

Annotated Dewhurst Macfarlane AESS specification

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05 12 13 - ARCHITECTURALLY EXPOSED STRUCTURAL STEEL (AESS)

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 "Specifications" Section, apply to this Subsection.
- B. For definitions of Categories of AESS 1, 2, 3, 4, and C see Table 1 "AESS Matrix"

The matrix referenced here was created by the CISC specification committee. It categorizes AESS work in to 5 subcategories using criteria such as viewing distance and context.

1.2 SUMMARY

- A. This Subsection includes requirements regarding the appearance, surface preparation and integration of Architecturally Exposed Structural Steel (AESS) only.

For technical requirements, refer to the other Subsections of Division 5 "Structural Steel" Section. This Subsection applies to any structural steel members noted on Structural Design Documents as AESS. All AESS members must also be identified by their Category.

- B. Related Sections: The following Sections contain requirements that may relate to this Subsection:

- 1. Division 1 "Quality Control" Section for independent testing agency procedures and administrative requirements;
- 2. Division 5 "Steel Joist" Section;
- 3. Division 5 "Metal Decking" Section for erection requirements relating to exposed steel decking and its connections;
- 4. Division 9 "Painting" Section for finish coat requirements and coordination with primer and surface preparation specified in this Subsection.

1.3 SUBMITTALS

- A. General: Submit each item below according to the Conditions of the Contract and Division 1 "Specifications" Section.

- B. Shop Drawings detailing fabrication of AESS components:

- 1. Provide erection drawings clearly indicating which members are considered as AESS members and their Category;
- 2. Include details that clearly identify all of the requirements listed in sections 2.3 "Fabrication" and 3.3 "Erection" of this specification. Provide connections for AESS consistent with concepts, if shown on the Structural Design Documents;
- 3. Indicate welds by standard CWB symbols, distinguishing between shop and field welds, and show size, length and type of each weld. Identify grinding, finish and profile of welds as defined herein;

Many weld processes (such as plug welds, slot welds, tacks, intermittent or flush ground welds) are specific to AESS work and not part of a typical structural fabricators certified procedure repertoire. In addition, many require the addition of components and features that might not be present in the contract drawings issued by the architect or engineer and these must be capable of bearing the same loads the original design called for.

The added material should not be considered an extra, but rather part of the work required to meet the visual criteria of the AESS spec.

Be sure to note that the fabricator may need to obtain certification for the welds to be used, or the project could be stalled for months while post-weld testing is done on suspect welds.

4. Indicate type, finish of bolts. Indicate which side of the connection bolt heads should be placed; use flathead fasteners, rear face studs, zero-clearance locating pins or other low visibility / tight tolerance fasteners to the greatest extent possible

The location and type of fasteners is of prime importance in AESS work. In general, if fasteners are required the architect will want to see them minimized, ordered neatly and have decorative heads such as hex-socket cap screws. An alternative approach is to use custom machined pins and retainers with internal (hidden) threads.

5. Indicate any special tolerances and erection requirements.

Standard fabrication and erection tolerances are quite generous by architectural standards, so be sure to define the tolerance you want, be it hairline joints, +/- 1/8" / 2 mm etc.

Especially troublesome is any spec defining allowable deviation from a true line or plane. If the value is defined as being proportional to length or width, and the object is 100 feet long, the variation can be very large and still comply.

