



Steel Design Guide

Serviceability Design Considerations for Steel Buildings

Second Edition



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Second Edition

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Preface

This Design Guide is the second edition of AISC *Design Guide 3*, which was originally titled *Serviceability Design Considerations for Low-Rise Buildings*. The new title *Serviceability Design Considerations for Steel Buildings* reflects the addition of information on tall buildings and the following more general information:

1. A review of steel building types, occupancies and serviceability design considerations related to each, as applicable.
2. Revision to current editions of references.
3. Information on ponding for roof design.
4. Information on floors, including discussion regarding cambering beams and how deflection issues relate to the construction of concrete slabs.
5. Revision of floor vibration information to follow AISC *Design Guide 11, Floor Vibrations Due to Human Activity* (Murray and others, 1997).

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Chapter 1

Introduction

Serviceability is defined in the AISC Specification as “a state in which the function of a building, its appearance, maintainability, durability, and comfort of its occupants are preserved under normal usage”. Although serviceability issues have always been a design consideration, changes in codes and materials have added importance to these matters.

The shift to a limit-states basis for design is one example. Since 1986, both the AISC *LRFD* and AISC *ASD Specifications* have been based upon the limit-states design approach in which two categories of limit states are recognized: strength limit states and serviceability limit states. Strength limit states control the safety of the structure and must be met. Serviceability limit states define the functional performance of the structure and should be met.

The distinction between the two categories centers on the consequences of exceeding the limit state. The consequences of exceeding a strength limit may be buckling, instability, yielding, fracture, etc. These consequences are the direct response of the structure or element to load. In general, serviceability issues are different in that they involve the response of people and objects to the behavior of the structure under load. For example, the occupants may feel uncomfortable if there are unacceptable deformations, drifts, or vibrations.

Whether or not a structure or element has passed a limit state is a matter of judgment. In the case of strength limits, the judgment is technical and the rules are established by building codes and design specifications. In the case of serviceability limits, the judgments are frequently non-technical. They involve the perceptions and expectations of building owners and occupants. Serviceability limits have, in general, not been codified, in part because the appropriate or desirable limits often vary from application to application. As such, they are more a part of the contractual agreements with the owner than life-safety related. Thus, it is proper that they remain a matter of contractual agreement and not specified in the building codes.

In a perfect world the distinction between strength and serviceability would disappear. There would be no problems or failures of any kind. In the real world all design methods are based upon a finite, but very small probability of exceedance. Because of the non-catastrophic consequences of exceeding a serviceability limit state, a higher probability of exceedance is allowed by current practice than for strength limit states.

The foregoing is not intended to say that serviceability concerns are unimportant. In fact, the opposite is true. By

having few codified standards, the designer is left to resolve these issues in consultation with the owner to determine the appropriate or desired requirements.

Serviceability problems cost more money to correct than would be spent preventing the problem in the design phase. Perhaps serviceability discussions with the owner should address the trade-off between the initial cost of the potential level of design vs. the potential mitigation costs associated with a more relaxed design. Such a comparison is only possible because serviceability events are by definition not safety related. The Metal Building Manufacturers Association (MBMA) in its *Common Industry Practices* (MBMA, 2002) states that the customer or his or her agent must identify for the metal building engineer any and all criteria so that the metal building can be designed to be “suitable for its specific conditions of use and compatible with other materials used in the Metal Building System.” Nevertheless, it also points out the requirement for the active involvement of the customer in the design stage of a structure and the need for informed discussion of standards and levels of building performance. Likewise the AISC *Code of Standard Practice* (AISC, 2000) states that in those instances where the fabricator has both design and fabrication responsibility, the owner must provide the “performance criteria for the structural steel frame.”

Numerous serviceability design criteria exist, but they are spread diversely through codes, journal articles, technical committee reports, manufacturers’ literature, office standards and the preferences of individual engineers. This Design Guide gathers these criteria for use in establishing serviceability design criteria for a project.

Serviceability Requirements in the AISC Specification

The *LRFD Specification* (AISC, 1999) lists five topics that relate to serviceability concerns. They are:

1. camber
2. expansion and contraction
3. deflections, vibrations, and drift
4. connection slip
5. corrosion

Camber

Camber may or may not be a solution to a serviceability issue, and the authors have attempted to identify appropri-

ate and inappropriate use of camber in this Design Guide. In most instances, the amount of total movement is of concern rather than the relative movement from the specified floor elevation, in which case camber is not an appropriate solution. There are, however, situations where camber is appropriate, such as in places where it is possible to sight down the under side of exposed framing.

