APEGBC

Professional Practice Guidelines

Designing Guards for Buildings

Professional Engineers and Geoscientists of BC

Structural Engineers Association British Columbia

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1.0 Introduction

1.1 Background

1.1.1 Guards are typically considered as secondary or non-structural elements of a building as they do not support the primary structure; however, guards play a significant role in public safety.

1.2 Purpose and Scope

1.2.1 The purpose of this document is to serve as a design guide for individual practitioners when preparing drawings and specifications in the design and implementation of guards used in buildings.

1.2.2 Specific requirements for guards may differ between authorities having jurisdiction. It will be the responsibility of the designer to be familiar with local requirements.

1.2.3 This document is not intended to be used as the standard for guard design. It is up to the individual designer to perform the required due-diligence in preparing the drawings and specifications. This document must not be used in a way that reduces any requirement specified in any applicable code, by-law or standard.

2.0 Review of Codes and Standards

2.1 The *National Building Code of Canada 2010* (*NBCC 2010*) is an objective-based code. The relevant objectives and functional statements with respect to guards are as follows:

- Objectives:
  - → OS2 Structural Safety
  - → OS3 Safety in Use
  - → OP2 Structural Sufficiency
- Functional statements
  - → F10: To facilitate the timely movement of persons to a safe place in an emergency.
  - → F20: To support and withstand expected loads and forces.
  - → F30: To minimize the risk of injury to persons as a result of tripping, slipping, falling, contact, drowning or collision.

2.2 The following summarizes selected criteria relevant to the design of guards as presented in the *British Columbia Building Code* (*BCBC 2012*) which is based on the *NBCC 2010*. See appendix A for excerpts taken from the codes and standards referenced below.

- *BCBC 2012* Division B - Part 3 Requirements: For commercial occupancies.
  - → Applies to areas for which access is provided for purposes other than maintenance.
  - → Requires that a guard be provided at a height of not less than 1070 mm from the finished floor where an elevation difference greater than 600 mm exists.
  - → The size of openings must not allow the passage of a sphere greater than 100 mm in diameter.
  - → Attachments or openings located between 140 mm and 900 mm above the finished floor must not facilitate climbing.
  - → Handrails where required must be graspable (if circular: 30 mm – 40 mm in diameter; or if square: 100 mm - 125 mm perimeter and 45 mm maximum cross-sectional dimension) and must be between 865 mm and 965 mm above the finished floor.
  - → Handrails must be designed to resist a concentrated load of 0.9 kN and a uniform load of 0.7 kN/m applied in any direction.
- *BCBC 2012* Division B - Part 4 Requirements: For structural design criteria.

- → The minimum specified horizontal load must be 3.0 kN/m for guards located at in a means of egress,
- → a concentrated load of 1.0 kN where gathering of many people is improbable, or
- → a uniform load of 0.75 kN/m or a concentrated load of 1.0 kN in other locations.

NOTE: These differences can be critical to both the design of the guards and the structure to which the guards are attached. These requirements should be very carefully stated in the design requirements.

- → Individual elements below or within the guard must be designed for a load of 0.5 kN applied over an area of 100 mm x 100 mm not to be considered concurrent with the horizontal guard load.
- → A vertical load of 1.5 kN/m applied at the top of the guard must be resisted but need not be considered to act simultaneously with the horizontal load.

- *BCBC 2012* Division B - Part 9 Requirements: For residential occupancies.
  - → These requirements are similar to those described in Part 3 and Part 4 as referenced above.
- WorkSafe BC requirements: Protection of workers.
  - → These legal requirements apply to all workplaces and arise from the *Occupational Health and Safety Regulation*. Enforcement of these regulations falls under the jurisdiction of WorkSafeBC.
  - → These requirements are intended to provide safe environments for workers in areas that are not specifically accessible to the public as defined in the above *BCBC* references.
  - → A guardrail consists of a top rail located 102 cm to 112 cm above the work surface and an intermediate rail located midway.
  - → It must be designed to withstand a load of 0.55 kN applied perpendicular to the span in a horizontal or vertical direction.
  - → It must not be made of fibre or wire rope without Board approval.
- CAN/CSB – 12.20-M89 STRUCTURAL DESIGN OF GLASS FOR BUILDINGS
  - → This is a limit states design code. The code addresses the brittle nature of glass where used as a structural material by stipulating that support members be designed with a redundant load path. The underlying principal being that if one member fails a cascading or catastrophic failure mechanism does not develop.

