.

Code Requirements

A multitude of code and design issues go into the creation of a stair, including: location; number of stairs; egress stair width; structural and accessibility provisions for railings; treads and risers; and aesthetic considerations. Some of the codes the architect must address in stair design may include a state building code, model building code (such as the National Building Code of BOCA), OSHA, NFPA, state and local Access Board regulations, and the Americans with Disabilities Act Accessibility Guidelines (referred to as "ADA").

A pre-qualified fabricator should be familiar with: requirements for concentrated and uniform loads for railings and guard panels; dimensional requirements of handrails, guardrails, treads and risers; and standard accepted practice. However, with ever-changing codes and the wide variety of public safety provisions (sometimes ambiguous or conflicting), the project's Architect of Record, ultimately, should assure the adequacy of stair and railing systems.

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Contract Documents: The Fabricator's Lament

Difficulties currently associated with bidding, detailing and fabricating metal stair and railing systems under the *DESIGN-FABRICATE* scenario include:

- Insufficient information in Contract Documents. Incomplete design criteria lead to nonresponsive and erratic bidding, an extended review process, and a likelihood that the successful bidder will plague the project with future backcharges.
- Contract Documents not in compliance with codes or regulations. Components specified may not be checked for structural adequacy or other current provisions.
- Lack of communication with design professionals. On some projects there is no mechanism or inadequate time for bidders to report errors or deficiencies in the Contract Documents. When deficiencies are not corrected prior to award, the successful bidder is at risk to be held responsible for the expense of furnishing corrected, code-compliant stairs and railings.
- Inadequate space for the stair system. While dimensional errors or omissions in Contract Documents may be discovered and corrected during detailing, sometimes the stairs are installed before discovery occurs.
- Requirement of a stamp on shop drawings. Although the involvement of an independent design professional by the fabricator may be justified in some cases, that design professional's stamp on the shop drawings raises unresolved legal and insurability issues for the fabricator. In most cases (and as proposed in the Guideline), verification of the adequacy of the design should be performed by the AR and/or SER.
- Rejection of a fabricator's design that complies with Contract Documents. Most often this occurs when the architect neglects to specify all design criteria (including aesthetic) pertinent to the project. The fabricator's standard procedures and details for those items not specified should be acceptable as long as they are in compliance.

In general, ambiguities and deficiencies in Contract Documents can be classified as: 1) stair geometry; 2) stair support scheme; and 3) stair component design.

1. STAIR GEOMETRY. The lack of basic information, such as the opening, length and width of the stair, confounds the process right from the start.

Stair opening dimensions being improperly thought out leads to conflicts with standard

riser heights and tread lengths (usually 7 in. and 11 in., respectively), resulting in potential problems meeting code and safety provisions. Also, insufficient space for landings can result. For example, a 3-ft 8-in. stairway width is called out, only to discover during installation that a landing of only 3-ft 0-in. can be accommodated.

Stair width must be established with ADA requirements in mind. Offset handrails projecting up to 3½ in. into the required width of an egress stair may be acceptable, provided adequate stair well-to-wall clearance is provided. In some instances well rail posts have had to be offset into a stair to give sufficient handrail clearance. Another scenario develops at the site when inadequate width requires stair stringers to be cut into sheet rocked stairwells to bring the drywall finish flush with the web of the stringer.

Lack of adequate *floor-to-floor height* can cause problems with headroom as well as with riser and tread dimensions. In one project a C6 X 8.2 header channel was reinforced and reduced to 2½ in. depth to provide the acceptable head clearance. Needless to say, cutting headers in the field while maintaining structural integrity of landings is not only expensive, but it can compromise the desired appearance of a stair assembly.

Indeed, many of the problems with erroneous or missing stair system dimensions are not ascertained or addressed until well into construction, or even until the final inspection by the code enforcement official. Dimensional issues should be easily resolved during working drawings or, at the latest (and with perhaps somewhat more difficulty), during detailing. Otherwise, the owner is risking costly retrofit and delays in occupying the building.