C. The following schedule and conditions shall pertain to the shop drawing review process:

1. The engineer of record shall have 10 business days to review the drawing after receiving them.
2. Contractor shall submit shop drawings for review a minimum of 20 business days prior to requiring them on site, including any time required need for resubmission. The time does not absolve the contractor or any time that may be required for the resubmission and review of submittals.
3. The architect, engineer and owner shall not be held liable for any costs or delays in the project resulting from insufficient time to review shop drawings, the failure of the contractor to submit drawings in a timely manner, or resubmissions resulting from shop drawings being marked "Revise and Resubmit" or "Rejected" (or some equivalent language or wording).
4. The architect, engineer and owner will also not be held liable for cost and or delays in the project resulting from shop drawings which were resubmitted for approval to the architect and engineer in error, such as drawings which are marked "Proceed as noted, submit corrected copy for record" (or some equivalent language or wording).
5. The contractor must factor in any additional time which may be required for a resubmission into there submittal review and construction schedules.
6. Only shop drawings marked "No Exceptions Taken" and "Furnished as Noted" (or some equivalent language or wording) may be used by the contractor to commence work. Shop drawings marked "Revise and Resubmit" and "Rejected" (or some equivalent language or wording) shall be corrected and completed as required and resubmitted for approval to the architect and engineer. They may not be used to commence work.
7. The architect, engineer and owner shall not be held liable in any way (financial, time delays, etc) for any materials and works which must be removed, reworked or replaced

prior to the receipt of the appropriate approved submittal. Any work completed by the contractor prior to the receipt of the appropriate approved submittal is done at the full risk to the contractor.

The emphasis on time is intended to prevent either the fabricator or contractor from using the pressure of time as an excuse to force through low-quality work or to charge extras for complying with a diligent submittal regimen.

8. Shop drawings must be in full compliance with Building Code Requirements.

This requirement is a pitfall for the unwary, as it requires the fabricator to consider and implement issues such as resonance, railing spacing, rise / run relationships, handrail strength, etc. which may not have been fully or correctly defined in the contract documents.

1.4 QUALITY ASSURANCE

- A. Fabricator Qualifications: In addition to those qualifications listed in other Subsections of Division 5 "Structural Steel" Section, engage a firm competent in fabricating AESS similar to that indicated for this Project with sufficient production capacity to fabricate the AESS elements.
- B. Erector Qualifications: In addition to those qualifications listed in other Subsections of Division 5 "Structural Steel" Section, engage a competent Erector who has completed comparable AESS work.

Taken together, these two items by themselves should prevent non-compliant bidders from bidding and deficient work from reaching the field. The problem arises if the evaluation of the proposed fabricators' references is incomplete, or if a "look the other way" attitude results from conflicting price / quality criteria. Also some unique and original work can present challenges that even the most experienced fabricators will find challenging.

- C. Comply with applicable provisions of the following specifications and documents:

1. ASTM A6 - Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling, latest edition
2. AISC Code of Standard Practice, latest edition.
3. AWS D1.1 "Structural Welding Code", latest edition
4. SSPC Painting Manual, latest edition
5. SSPC Surface Preparation Specifications and Practices, latest edition

Unfortunately, standard structural industry practices do not treat steel or steel finishes with adequate care for high-end AESS work. Therefore special consideration must be given to appearance during purchasing, selection, logistics and handling if the raw material is to arrive at the fabricators plant in acceptable condition for use in AESS work.

- D. Visual samples shall include the following:

1. Physical sample of surface preparation and welds using material of full thickness and weld procedures and positions identical to production

The issues of thickness, position and process are mentioned here, because it is very difficult to produce a full-penetration, x-ray quality AESS weld in positions such as overhead. The inclusion of this line might force a re-think of the design, so as to eliminate troublesome material / connection / position combinations, as I do when designing the structures for objects such as stairs.

2. First off inspection: First element fabricated for use in finished structure subject to alterations for subsequent pieces. This inspection may also be considered the inspection of the full scale mock-up.
3. Mockups: Full- scale Mockups are to demonstrate aesthetic effects as well as qualities of

materials and execution:

- a. Mockups may have finished surface (including surface preparation and paint system);
- b. Architect's approval of mockups is required before starting fabrication of final units;
- c. Mockups are retained until project is completed;
- d. Approved full-scale mockups may become part of the completed work.

The staged approach to review (samples, mockups, full-scale work) provides the maximum number of opportunities for "intervention" by the design team and avoids the problem of a project developing momentum which prevents a fix from being implemented due to the amount of work already completed and schedule constraints.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Ensure that all items are properly prepared, handled and/or packaged for storage and shipping to prevent damage to product.
 1. Erect finished pieces using threaded eyes, softened slings or other methods such that they are not damaged. Provide padding as required to protect while rigging and aligning member's frames. Weld or bolt tabs for temporary bracing and safety cabling only at points concealed from view in the completed structure or where approved by the Architect.