Expansion and Contraction

Expansion and contraction is discussed to a limited extent. The goal of this Design Guide is to discuss those aspects of primary and secondary steel framing behavior as they impact non-structural building components. For many types of low-rise commercial and light industrial projects, expansion and contraction in the limited context given above are rarely an issue. This does not mean that the topic of expansion and contraction is unimportant and, of course, the opposite is true. For large and/or tall structures, careful consideration is required to accommodate absolute and relative expansion and contraction of the framing and the non-structural components.

Connection Slip

Connection slip has not been addressed explicitly in this Design Guide. However, it is the authors' intent that the various drift and deflection limits include the movements due to connection slip. Where connection slip, or especially the effect of accumulated connection slip in addition to flexural and/or axial deformations, will produce movements in excess of the recommended guidelines, slip-critical joints should be considered. Slip-critical joints are also required in specific instances enumerated in Section 5 of the *Specification for Structural Joints Using ASTM A325 or ASTM A490 Bolts* (RCSC, 2000). It should be noted that joints made with snug-tightened or pretensioned bolts in standard holes will not generally result in serviceability problems for individual members or low-rise frames. Careful consideration should be given to other situations.

Corrosion

Corrosion, if left unattended, can lead to impairment of structural capacity. Corrosion is also a serviceability concern as it relates to the performance of non-structural elements and must be addressed by proper detailing and maintenance. The primary concerns are the control or elimination of staining of architectural surfaces and prevention of rust formation, especially inside assemblies where it can induce stresses due to the expansive nature of the oxidation process. Again, the solutions are proper detailing and maintenance.

Serviceability Requirements in ASCE 7

ASCE 7-02, *Minimum Design Loads for Buildings and Other Structures* (ASCE, 2002) addresses serviceability in paragraph 1.3.2 Serviceability as follows:

“Structural systems, and members thereof, shall be designed to have adequate stiffness to limit deflections, lateral drift, vibration, or any other deformations that adversely affect the intended use and performance of buildings and other structures.”

ASCE 7-02 provides an appendix with commentary entitled Serviceability Considerations. While this appendix is non-mandatory, it does draw attention to the need to consider five topic areas related to serviceability in the design of structures:

- deflection, vibration, and drift
- design for long-term deflection
- camber
- expansion and contraction
- durability

The ASCE 7 appendix introduction notes that “serviceability shall be checked using appropriate loads for the limit state being considered.” The commentary to the Appendix provides some suggestions with regard to loads and load combinations. For example, two load combinations are suggested for vertical deflections of framing members:

$$D + L$$

$$D + 0.5S$$

These are recommended for limit states “involving visually objectionable deformations, repairable cracking or other damage to interior finishes, and other short term effects.” For serviceability limit states “involving creep, settlement, or other similar long-term or permanent effects,” the suggested load combination is:

$$D + 0.5L$$

With regard to lateral drift, the commentary cites the common interstory drift limits of $L/600$ to $L/400$. The commentary also notes that an absolute interstory drift limit of $3/8$ in. (10 mm) may often be appropriate to prevent damage to non-structural elements. This absolute limit may be relaxed if there is appropriate detailing in the non-structural elements to accommodate greater drift. The commentary provides the following load combination for checking short-term effects:

$$D + 0.5L + 0.7W$$

The reader is encouraged to refer to the appendix commen-

tary, which provides additional insights into the issue of serviceability and an extensive list of references.

This Guide will address the following serviceability design criteria:

1. roofing
2. skylights
3. cladding
4. interior partitions and ceilings
5. vibrations
6. equipment

Most of these criteria limit relative and absolute deflection and, in the case of vibrations, place limits on the range of response and controls for the physical characteristics of structures and elements. Additionally, the presentation and discussion of a consistent loading and analysis approach is essential to these criteria. Without these three elements (load, analysis approach, and serviceability limit) a serviceability design criterion is useless.

This Design Guide provides serviceability design criteria are for selected applications. Source material has been documented wherever possible. Many of the design criteria are based upon the authors' own judgment and rules of thumb from their own experience. It should be noted that when applicable building codes mandate specific deflection limits the code requirements supersede the recommendations of this Design Guide.

Structures framed in structural steel accommodate numerous occupancies and building types. The following discussion addresses ten occupancy types and the specific serviceability design considerations associated with these occupancies.

Storage/Warehouses

Most modern storage facilities, unlike those of previous eras, are single story buildings. As such, modern storage occupancies usually enclose large unobstructed areas under a roof. The significant serviceability design considerations are:

- roof slope and drainage
- ponding stability
- roof deflection
- wall support and girt deflection
- frame drift
- expansion joints

Manufacturing

Like Storage/Warehouse facilities, modern manufacturing facilities are large single story structures, which may include extensive mezzanines. The most significant serviceability design considerations for this occupancy type are:

- roof slope and drainage
- ponding stability
- roof deflection
- wall support and girt deflection
- frame drift
- expansion joints
- vibration in mezzanine areas
- suspended equipment
- crane operation
- corrosion
- equipment vibration

In addition to the serviceability considerations provided in this Guide, the reader is referred to AISC *Design Guide 7, Industrial Buildings: Roofs to Column Anchorage* (AISC, 2004) for a useful discussion on manufacturing facilities.