→ Free standing glass guards must have a top cap which spans over two or more panels and be designed to resist the factored load after failure of alternate panels.

→ The deflection of the guard at the point of application of the load, with all panels intact must not exceed 40 mm.

3.0 Design Considerations

3.1 A guard is meant to prevent an individual from falling from a higher elevation to a lower elevation. A guard should also create a sense of safety among building occupants.

3.2 Design of a guard must consider the following:

1. Where is a guard required
2. Dimensional requirements
3. Strength Design including the load path to the primary structure.
4. Serviceability (deflection / grasp-ability / climb-ability)
5. Relationship to Building Envelope
6. Aesthetics

3.3 When using aluminum, consideration should be made for the loss of temper and associated reduction in strength where welded connections are used. Refer to CAN/CSA S-157 Strength Design of Aluminum for Buildings.

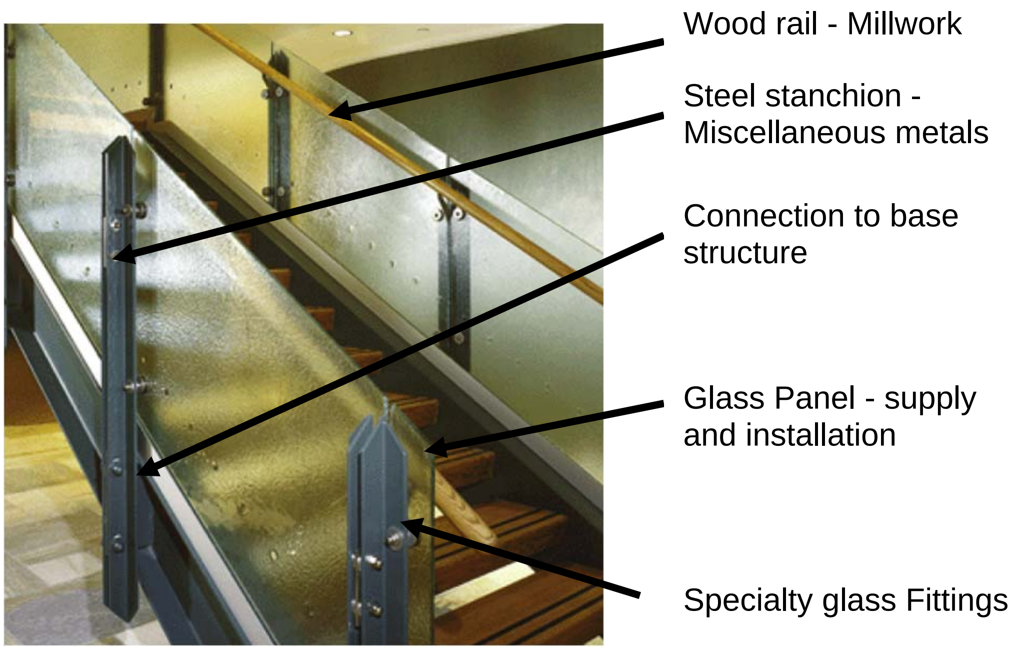
3.4 Special consideration must be given to the use of glass as guard elements. Some means of structural redundancy must be built into the system to prevent progressive collapse of the assembly following the failure of a glass member. In particular, when using tempered glass there exists a potential for spontaneous breakage due to impurities (also referred to as Nickel Sulfide inclusions). Refer to the design guides published by the Glazing Contractors Association of BC (now Fenestration BC) entitled: "*Glass Design to Human Impact Load*" and "Glass Guards and Balustrades".

3.5 Consideration should also be given to windows acting as guards where the sill extends below 1070 mm of the finished floor. In this instance the window must be treated as a wall separating the elevation difference and be designed to withstand the appropriate guard load. Further consideration should be given to operable sashes where there may be a risk of falling through the open window. Such windows must be equipped with a limiter to restrict the size of the opening. Although, there may be cases where operable windows are required to allow egress during a fire in which case there can be two contradictory code requirements.