The centre-of-gravity (COG) tools in parametric programs like SolidWorks are very useful for the planning of handling procedures to be implemented during shipping and erection of AESS work. With these tools it is possible to pre-define handling points and predictively install handling features such as threaded pad eyes. This approach eliminates much of the danger and marring that results from the use of sledgehammers and pinch-bars to coax material in to position.

PART 2 – PRODUCTS

2.1 MATERIALS

- A. Structural Steel Shapes, Bars and Plates
 1. Steel Plate: ASTM A36
 2. W Shapes: ASTM A992
 3. L, C and MC Shapes: ASTM A36
- B. Structural Bolts
 1. High Strength Bolts: ASTM A325 or F1852

2.2 SPECIAL SURFACE PREPARATION

- A. Surfaces that are to be painted or filled must be cleaned using steam or hot water in conjunction with trisodium phosphate (TSP) or other similar cleaning agent.

This spec has been inserted in lieu of the "solvent cleaning" spec often found here. Apart from the hazards of using solvent-soaked rags in a shop where welding is done, the use of solvents simply spreads the oils and grease around, as the solvent is not used in sufficient quantities to actually dissolve and flush away contamination.

Only copious mixed hot water / steam blasting, with the addition of cleansers like TSP can remove all surface contamination. As a simple test, steel that is properly cleaned will rust in just a few hours.

- B. Primers: See Architectural Drawings
- C. Paint System: See Architectural Drawings

- D. Epoxy Filler: Product data, application procedure, location and anticipated thickness of filler must be submitted for approval prior to commencement of work.

AESS work often requires the use of filler, which must be a robust variety suited to the service conditions.

2.3 MATERIAL SELECTION AND PREPARATION

- A. Materials to be used in the structure shall be selected for visual criteria, straightened in advance of cutting, or straightened during the fit up process. Material used shall be free of visual defects such as pits, rolled in scale, roll marks or waves, gouges, inclusions, lamination failures, clamp marks, hammer marks, etc. which cannot be removed by invisible rescue welding and grinding.

This is actually the most challenging part of the AESS spec to implement, because, as previously mentioned, most suppliers are not on board, and so the fabricator will require a good working relationship with their suppliers to meet this component of the spec. This may include walking the warehouse, rejecting some plate etc.

2.4 FABRICATION

- A. For the special fabrication characteristics, see Table 1 – AESS Category Matrix. Structure to meet the AESS requirements as specified on the construction drawings.
- B. Fabricate and assemble AESS in the shop to the greatest extent possible. Locate field joints in AESS assemblies at concealed locations or as approved by the Architect.
- C. Fabricate AESS with surface quality consistent with the AESS Category and visual samples if applicable.
- D. Transitional grinding of material which has not had the scale removed on flat or gently curved exposed surfaces is not permitted.

Two adjacent components are often joined by welding and the welds are then ground flush. Because the scale on the steel is much harder than the steel itself, the transition from scale to bare steel is visible on the surface as irregular lines parallel to the ground area. To avoid this problem, steel which will be flush ground after welding should be sandblasted prior to welding.

- E. The use of aids such as clamps, jigs, fixtures and strongbacks is required during fit up and welding so as to ensure the work remains geometrically true and straight so as to ensure that sweet lines are achieved throughout the workpiece after welding is complete.

Steel which is welded without restraint will warp as the welds cool and shrink.

- F. The use of filler is not permitted in thicknesses greater than 1/8" and shall be applied only to freshly sandblasted steel and shall be covered by a primer / paint suitable for both filler and base material.

Scale has no "tooth" and is not bound structurally to the steel below it, so even filler which is correctly applied may simply flake off, or fall off with the scale stuck to its underside.

- G. Cold rolled material should be used to the greatest extent possible.