Heavy Industrial/Mill Buildings

Heavy industrial and mill construction has many of the same serviceability considerations as Manufacturing. Additionally, care must be taken to ensure the proper operation and performance of the cranes. AISC *Design Guide 7, Industrial Buildings: Roofs to Column Anchorage* (AISC, 2004) is worthwhile reading on this subject. The significant serviceability design considerations are:

- crane operation
- roof slope and drainage
- ponding stability
- roof deflection
- wall support and girt deflection
- frame drift
- expansion joints

Mercantile/Shopping Malls

Mercantile structures are frequently large one and two story structures sharing some of the same serviceability design considerations as Storage/Warehouse occupancies. With large areas of roof drainage, roof deflections and expansion joints require special attention. As AISC *Design Guide 11, Floor Vibrations Due to Human Activity* (AISC, 1997) points out, objectionable vibrations have been observed in the second floor levels of these types of structures. Objectionable floor vibrations can result from a lack of damping in open pedestrian areas and walkways. This is discussed in detail in *Design Guide 11*. The significant serviceability design considerations for mercantile occupancies are:

- roof slope and drainage
- ponding stability
- roof deflection
- frame drift
- expansion joints
- floor vibration
- skylights
- corrosion in winter garden and large fountain areas

Health Care and Laboratory Facilities

Although hospitals and clinics are generally multi-story structures, they can be constructed as single-story facilities. The performance of the floor structures is of significant concern, and special attention should be given to the effect of floor vibration on sensitive laboratory equipment. The relationship between the frame and the curtain wall is another important design consideration, as is the performance and operation of traction elevators. The significant serviceability design considerations for health care occupancies are:

- roof slope and drainage
- ponding stability
- roof deflection
- curtain wall/spandrel deflection
- frame drift
- expansion joints
- floor deflection

- vibration of floors
- concreting of floors
- suspended equipment
- elevator operation
- skylights

Educational

Schools and other academic buildings are constructed as both single and multi-story structures. Typical serviceability considerations for floors, roofs and walls apply to all such structures. Structures in schools with swimming pools must be protected against a potentially corrosive environment. Schools with physical education facilities on upper levels must consider the impact of floor vibrations on the structure, especially those due to rhythmic excitation. Lenzen (1966), cites the case of a school in which floor vibrations were not perceptible when the teacher and students were present, but vibration was deemed to be annoying when the classroom was empty except for teachers working after classes. The significant serviceability design considerations for educational occupancies are:

- roof slope and drainage
- ponding stability
- roof deflection
- curtain wall/spandrel deflection
- frame drift
- expansion joints
- floor deflection
- vibration of floors
- concreting of floors
- skylights
- corrosion

Office Buildings

Office buildings are constructed in all heights from single-story buildings to high-rise towers. The relationship of the building frame to the curtain wall is important, as are frame drift and floor deflection. Floor vibration can be an issue.

Elevator operation is also a significant concern. The major serviceability considerations for office occupancies are:

- roof slope and drainage
- ponding stability
- roof deflection
- curtain wall/spandrel deflection
- frame drift
- perception of wind-induced acceleration
- expansion joints
- floor deflection
- vibration of floors
- concreting of floors
- suspended equipment
- elevator operation
- skylights

Parking Structures

Structural steel-framed parking structures are frequently open structures, which exposes the framing. Protection of the structural steel and connections from corrosion and good drainage are significant concerns. More detailed information on the design of steel-framed open-deck parking structures is available in AISC *Design Guide 18, Open-Deck, Steel-Framed Parking Structures* (Churches, and others 2003). The significant serviceability design considerations for parking structures are:

- deck slope and drainage
- expansion joints
- concreting of floors
- corrosion

Residential/Apartments/Hotels

Residential occupancies that are steel framed are commonly mid- to high-rise structures. Frequently the taller of these

structures are mixed use buildings with portions of the space devoted to office and retail occupancies. Most, if not all, of the serviceability design considerations for office occupancies apply to residential occupancies. These are:

- roof slope and drainage
- ponding stability
- roof deflection
- curtain wall/spandrel deflection
- frame drift
- perception of wind-induced acceleration
- expansion joints
- floor deflection
- vibration of floors
- concreting of floors
- suspended equipment
- elevator operation
- skylights
- corrosion in chlorine-disinfected swimming pools

Assembly/Arenas

Assembly occupancies are not discussed extensively in this Design Guide. These buildings are by nature unique, one-of-a-kind structures with large open spans. The accommodation of large deflections and the associated cambers and thermal movements are critical aspects of the design. Additionally, the potential for rhythmic excitation of the structure by the crowd must be considered.