2. STAIR SUPPORT SCHEME. Often fabricators are asked to quote projects based on drawings containing generic or "boiler plate" sections that are pasted on the architectural plans, and are not compatible with the design or with site conditions. An example is hanger rod stair supports at floors and landings with no indication of what structural steel to tie into. Sometimes no support scheme is shown at all so bidders must guess (and likely inflate) its dollar value to allow for contingency.

If the *stairwell wall* is concrete block but no details for supports are indicated on architectural drawings, the fabricator assumes that clips attached to the wall or bearing plates installed in cutouts will support headers and stringers. Then a telephone call or fax from the field reveals that the block wall, shown to be concrete-filled, is hollow and will not accept the expansion bolts by which clips are to be attached.

Surely the owner is not served by a set of *Contract Documents*, the bids for which are inflated to cover uncertainties and potential pitfalls—foreseen or unforeseen—that any responsible fabricator must figure.

3. STAIR COMPONENT DESIGN.

✓ When the architectural plans are silent about the size of stair stringers, the bidders know that sizing them is part of the scope of work. Often times, however, the stringer is "pseudo-designed" and, for example, is indicated by one of the following:

"Stringer": "C12"; "MC" ; or "MC12"

One conscientious bidder may determine that the stair requires a C12 X 20.7, while another may really need the job (or not know any better) and arbitrarily use an MC10 X 8.4. With this kind of estimating, who will get the job? And when the time arrives for shop drawing review, who will backcharge for the larger channel, claiming that the MC10 X 8.4 met the Contract Documents? If the architectural plans call out stringer sizes they should be correct and complete, otherwise it is preferable to omit size designations entirely.

✓ When an indifferent bidder is estimating what size of header or support beams to supply, the answer might be to supply what was used on the last project because they were approved and they "worked".

✓ Are the stair pans 10, 12, or 14 gauge? If the stair is 4-ft 6-in. wide, a 14 gauge may be approved, but there is a good chance the concrete in the tread will crack.

✓ Is the desired railing 1½ in. O.D. or a nominal 1¼ in.? A nominal Schedule 40, 1¼ in. pipe has a 1⅝ in. O.D. If exactly 1½ in. O.D. is desired, more expensive round tubing must be specified. ADA allows the use of the nominal 1½ in. Schedule 40 pipe for handrails, meaning that its 1.90 in. O.D. is acceptable.

✓ Is the pipe Schedule 10, 40 or 80—and just the posts or the whole railing system? Considering the 200-lb (or even 300-lb in some jurisdictions) concentrated load on a handrail at any point and in any direction, how safe is connecting a nominal 1½ in. Schedule 80 post to an MC10 X 8.4 or an MC12 X 10.6 stringer when the post is ⅜ in. wider that the channel flange and thus overhangs? Further, with the stringer unstiffened at the post, what is the likelihood of a failure under an extreme load?

✓ Then there are the aesthetic issues. The architect may have had in mind what the stair system should look like upon completion. But while performing a walk-through, the architect notices that fillet welds attach balustrades to the cap and stringer and asks, "What happened to the 90 degree corner?" If the architect is implying that welding, as a method of attachment, is unacceptable, how else are balustrades attached? Fillet welds were shown on shop drawings that were reviewed by the architect and released for fabrication. What looked fine on

Figure 2: Monumental stairs are usually highly visible and therefore require exceptional care and craftsmanship. Photo courtesy of Leers Weinzapfel Associates

paper apparently did not pass aesthetic muster in the field.

