VULCAN
STEEL STRUCTURES, INC.

SERVICEABILITY CONSIDERATIONS

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SERVICEABILITY CONSIDERATIONS

The American Institute of Steel Construction (AISC) *Specification for Structural Steel Buildings* says “Serviceability is a state in which the function of a building, its appearance, maintenance, durability and comfort of its occupants are preserved under normal usage. Limiting values of structural behavior to ensure serviceability shall be chosen with due regard to the intended function of the structure.” The specification then goes on to list five topics which relate to serviceability: (1) camber, (2) expansion and contraction, (3) deflection, vibration and drift, (4) connection slip, and (5) corrosion.

In other words, serviceability has to do with the performance of a building rather than the safety, or strength, of the structure. Numerous, and sometimes conflicting, serviceability design criteria exist, but they are spread diversely through codes, technical articles, reports, manufacturers’ literature, and individual engineers. In 1990, the Metal Building Manufacturers Association (MBMA), the American Iron and Steel Institute (AISI) and the AISC jointly sponsored a Steel Design Guide publication titled *Serviceability Design Considerations for Steel Buildings* to “...develop a clearer understanding of serviceability considerations...”; however, the publication (referred to here as “the Guide”) is devoted almost exclusively to deflections, vibrations and drift. The Guide is now in its second edition which was first published in 2004.

1. DEFLECTIONS

Vulcan has established minimum deflection criteria based on the Guide for use when the required building code has not addressed the situation. It is important to be familiar with the serviceability considerations because the loads used for deflection may not be the same as those used for strength design, and the deflection criteria itself may change due to materials by others that attaches to the metal building. Deflection criteria are usually given as a ratio, the span over the limit, i.e. L/180 or H/60. The “L” in the first ratio is for Length, as in the length of a purlin or the length of a rafter. The “H” is for Height, as in the height of a column. Whether the ratio uses an L or an H is not important, as long as one understands that the letter is used to designate some distance. The limit is always a number. The larger the number, the smaller the deflection allowed. To find the amount of the allowed deflection, a simple calculation is performed.

Example 1: Find the maximum allowed vertical deflection, based on L/180, for a rigid frame that is 60’ wide.

$$\text{Allowed deflection} = \frac{12 \times 60}{180} = 4.00 \text{ inches}$$

Example 2: Find the maximum allowed horizontal (or lateral drift, or sideways) deflection, based on H/60, for a rigid frame with a 16’ eave height.

$$\text{Allowed deflection} = \frac{12 \times 16}{60} = 3.20 \text{ inches}$$

The number 12 used in each of the above calculations is to convert the distance from feet to inches.

The following is Vulcan standard deflection criteria, unless more stringent criteria are specified, either by a building code or by the project specifications. Deflection criteria for special conditions are determined on a case-by-case basis. The following are vertical deflections for standard components:

Roof Panel:	Through-Fastened or Standing Seam Panel where L is the distance between purlins. L/180 for Live, Snow or Wind L/150 for Dead + Live

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Purlins: Metal Roof Only where L is the bay length
L/150 for Live, Snow or Wind.
L/120 for Dead + Live

Supporting Non-Plaster Ceiling
L/240 for Live, Snow or Wind
L/180 for Dead + Live

Supporting Plaster Ceiling
L/360 Live, Snow or Wind
L/240 Dead + Live

EW Rafter: Metal Roof Only where L is the distance between columns
L/180 for Live, Snow or Wind
L/120 for Dead + Live

Supporting Non-Plaster Ceiling
L/240 for Live, Snow or Wind
L/180 for Dead + Live

Supporting Plaster Ceiling
L/360 Live, Snow or Wind
L/240 Dead + Live

Main Frames:
Vertical: Metal Roof Only where L is the width of the frame
L/180 for Live, Snow or Wind
L/120 for Dead + Live

Supporting Non-Plaster Ceiling
L/240 for Live, Snow or Wind
L/180 for Dead + Live

Supporting Plaster Ceiling
L/360 Live, Snow or Wind
L/240 Dead + Live

The following horizontal deflections are based on the wall construction:

Standard Metal Building

Wall Panel: L/90 where L is the distance between girts.
Girts: L/90 where L is the bay length.
EW Columns: H/90 where H is the height of the column.

Main Frames: H/60 where H is the eave height.
For crane buildings:
H/100 for pendant operated cranes
H/240 for cab-operated cranes

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Gypsum Board

Girts:	L/120
EW Columns:	L/120
Main Frames:	H/60

Dryvit

Wall Panel:	L/240
Girts:	L/240
EW Columns:	L/240
Main Frames:	H/100

Plaster

Wall Panel:	L/240
Girts:	L/240
EW Columns:	L/240
Main Frames:	H/100

Face Brick/Masonry/Tilt-wall

Wall Panel:	L/240
Girts:	L/240
EW Columns:	L/240
Main Frames:	H/100

The following are deflections for special items:

Crane Runway Beams: where L is the length of the beam.

Vertical:	L/450 Monorails and Under Hung, CMAA class 'A', 'B' & 'C' Top running cranes: L/600 for CMAA class 'A', 'B' & 'C' L/800 for CMAA class 'D' L/1000 for CMAA class 'E' & 'F'
Horizontal:	L/400 All Cranes

Masonry Spandrel

Beam:	L/240 where L is the length of the beam
Lintel Beam:	where L is the length of the beam
Vertical:	L/600 support of masonry L/360 support of stud wall and dryvit L/360 support of stud wall and plaster
Horizontal:	Same as girts shown above
Floor Beam:	L/240 for dead plus live loads L/360 for live load only

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The wind speed maps in the building codes are based on a 50- year mean recurrence interval, and the design pressures for strength are based on this. For deflection calculations, the Guide says, “Ten-year recurrence interval winds are recommended due to the non-catastrophic nature of serviceability issues and the need to provide a standard consistent with day-to- day behavior and average perceptions. Fifty-year winds are special events.” Ten-year winds will produce a wind pressure that is approximately 75 percent of the 50-year wind pressure. In the case of a customer-supplied specification that includes deflection criteria as a part of the specification, deflections will be based on the 10-year wind, unless the design pressure is specifically required.

The recommended deflection criteria for a wall system depends upon the type of wall used, for both exterior and interior finishes. For exterior walls, “...lateral deflection...is of little concern in the case of metal systems, of moderate concern for tiltup concrete and full height precast systems, and of great concern in masonry systems.” The Guide goes on and makes a further distinction between reinforced and nonreinforced masonry.

Seismic applications also must be considered in the building performance. Again, quoting from the Guide -- “It should be noted that this Guide does not provide guidance on serviceability limit states exceeded due to the deformations and interstory drifts of a structural frame subjected to seismic loading. Such requirements are explicitly included in the building code and the reader is referred there.”

2. EXPANSION JOINTS

Vulcan will provide expansion joints on unusually wide or long buildings. Buildings over 600 feet long may be provided with a longitudinal joint running from sidewall to sidewall. Expansion joints will be provided every 300 feet after the first joint.

Single Slope buildings over 2 0 0 feet wide, and gable buildings over 400 feet wide will receive a transverse expansion joint running from endwall to endwall.

Expansion joints can be installed more frequently; however, this must be specified on the job Contract.