3.6 In the cases of unique architectural designs, non-traditional construction methods or use of exotic materials (i.e. art glass or reclaimed timber) where the available codes and standards do not provide adequate guidance the designer may employ destructive testing. A guide for the load testing of guards has been developed and included in appendix B.

4.0 Continuity of Responsibility

4.1 The supply and installation of guards often involves multiple trade disciplines. In turn there may be several design professional involved in the design oversight for individual elements of the guard. For example a typical glass balustrade may include a specialty fitting supplier, a glass supplier, a glazing installer, a miscellaneous metals subcontractor as well as a millworker. Consider the figure below:



4.2 As a result there can be a discontinuity arising from the diffusion of design oversight. Each element may be the responsibility of a different design professional with little or no coordination between them. Notwithstanding, design oversight ultimately rests with the architect. Structural design of guards and their attachments is covered under the Architectural section of the BCBC Letters of Assurance.

4.3 When preparing shop drawings, the design professional must be carful to define their scope of work clearly while at the same time ensuring that connecting elements are suitable for the completed system. For example, if reviewing shop drawings for the glass elements only, it should be clearly stated that the design of the glass is based on the continuity of the rail and that the rail must be designed accordingly. In this instance, the designer providing a letter of assurance for the glazing component may insist that he have copies of the letters of assurance provided for the guard rail, stanchions and connections to base structure.

4.4 Designers may oversee individual elements. However, it is the responsibility of the designer to ensure that a competent load path exists and that a complete guard assembly is possible. Taking professional responsibility for one component in an assembly does not nullify the responsibility to also ensure that other components fit together to create a complete structural assembly including an appropriate attachment to the base structure.

4.5 Shop drawings should be prepared in accordance with the Guidelines on Shop Drawings published by APEGBC. The following basic elements must be identified on the shop drawings:

- Clearly show the elements for which design responsibility is assumed (e.g. use darker line types).
- Show the completed guard assembly and clearly identify the structural function and requirement for those components for which design responsibility is assumed to be by others.
- Identify the intended load path to the base structure.
- Show reaction loads.
- Show connection details.
- Provide general notes indicating materials used, design codes referenced, and description of the scope of work.
- Provide a plan drawing showing the extent and location of items.

5.0 Acknowledgements

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APPENDIX A - CODE REFERENCES

The following paragraphs are taken in whole or in part from the codes and standards referenced. The reader should refer to the document for the exact and most current wording. These citations are provided for reference only and should not be directly relied upon for design calculations.

<u>Part 3 Requirements</u>

3.3.1.18. Guards

3.3.2.9

3.4.6.5. Guards

3.4.6.4. (9) – for loads on handrails

<u>Part 4 Requirements</u>

4.1.5.15. Loads on Guards

[See Appendix A]

<u>Part 9 Requirements</u>

9.8.8. Guards

9.8.8.1. Required Guards

[See Appendix A]

[See also Article 9.7.5.3.]

Table 9.8.8.2

<u>WorkSafe BC requirements</u>

Section 4.54 of the *Regulation* provides the following definitions:

In sections 4.54 to 4.63

In sections 4.55 guardrail locations are prescribed as follows:

Section 4.58(4) of the *OHS Regulation* (*"Regulation"*) states:

Refer to Worksafe BC OHS regulations.

<u>CAN/CSB – 12.20-M89 STRUCTURAL DESIGN OF GLASS FOR BUILDINGS</u>

7.1 Glass Guards and Balustrade

Appendix A3.1 Glass can be used as a structural material, as it is both strong and rigid. The main distinguishing characteristic of glass is its brittleness. Consequently when glass is used as a structural component it must be designed to withstand the design loads, to accommodate all movements of its supporting members and have a redundancy of at least one fail-safe load path in the event of the failure of a component.