What to do? Specific design criteria for metal stairs and railings may vary from one jurisdiction to another. In Massachusetts, for example, various editions of the State Building Code (and specifications of state and quasi-public agencies) have, from time to time, conflicted with those criteria in the Model Building Codes and federally mandated provisions. Railing loads, baluster spacing and height of top rails are some of the criteria which have been subject to examination and change in recent years. However, once the governing criteria are established, the design of conventional metal stair and railing systems is rather straightforward. *The Metal Stair Manual* published by the National Association of Architectural Metal Manufacturers (Fifth Edition, March 1992) is one of a number of resources available for design procedures, design aids, and examples.

Minimum Information for Bidding

Miscellaneous metal fabricators are manufacturers and not designers, per se. In general they are small companies, mostly 3 to 50 employees, with a majority being small family businesses with 10 to 20 employees. Most do not have the resources to have full time engineers or architects on staff. Thus, in order to assure public safety, and for a miscellaneous metal fabricator to responsively bid stair and railing work under a *DESIGN-FABRICATE* scenario, the Contract Documents should provide basic design criteria and a distinct scope of work. The following information should be included for a basic fire stair system that is to be competitively bid.

- Rough dimensioning — stair width and length and floor-to-floor height
- Stair supports — general concept
- Stair components — code-compliant shape and size of stringers and headers
- Railing system— code-compliant concept and handrail design
- Stair and railing finishes

The Guideline for Design-Fabricate

The following Guideline reflects the results of deliberations by a Task Group in the Boston area composed of architects (representing the Boston Society of Architects), structural engineers (representing the Boston Association of Structural Engineers), and steel fabricators (representing the Structural Steel Fabricators of New England). On average the Task Group met bi-monthly during 1992 and 1993, and, as the Guideline developed, conducted workshops to obtain feedback.

The primary objective was to develop a Guideline that, rather than attempt to assign legal responsibility or liability to particular disciplines, would define the *DESIGN-FABRICATE* scenario in terms of *TASKS* that each discipline is best equipped to undertake, in the interest of achieving the end product of code-compliant and safe stair and railing stairs for the public. As a secondary objective, the Group desired to refine a process that had become more confrontational (to every party's detri-

ment) in recent years due to the new realities of the marketplace.

As the Guideline is examined, design professionals should take particular note of the following.

✓ The architect should include structural engineer review of stairs and railings prior to releasing the project for bidding. In discussing the architect's basic service fee, the owner should be informed that the cost for this engineer's service will translate into more responsive bids and less likelihood of future backcharges and delays - and most likely a lower total cost. (Section 1.2)

✓ The architect should provide sufficient information in drawings and specifications for typical and atypical materials and components so that the project can be responsively bid under the DESIGN-FABRICATE scenario. Contract documents should be reviewed for code compliance, preferably with the structural engineer. (Sections 2.1, 2.2)

✓ A qualified fabricator should be consulted during early design stages for advice on connections, mounting, finishes and ease of fabrication and erection. (Section 2.1)

✓ Highlight in the drawings and specifications the stairs and railings that are highly visible and require greater care and craftsmanship than standard egress stairs. Generally, "monumental stairs" (Figure 2) require the greatest degree of care, and "interconnecting stairs" (Figure 3) that may be used frequently and may also serve as fire stairs, unless highly visible, probably would not require as much craftsmanship. With egress stairs intended for use only during a fire or other emergency, aesthetics are usually of minor concern. (Section 2.1)

✓ If possible, pre-qualify bidders and, if in doubt about a bidder's capability, require some documentation of experience. (Section 3.1)

✓ Unless they involve noncompliance, allow for variations to Contract Documents only after a bidder has been selected. If a credit is possible or fabrication can be made easier, state in the specifications that variations will be considered but that costs for new drawings and review for compliance must be borne by the fabricator. (Section 5.1)

✓ Requiring a pre-qualified fabricator to have non-highly visible fire or interconnecting stair designs certified by a design professional should not be necessary if the SER will be involved in their review.