Cold-rolled material is straighter, dimensionally more perfect and a lot more expensive than hot-rolled steel. Alternatives include hot-rolled pickled and oiled plate.

2.5 SHOP CONNECTIONS

- A. Bolted Connections: Make in accordance with Section 05120. Provide bolt type and finish as specified and place bolt heads as indicated on the approved shop drawings.
- B. Welded Connections: Comply with AWS D1.1 and Section 05120. Appearance and quality of welds

shall be consistent with the Category and visual samples if applicable. Assemble and weld built-up sections by methods that will maintain alignment of members to the tolerance of this Subsection.

1. Welded connections between components shall be designed so tensions due to shrinkage are balanced. Materials shall be pre-heated as required prior to welding so as to avoid locked-in thermally-induced warpage.
2. Welds shall be executed in a suitable rotation (tacking and stitch welding) or in such a sequence (multi-pass) so as to avoid thermally-induced and asymmetrical stress accumulation.

All of the procedures mentioned in this section should be SOP, but unfortunately they are poorly understood by most fabricators. Site visits will be required to ensure that these practices are implemented correctly as it will be "too late" to fix the problems once the material is fully welded.

2.6 ARCHITECTURAL REVIEW

- A. The Architect shall review the AESS steel in place and determine acceptability based on the Category and visual samples. The Fabricator/Erector will advise the consultant the schedule of the AESS Work.
- B. The architectural review for initial acceptance for installation and final acceptance of installed/erected work shall be done in accordance with section 2.7 – Acceptance Criteria

2.7 ACCEPTANCE CRITERIA

- A. The structure shall be approved for installation following a visual inspection by the owner's designated representative. The visual inspection shall be conducted under the following test conditions.
 1. The structure shall be located so that it can be viewed from all sides (top, bottom, front, back, left right).
 2. The ambient light shall best approximate the average lighting condition under which the structural will be typically viewed.
 3. A movable spot light with an intensity equal to approximately twice the average lighting condition shall be shown on the structure. The spot light shall be adjusted such that the light strikes the structure at an angle 90 degrees to the face (i.e. perpendicular) to 20 degrees (i.e. raking) to the face. The lighting shall be positioned as to produce the worst visual appearance of the structure. The lighting condition shall be repeated on all sides required by the owner's designated representative.

This section describes a raking light test procedure which is borrowed from the automotive and cabinetmaking industries. In a cabinetmakers finishing area, or at the end of an autobody paint area, are always found either a window, or a bank of fluorescent lamps. To evaluate the quality of a surface, the tradesman positions himself so the light source is reflected off the surface, which reveals every imperfection. Illuminating the object in this way the spec describes highlights surface imperfections that would be visible due to street lighting, sunlight, etc.

- B. If the structure is found to be visually acceptable to the owner's designated representative, the structure may be installed as-is, with the following stipulations:
 - 1. If the structure is found to be in nonconformance to some other provision of this specification (i.e. tolerance, surface treatment, etc). The owner shall be entitled to a negotiated credit for this non-conformance, or to remediation of such non-conformance at no cost to the owner.
- C. If the structure is found to be visually unacceptable to the owner's designated representative, the following criteria shall be applied:
 - 1. If the structure is found to be in nonconformance to some other provision of this specification (i.e. tolerance, surface treatment, etc). The owner shall be entitled to remediation of those issues at no cost. Any remediation above what is required by these specification shall be subject to a change order request on the part of the fabricator to complete said work. The scope, price and contractual arrangement for this work must be completed prior to commencement of this work. Failure to do this will result in the owner and their designated representatives being absolved of any finical liability for such work. The owner may, personally, or through there designated representative by wave there right to an agreed to change order prior to the commencement of remedial work. Any waiver of rights in this specifications must be done in writing. Verbal arrangements shall not be considered a formal notice to proceed with any remedial work.
 - 2. If the structure is found to be in conformance with all other provision of this specification (i.e. tolerance, surface treatment, etc), but is not considered visually acceptable by the owners designated representative, the additional remediation shall be completed after the completion of a negotiated change order between the owner and the fabricator.