Appendix A5. Glass Guards and Balustrades

A5.1 When a brittle material with variable mechanical properties like glass is used as a structural component with the potential for catastrophic consequences in the event of failure, both increased load factors and alternative load paths are required in the design. For glass guards and balustrades the standard addresses these factors by the requirement for alternate lights be assumed failed in the strength determination, and a rigid continuous guard over two or more lights.

A5.2 Glass guards may have exposed edges and as glass edges are intrinsically weak, especially with thin glass, the designer should give consideration to “hard body” impact at the edges and provide protection if necessary. Examples of hard body impact include stones and floor cleaning equipment.

A5.3 The fixing of the glass at the base must ensure that all bending moments can be resisted and that rotation is minimized. An expanding grout may be used to fix glass. When supporting fins of glass are used they must be fixed by friction bolts or adhesive in accordance with established engineering principals.

APPENDIX B - GUIDE FOR TESTING OF GUARDS

Scope

While suppliers often state that their testing shows that guards have more capacity than required; the testing methods used, the load levels applied and the failure mode are not always provided or evident. This Appendix is intended to address these questions.

Design of Guards

1) Guards must be designed to the applicable CSA design standard(s) for the material(s) used in their construction for the loading specified in NBC 4.1.5.15.
2) In lieu of the design requirements in 1), guards design may be accepted on the basis of load testing complying with the following paragraphs.
3) All guards must be tested in accordance to Clause 13 of CSA S157-05 unless there are equivalent testing requirement in the related material standard.
4) ASTM E985 may also be referenced for defining test methods pertinent to permanent metal railing systems and rails.
5) Guards must be tested in an approved testing laboratory (or equivalent as deemed by the Professional Engineer) under the supervision of a Professional Engineer. some manufactures may be able to install good testing setups and therefore not need the use of a testing laboratory but then the P. Eng. should direct the test and certify that the testing equipment meets the requirements of ASTM E 935.
6) The testing must be carried out in accordance with ASTM E935 - Standard Test Methods for Performance of Permanent Metal Railing Systems and Rails for Buildings latest edition as suggested by Clause 13.2.2 of CSA S157-05. Railings must be tested by methods A, B, C and D if applicable.
7) The loads to be used in the tests must be based on the specified loads from NBC 4.1.5.15.
8) The applied forces for the ultimate limit state testing as required by Clause 13.2.1.2 must be:
    a) A factored load of 1.67 times the specified load without any yielding of the assembly ($\Phi = 0.9$)
    b) A factored load of 2.0 times the specified load if the failure mode is ductile ($\Phi = 0.75$).
    c) A factored load of 2.25 times the specified load if the failure mode is brittle ($\Phi = 0.67$).
9) The resistance of the Guard must be taken as the characteristic resistance in accordance to Clause 13.3.2.1.
10) For glass guards refer to ASTM E 2353 “Standard Test Methods for Performance of Glass in Permanent Glass Railing Systems, Guards and Balustrades”.

APPENDIX C – CASE STUDIES

The following case studies are intended to illustrate different scenarios that may be encountered with an engineered guard assembly. These cases are fictitious and are intended to provide anecdotal precedents in partitioning design responsibility among different stakeholders in the construction team.

Scenario 1: Traditional new construction project involving a Part 3 building with an architect and base building structural engineer. The building is a typical Lower Mainland concrete tower with guards surrounding exterior balconies. The work is proceeding under a permit granted by the respective authority having jurisdiction. The guards proposed for this project include aluminum posts and top rail with glass in-fill.

Key Roles defining areas of professional responsibility:

1. Architect – Contract is with the Owner; has signed the letters of assurance (Schedule B) assuming responsibility for the architect's scope which includes the purview over structural design and attachment of guard components.
2. Base Building Structural Engineer – Contract is with the Architect; has signed letters of assurance (Schedule B) assuming responsibility for the structural integrity of the base building including effects of secondary components such as guards and their attachments to the base building.
3. Specialty Structural Engineer – Contract is with the supplier / sub-contractor who is in turn contracted to the general contractor; has signed a letter of assurance (Schedule S – in accordance with bulletin K).