Figure 3: Interconnecting stairs also are highly visible and should be highlighted in drawings and specifications. Photo courtesy of Leers Weinzapfel Associates

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Guideline For Contracting For Metal Stair And Railing Work: Design-Fabricate Scenario

The preferred scenario under which Contract Documents are issued for bids is when complete, code-compliant design of metal stair and railing systems is prepared and fully specified by the Design Professional(s) of Record. The purpose of this guideline is to assist all parties when, alternatively, metal stair and/or railing work is assigned as a DESIGN-FABRICATE package by the Contract Documents and bid accordingly.

1. OW/AR and AR/SER CONTRACTS

1.1 Architect of Record (AR) contracts with Owner (OW) to review the metal fabricator's submittals containing the final design of stairs and railings. OW is made aware that the cost of final design will be included in the fabricator's bid to the general contractor.

1.2 AR contracts with Structural Engineer of Record (SER) to review fabricator's stair submittals for structural adequacy per applicable codes.

2. CONTRACT DOCUMENTS

2.1 Contract Documents for DESIGN-FABRICATE metal stair and railing work contain sufficient information for fabricators to prepare responsive and timely bids. The Contract Documents, as a minimum, specify the following.

- **a)** Limits of stair and railing work to be bid.
- **b)** Type of stair and railing, and general dimensions including floor-to-floor eights and location and sizes of floor openings.
- **c)** Capacities of the structural frame at points where stair and railing systems are supported. Connections to points of support other than structural steel should be specified.
- **d)** Loadings, criteria, and regulatory provisions (accessibility, safety, etc.) that affect the design. Local and national codes and regulations should not have to be researched by fabricators to prepare bids.
- **e)** All architectural and aesthetic requirements that restrict the style, geometry, material, or member shapes or sizes of stair and railing systems. Specifying what the AR will not accept is just as important for bidders.
- **f)** Any requirement for the fabricator to have a stair or railing design certified in writing by a qualified design professional for structural adequacy. Alternative: Contract Documents require the fabricator to reference design procedures (such as the NAAMM Metal Stairs Manual and the AISC Manual of Steel Construction) or to submit calculations performed by the detailer.
- **g)** A listing of documents to be submitted for review by the AR or SER. Examples: shop drawings, calculations, references, procedures, etc.

2.2 Bidders for miscellaneous metals should receive a complete set of plans and specifications. Stair and railing fabricators normally supply other miscellaneous metals for the project. All pertinent components and details may not be shown on the architectural plans.

3. BIDDING

3.1 Contract Documents pre-qualify bidders for metal stair and railing work. Pre-qualification criteria available include: AISC Category Ib Quality Certification; membership in a relevant industry organization; experience and professional references; or a bid list approved by the AR.

3.2 During the bidding process a communication mechanism exists and adequate time is available for corrections to the Contract Documents that are identified by bidders.

3.3 Fabricators may bid stair and railing work using their standard details if not in conflict with Contract Documents. Economy of design and construction will be best served by allowing fabricators to bid using details best suited to their shop operations as well as erection safety and efficiency.

4. FABRICATOR's SUBMITTALS

4.1Shop and erection drawings should be submitted, showing all structural details and dimensions.

4.2 Written certification from a qualified design professional is submitted, but only if specified in the Contract Documents. The design professional should attest to the structural adequacy of the fabricator's design.

4.3 AR and SER review submittals for structural adequacy and compliance with Contract Documents. Extent of this review depends on the basis for selection of the metal fabricator, involvement of another design professional by the fabricator, or other factors.

4.4 Fabricator's designs and details are acceptable if structurally adequate and not in conflict with Contract Documents. Fabricators should not be expected to anticipate constraints on the design that were not specified in the Contract Documents.

5. FABRICATION AND ERECTION

5.1 Fabrication and erection conform to approved submittals. Deviations are not permitted unless approved by the AR/SER.

5.2 Fabricator is responsible for accuracy of detail dimensions and for fit-up in the field. However, the fabricator relies on the accuracy of dimensions provided in Contract Documents.