PART 3 PART 3 - EXECUTION

3.1 EXAMINATION

- A. The erector shall check all AESS members upon delivery for twist, kinks, gouges or other imperfections, which might result in rejection of the appearance of the member. Any correction and fixes to the structure to correct visual imperfections which occurred after the initial visual acceptance outlined in Section 2.7, shall be remediated at no cost to the owner. Any modifications to the structure to suit field conditions outside the fabricators direct control shall be completed after the successful negotiations of a change order between the owner and the fabricator.

3.2 PREPARATION

- A. Provide connections for temporary shoring, bracing and supports only where noted on the approved shop erection drawings. Temporary connections shown shall be made at locations not exposed to view in the final structure or as approved by the Architect. Handle, lift and align pieces using padded slings and / or other protection required to maintain the appearance of the AESS through the process of erection.

3.3 ERECTION

- A. Set AESS accurately in locations and to elevations indicated, and according to the AISC Code of Standard Practice.
- B. In addition to the special care used to handle and erect AESS, employ the proper erection techniques to meet the requirements of the specified AESS Category:
 - 1. AESS Erection tolerances: Erection tolerances shall meet the requirements of standard frame tolerances for structural steel per the AISC Code of Standard Practice;

2. Bolt Head Placement : All bolt heads shall be placed as indicated on the structural design document. Where not noted, the bolt heads in a given connection shall be placed to one side;
3. Removal of field connection aids: Run-out tabs, erection bolts and other steel members added to connections to allow for alignment, fit-up and welding in the field shall be removed from the structure. Welds at run-out tabs shall be removed to match adjacent surfaces and ground smooth. Holes for erection bolts shall be plug welded and ground smooth where specified;
4. Filling of connection access holes: Filling shall be executed with proper procedures to match architectural profile, where specified;
5. Field Welding: Weld profile, quality, and finish shall be consistent with Category and visual samples, if applicable, approved prior to fabrication.

3.4 FIELD CONNECTIONS

- A. Bolted Connections: Make in accordance with Section 05120. Provide bolt type and finish as specified and place bolt heads as indicated on the approved shop drawings.
- B. Welded Connections: Comply with AWS D1.1, AISC Code of Standard Practice and Section 05120. Appearance and quality of welds shall be consistent with the Category and visual samples if applicable. Assemble and weld built-up sections by methods that will maintain alignment of members to the tolerance of this Subsection.
 1. Assemble and weld built-up sections by methods that will maintain alignment of axes. Verify that weld sizes, fabrication sequence, and equipment used for AESS will limit distortions to allowable tolerances.
- C. Field connections shall meet the same requirements as those required in section 2.5.

3.5 ARCHITECTURAL REVIEW

- A. The Architect shall review the AESS steel in place and determine acceptability based on the Category and visual samples (if applicable). The Fabricator/Erector will advise the consultant the schedule of the AESS Work.
- B. Final Acceptance shall follow the procedure set out in Section 2.7 of these specifications.

3.6 ADJUSTING AND CLEANING

- A. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint shall be completed to blend with the adjacent surfaces of AESS. Such touch up work shall be done in accordance with manufacturer's instructions, subject the visual acceptance requirements of section 2.6.
- B. The application of filler must be done in accordance with Section 2.4.
- C. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A780.

Table 1 – AESS Category Matrix (borrowed from the CISC sample spec)