Key interactions during the course of construction:

1. Architectural drawings and specifications provide general details of form including shape, color, overall dimensions and materials of construction for the proposed guards.
2. General contractor engages a sub-contractor to provide a proposed system to generally conform to the Architectural specifications. The sub-contractor provides shop drawings detailing all aspects of the proposed guard. An initial submission may not be stamped as it may be incomplete and intended to solicit feedback from the architect about specific design characteristics that may be entirely aesthetic.
3. Once such details are agreed upon, the sub-contractor will submit a set of shop drawings that bear the seal of a professional engineer registered in British Columbia. These shop drawings should include all relevant details to show the structural function of the assembly including materials used, fasteners, and how the guard interacts with the base building including indication of the forces transferred to the base building. These shop drawings are forwarded on to the Architect via the General Contractor.
4. Design by Specialty Engineer to provide connection to the primary structure and must include the design of collateral secondary elements as necessary to pass the

load through to the primary structure. If connecting to a steel stud, for example, the shop drawings must indicate the requirement for the connection (e.g. 18 ga steel stud required at the guard attachment).

5. Specialty Engineer to follow instructions for connection to primary structure as provided by the Structural drawings. This engineer must contact the base building Structural Engineer of Record to discuss any anchorage concerns.
6. The Architect will review the shop drawings and forward a set of the drawings to the base building Structural Engineer to review the guards for their effect on the base building. The Structural Engineer will not review the structural adequacy of the guard assembly but he will review the adequacy of the proposed fasteners to transfer the guard loads to the base building.
7. Once the shop drawings have been reviewed and accepted the installation will proceed. During the installation, the specialty engineer acting for the sub-contractor should visit the site at his discretion to conduct field reviews as required and as defined in Bulletin K. The scope of the field review should align with the scope of responsibility defined in the sealed shop drawings.
8. At completion of the installation the specialty engineer will submit the Schedule S. If required, he will contact the base building structural engineer to clarify any matters that relate to the structural interaction between the guard assembly and the base building. This is a declaration that the specialty engineer makes in signing the Schedule S. This is consistent with the following statement in the Model Schedule S-B Assurance of Professional Design and Commitment for Field Review which reads as follows:

I confirm I have liaised as required with the appropriate Registered Professionals for the purposes of my services.

<u>Additional Comments</u>

Scenario 1 is likely the most common that will be encountered in typical lower mainland construction projects. There are a number of similar variants of this scenario that warrant further discussion as follows:

<u>Scenario 1a:</u> New construction project with guard assembly incorporating several engineered components. This will be similar to Scenario 1 yet more demanding for the coordinating professional as there will be a number of specialty engineers involved in defining the completed assembly. Some components will interact with the base building, while others will interact with other specialty components. Ensuring against conflicting requirements as well as gaps in responsibility will be a significant challenge in this scenario.

A modification to the definition of the key players is as follows:

1. Multiple Specialty Structural Engineers – Contracts will be with a number of the suppliers / sub-contractors who are in turn contracted to the general contractor; each have signed letters of assurance (Schedule S – in accordance with bulletin K).

Scenario 1b: Another common case on Part 4 buildings occurs where there are a variety of guard elements that are fabricated from a "basic" material, say structural steel. For example: common steel picketed guard/handrail in a concrete stairwell, to be fabricated by the steel fabricator or possibly the miscellaneous metals fabricator if such a sub-contract is in place.

Often these items can fall into the lap of the base building Structural Engineer which will be the case if all the details of the guard assembly are shown on the structural drawings or on the architectural drawings with some structural comments.

Other times the fabricator goes ahead and prepares shop drawings based on the architect's drawings. Often, the shop drawings contain a variety of structural problems that are revealed following review by the Structural Engineer.

It is recommended that a specialty engineer be engaged in these circumstances. The requirement for engineering should be no different than for other pre-engineered components such as open web steel joists or commercial glazing assemblies.

This should be made clear in the specifications. Typically miscellaneous metals are defined in the Division 5 specifications. However, any project that includes guards should include a separate specification to cover all guard assemblies. This would cover "architectural" guard assemblies that might be typically encountered in living spaces like balconies and mezzanines as well as utilitarian guards that might be typically seen in exit stairs and parkades.

Appendix D contains an example generic NMS Master Format Specification.

Scenario 2: Proprietary Guard system involving a "pre-engineered" guard assembly essentially "ordered out of a catalogue.

Key Roles defining areas of professional responsibility:

1. Architect – Contract is with the Owner; has signed the letters of assurance (Schedule B) assuming responsibility for the architect's scope which includes the purview over structural design and attachment of guard components.
2. Base Building Structural Engineer – Contract is with the Architect; has signed letters of assurance (Schedule B) assuming responsibility for the structural integrity of the base building including effects of secondary components such as guards and their attachments to the base building.

Key Interactions during the course of construction:

1. Architectural drawings and specifications provide a specific product to be installed. Shop drawings may or may not be required depending on the nature of the product and project. However, it is still essential for the Structural Engineer to be made aware of the fastening method and configuration such that he can provide suitable base building structure to resist the guard loads.
2. General contractor purchases product and installs it as per the manufacturers' instructions.

3. guard supplier must provide capacity criteria and installation details for all aspects including base connection (use hilti products for example).
4. In this case there is no need for a specialty engineer as the architect assumes the design responsibility of the system. They may rely on pre-engineering that has been completed by the manufacturer. This will be entirely at the Architect's discretion. Regardless of what information the architect relies upon, he will assume responsibility for assuring all building code requirements related to the guard assembly including those defined in Part 4.

Scenario 3: Renovation project with no architect. Engineer acts as prime consultant, building envelope engineer and structural engineer.

Key Roles defining areas of professional responsibility:

1. Prime consultant engineer - Contract is with the Owner; has signed the letters of assurance (Schedule B) assuming responsibility for the architect's scope which includes the purview over structural design and attachment of guard components.
2. Specialty Structural Engineer – Contract is with the supplier / sub-contractor who is in turn contracted to the general contractor; has signed a letter of assurance (Schedule S – in accordance with bulletin K).

Key Interactions during the course of construction:

1. These will similar to the interactions defined in Scenario 1.
2. The prime consultant should include a structural engineer to cover the review of structural effects to the base building. The Structural Engineer will be expected to sign letters of assurance to cover the Part 4 requirements of the permit application.

Scenario 4: Renovation project with no base building Structural Engineer. Such projects might include a simple renovation project where the permit application is made by a designer (i.e. not registered with AIBC), a general contractor, or Homer Owner. Such projects would typically include a residential renovation (i.e. addition of balcony or patio).

Key Roles defining areas of professional responsibility:

1. Designer, General Contractor, Home Owner – There are no letters of assurance; permit is granted under purview of the building inspector (in the City of Vancouver this is sometimes referred to as a "field review" permit).
2. Specialty Structural Engineer – Contract may be with the Owner, General Contractor, Or Supplier; must take responsibility for the specialty item as well as the effect on the base building.
3. Building Inspector – Represents Authority Having Jurisdiction; will conduct field reviews to ensure permit and building code compliance; will request engineering on various components as he sees fit during the course of his inspections.

Key Interactions during the course of construction:

1. The guard assembly will be installed by the Owner directly or by a contractor.
2. Once complete and prior to granting occupancy (i.e. closing the permit) the building inspector may request letters of assurance. There may be a number of components that will require letters of assurance such as engineered wood products (e.g. truss joist glulam header) or guards.
3. The Specialty Engineer should submit Letters of Assurance including Schedule B and C-B. These letters are different from the Schedule S because they will require that the engineer take responsibility for the connection to the base building and the effect on the base building. The Letters of Assurance will be addressed to the building inspector.
4. The Specialty Engineer should take special precautions in accurately defining his scope of responsibility as he will likely be the only professional engineer in the project.

APPENDIX D – MODEL SPECIFICATION FOR GUARDS

The following is intended to be an example of a specification that might be used to define the requirements for a guard assembly.