<i>Category</i>		AESS C <i>Custom Elements</i>	AESS 4 <i>Showcase Elements</i>	AESS 3 <i>Feature Elements</i>	AESS 2 <i>Feature Elements</i>	AESS 1 <i>Basic Elements</i>	SSS <i>Standard Structural Steel</i>
<i>Characteristics</i>				<i>Viewed at a Distance ≤ 20 ft</i>	<i>Viewed at a Distance > 20 ft</i>		<i>AISC</i>
Id							
1.1	Surface preparation to SSPC-SP 6		√	√	√	√	
1.2	Sharp edges ground smooth		√	√	√	√	
1.3	Continuous weld appearance		√	√	√	√	
1.4	Standard structural bolts		√	√	√	√	
1.5	Weld spatters removed		√	√	√	√	
2.1	Visual Samples		√	optional	optional		
2.2	Stricter fabrication tolerances		√	√	√		
2.3	Fabrication marks not apparent		√	√	√		
2.4	Welds uniform and smooth		√	√	√		
3.1	Mill marks removed		√	√			
3.2	Butt and plug welds ground smooth and filled		√	√			
3.3	HSS weld seam oriented for reduced visibility		√	√			
3.4	Cross sectional abutting surface aligned		√	√			
3.5	Joint gap tolerances minimized		√	√			
3.6	All welded connections		√	optional			
4.1	HSS seam not apparent		√				
4.2	Welds contoured and blended		√				
4.3	Surfaces filled and sanded		√				
4.4	Weld show-through minimized		√				
C.1							
C.2							
C.3							
C.4							
C.5							

Notes

- 1.1 Prior to blast cleaning, any deposits of grease or oil are to be removed using steam or hot water in conjunction with trisodium phosphate or similar cleaning agent.
- 1.2 Rough surfaces are to be deburred and ground smooth. Edges must be prepared so that they are consistent with the design intent of the structure.

Plate is typically cut by saw, water jet, LASER, plasma or oxy-acetylene torches. In ascending order, these five techniques leave progressively more obvious edge imperfections. These imperfections vary considerably based on the quality of equipment used and the setup employed, so a well-equipped and well-run shop is less likely to be forced to incorporate poorly-cut material. The same is true of beveling, milling being substituted for sawing.

Parts which are to be ground flush must be assembled so the lowest point of the undulations in the edges lies above the adjacent material, requiring some thought at the time the components are dimensioned for cutting.

- 1.3 Intermittent welds are made continuous, either with additional welding, caulking or body filler. For corrosive environments, all joints should be seal welded. Seams of hollow structural sections shall be acceptable as produced.
 - 1.4 All bolt heads in connections shall be on the same side, as specified, and consistent from one connection to another. Whenever possible use smaller than usual bolts, flatheads, studs, pins, cogs and slots, all achieved with tight cutting / drilling tolerances and high-strength bolts
 - 1.5 Weld spatter, slivers, surface discontinuities are to be prevented from accumulating with spatter shields or sprays. Weld projection up to 2 mm is acceptable for butt and plug welded joints.
- 2.1 Visual samples are either a 3-D rendering, a physical sample, a first off inspection, a scaled mock-up or a full-scale mock-up, as specified in Contract Documents.

The inclusion of a 3D rendering as a compliant sample submission is noteworthy. If the fabricator is known to be competent, this is an economical and acceptable approach.

- 2.2 These tolerances are required to be stricter than those of standard structural steel as specified in ASTM A6 or AWS D1.1
- 2.3 Members marked with specific numbers ("piece marks") during the fabrication and erection processes are not to be visible.

- 3.1 All mill marks are not to be visible in the finished product.

See 1.2 above

- 3.2 Limited caulking or body filler is acceptable.

3.3 Seams shall be oriented away from view or as indicated in the Contract Documents.

3.4 The matching of abutting cross-sections shall be required.

Standard tolerances for HSS and HRMS make this section challenging, even more so if the components to be joined have been rolled, as rolling will deform the cross section. For this reason I chose to substitute built up sections in many projects, such as the sculptures in the Conrad Hotel Atrium.

3.5 This characteristic is similar to 2.2 above. A clear distance between abutting members of 3 mm is required.

3.6 Hidden bolts may be considered.

4.1 HSS seams shall be treated so they are not apparent.

4.2 In addition to a contoured and blended appearance, welded transitions between members are also required to be contoured and blended.

4.3 The steel surface imperfections should be filled and sanded.

4.4 The backface of the welded element caused by the welding process can be minimized by hand grinding the backside of the weld. The degree of weld-through is a function of weld size and material.

C. Additional characteristics may be added for custom elements.