1.0 GENERAL

1.1 WORK INCLUDED

1.1.1 Guards, guard rails and handrails indicated on the drawings.

1.1.2 Glass infill panels.

1.2 1.2RELATED WORK

1.2.1 Section 09900 – Finish Painting

1.2.2 Section 08800 - Glass

1.3 1.3REFERENCE STANDARDS (Most recent version unless noted otherwise)

1.3.1 CAN/CSA-S16.1, Limit States Design of Steel Structures.

1.3.2 CAN/CSA-S157, Limit States Design of Aluminum Structures.

1.3.3 CAN/CSA-O86.1, Limit States Design of Wood Structures.

1.3.4 CAN/CGSB-12.20, Structural Design of Glass for Buildings.

1.3.5 CAN/CGSB-12.1, Glass, Safety, Tempered or Laminated.

1.3.6 American Architectural Manufacturers Association.

1.3.7 ASTM A269, Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.

1.3.8 CAN/CSA-G40.20/G40.21, General Requirements for Rolled or Welded Structural Quality Steel.

1.3.9 CAN/CSA-G164, Hot Dip Galvanizing for Irregularly Shaped Articles.

1.3.10 CSA W59, Welded Steel Construction (Metal Arc Welding).

1.3.11 CSA W59.2, Welded Aluminum.

1.4 DESIGN CRITERIA

1.4.1 Loads and load factors are determined in accordance with the National Building Code and the bylaws of the local municipality. Resistances must be determined by the applicable material design standards.

<Spec note: Is loading for egress from assembly areas required? If so there can be significant loads transmitted to the base structure. This should be coordinated with the base building structural engineer.>

1.5 SUBMITTALS

1.5.1 If requested, submit three (3) certified copies of mill reports covering chemical and mechanical properties, and coating designation of steel used in this work.

1.5.2 Submit samples of framing and fastener components to Consultant if requested.

1.5.3 Submit duplicate samples of joining and finishes to the Consultant for approval.

1.5.4 Product Data

.1 Submit product data for mechanical fasteners, indicating sizes, shear, and pull-over loading capacity where applicable. Provide data indicating thickness and type of corrosion protection coating.

.2 Submit product data indicating suitability of explosive powder actuated fasteners for application.

1.5.5 Shop Drawings

.1 Shop drawings must incorporate plans, all elevations, sections and full size details for all work in this section. Completely detail items indicating all dimensions and methods of fixing, field jointing, attachment to building structure, size, thickness, gauges of metals and fasteners in accordance with APEGBC Guideline For Shop Drawing Preparation.

.2 No work must be fabricated until the shop drawings and samples have been reviewed by the Consultant. The Consultant’s review must be for conformity to the design concept, for general arrangement only and such review must not relieve the Contractor of any of their responsibilities.

.3 Shop drawings must be sealed by a Professional Engineer.

.4 The Engineer who sealed the shop drawings must provide periodic field review. Written inspection reports of field review must be submitted to the Consultant promptly as field reviews are made.

1.5.6 Submit evidence of welder qualifications specified in this Section.

1.5.7 Maintenance Data:

.1 Submit data covering the care, cleaning and maintenance of finishes for incorporation in maintenance manuals.

.2 Letters of Assurance: The Engineer who sealed the shop drawings must submit to the Consultant with the initial shop drawing submission, an Assurance of “Structural Design” and commitment for “Field Review”.

1.6 QUALITY ASSURANCE

1.6.1 Contractor to provide proof of manufacturer training for installation of proprietary fastener systems.

1.6.2 Welding must be by company certified by the Canadian Welding Bureau to CSA W47.1-92, Certification of Companies for Fusion Welding of Steel Structures.

1.6.3 Any glazed elements should be completed by Journeymen glaziers and be members in good standing with the provincial glazing contractors association.

1.7 DELIVERY, STORAGE AND HANDLING

1.7.1 Exercise care in storing, handing and erecting all material and support all materials properly at all times so that no piece will be bent, twisted or otherwise damaged structurally or visually.

1.7.2 Correct damaged material and where damaged is deemed irreparable by the Consultant, replace the affected item at no additional expense to the Owner.

1.7.3 Fabricate large assemblies so they can be safely and easily handled to their place of installation.

1.8 MOCK-UP – GUARD AND HANDRAILS

<Spec note: Delete if not required.>

1.8.1 Provide a complete mockup of a guardrail and or handrail on site for review by the Consultant. Make revisions to mockup as required by the Consultant.

1.8.2 Mock-up must include all components of the system, including typical joints and connection hardware, and typical tie-ins to adjoining systems, all finished as specified.

1.8.3 Modify the mock-up at no additional cost to the contract as may be required to meet design and performance requirements.

1.8.4 Mock-up, if deemed to be in general conformance with the Specifications and Drawings by the Consultant, must remain on site as finished part of the work.

1.9 SITE CONDITIONS

1.9.1 Ensure temperature and ventilation conditions are maintained for various components and materials of the system, as required by manufacturer.

1.9.2 Protect work of other sections and subtrades from damage resulting from work of this section.

1.9.3 Take necessary care to avoid damage of adjacent surfaces.

1.9.4 Examine the underlying visible surfaces and adjoining work and report defects at time of installation, which might impair the work of this section to the Consultant, in writing.

1.9.5 Commencement of work must imply acceptance of surfaces.

1.9.6 Cooperate with other trades to accommodate fixtures and attachments in the system.

1.10 REVIEW

1.10.1 The Design Engineer, responsible for the production of the shop drawings, must provide periodic field review during construction and must submit reports.

1.10.2 Additional inspection and testing of materials workmanship may be carried out by a qualified independent Inspection Agency appointed by the Consultant.

.1 The cost of this additional inspection must be paid by the Owner.

.2 Any testing or inspection required by the Consultant because of an error by the Contractor or due to departure from the contract documents by the Contractor, must be paid for by the Contractor.

1.10.3 Review must include

.1 Checking that mill test reports are properly correlated to materials.

.2 Sampling fabrication and erection procedures for general conformity to the requirements of the specification.

.3 Checking that the welding conforms to the requirements of this specification.

.4 Checking fabricated members against specified member shapes.

.5 Visual inspection of all welded connections including sample checking of joint preparation and fit-up.

.6 Sample checking of screwed and bolted joints.

.7 Sample checking that tolerances are not exceeded during fit-up or erection.

.8 Additional inspection and testing of welded connections as required by CSA W59.

.9 General Inspection of field cutting and alternations required by other trades.

.10 Submission of reports to the Consultant, the Contractor, and the authorities having jurisdiction covering the work inspected with details of deficiencies discovered.

1.10.4 The Contractor must provide the necessary cooperation to insure that the review can proceed.

1.10.5 The review provided in this section does not relieve the Contractor of their responsibility for the performance of the contract. The Contractor is solely responsible for quality control and must implement their own supervisory and quality control procedures.

1.10.6 Materials or workmanship not conforming to the requirements of the contract documents may be rejected at any time during the progress or work.

2. <u>PRODUCTS</u>

2.1 MATERIALS

<Spec note: Specify materials in this section or refer to appropriate Section, i.e. 05500 Metal Fabrications or 08800 Glass and Glazing>.

2.2 ANCHORING AND CONNECTION

<Spec note: Specify connectors in this section (proprietary connectors, inserts, screws, welding) or refer to appropriate Section, i.e. 05500 Metal Fabrication or 08800 Glass and glazing.

2.3 FINISHES

<*Spec note: Specify finishes in this section (galvanized, chromium plated, or painted steel) or to appropriate Section, i.e. Section 09900 Finishes)*

3. EXECUTION

3.1 GENERAL

3.1.1. Fabrication and erection must conform to the shop drawings. Modifications required to accommodate as-built conditions, other than minor dimensional changes, must be submitted for approval.

3.2 PREPARATION

3.2.1 Prior to start of erection, examine the work of the other sections upon which the work of this section depends and report to Consultant any unsatisfactory conditions.

3.2.2 Examine and obtain all necessary measurements of previously executed work that may affect the work to this Division.

3.3 ERECTION

<Spec note: Add specific installation/erection requirements here, or refer to appropriate Section>.

3.4 TOUCH-UP AND CLEANING

3.4.1 Touch-up rivets, field welds, bolts and burnt or scratched surfaces after completion of erection using primer for primed components and zinc-rich paint for galvanized components to match original finish.

3.4.2 Touch up damaged finishes.

END OF SECTION