Seismic Applications

It should be noted that this Design 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.

Chapter 2

Design Considerations Relative to Roofing

Roof serviceability largely relates to the structure's role in maintaining the integrity of the roofing membrane and the drainage system. Although ponding relates to both the strength and stiffness of the roof structure, ponding stability is ultimately a strength design consideration; see *AISC Specification* Section K2 (LRFD, 1999; ASD 1989). Because of the importance of ponding stability as a design issue, and because ponding instability is a function of load and deflection, the following discussion of the topic is included in this design guide.

Ponding Stability

The *AISC Specification* provides that unless a roof surface is provided with sufficient slope towards points of free drainage, or adequate individual drains to prevent the accumulation of rain water, the roof system must be investigated to ensure adequate strength and stability under ponding conditions. The ponding investigation must be performed by the specifying engineer or architect. ASCE 7-02 establishes adequate slope to drain as 1/4-in. per ft in Section 8.4. Additional information is provided in the Steel Joist Institute *Technical Digest No 3, Structural Design of Steel Joist Roofs to Resist Ponding* (SJI, 1971).

Ponding as a structural design phenomenon is of concern for two reasons:

1. The loading is water, which can fill and conform to a deflected roof surface.
2. The source of load (water) is uncontrollable, i.e. rain is a natural hazard.

When water can accumulate on a structural system due to impoundment or restriction in drainage, ponding must be checked. Reasons for the accumulation can be:

1. Dead load deflections of members in roofs designed to be flat.
2. Deflections of members, which places points in their spans below their end points.
3. Deflections of bays supporting mechanical units.
4. Members installed with inverted cambers.
5. Blocked roof drains.
6. Parapets without scuppers.
7. Parapets with blocked scuppers.

8. Intentional impoundment of water as part of a controlled-flow roof drain design.
9. Low-slope roofs, which allow water to accumulate due to the hydraulic gradient.

Ponding rainwater causes the deflection of a roof system, which in turn increases the volumetric capacity of the roof. Additional water is retained which in turn causes additional deflection and volumetric capacity in an iterative process. The purpose of a ponding check is to ensure that convergence occurs, i.e. that an equilibrium state is reached for the incremental loading and the incremental deflection. Also, stress at equilibrium must not be excessive.

The *AISC Specification* in Section K2 gives limits on framing stiffness that provide a stable roof system. They are:

$$C_p + 0.9C_s \leq 0.25 \quad (\text{Eq. K2-1})$$

$$I_d \geq 25(S^4)10^{-6} \quad (\text{Eq. K2-2})$$

where,

$$C_p = (32L_p L_p^4) / (10^7 I_p)$$

$$C_s = (32SL_s^4) / (10^7 I_s)$$

L_p = length of primary members, ft

L_s = length of secondary members, ft

S = spacing of secondary members, ft

I_p = moment of inertia of primary members, in.⁴

I_s = moment of inertia of secondary members, in.⁴

I_d = moment of inertia of the steel deck, in.⁴ per ft

Equation K2-2 is met in most buildings without the need for increased deck stiffness. Equation K2-1, in many cases, requires stiffer elements than would be required by loading. In the majority of cases, roofs that do not meet equation K2-2 can be shown to conform to the bending stress limit of $0.80F_y$ in the *ASD Specification* or F_y in the *LRFD Specification*. The relationship between the requirements of the two specifications is discussed in "Ponding Calculations in LRFD and ASD" (Carter and Zuo, 1999).

Appendix K of the *LRFD Specification* and the Commentary to the *ASD Specification* provide a procedure to meet the total bending stress requirement. It should be noted that the checking of bending stresses is not required if the stiffness controls of equations K2-1 and K2-2 are met. This procedure is based on:

1. A calculation of the deflection due to the accumulation of water in the deflected shape of the primary and secondary members at the initiation of ponding. These

deflected shapes are taken to be half sine waves, which is sufficiently accurate for this calculation.

2. In LRFD a load factor of 1.2 is used for dead and rain load per Appendix K with an implied value of $\phi = 1.0$ (see Carter/Zuo, 1999). In ASD a factor of safety of 1.25 for stresses due to ponding is used, which results in an allowable stress of $0.8F_y$.
3. Behavior of the members is in the elastic range so that deflection is directly proportional to stress.
4. Stress due to ponding is limited to F_y (LRFD) or $0.80F_y$ (ASD) minus the factored stress or stress in the members at the initiation of ponding, depending on the specification applied.

Thus, the method uses four variables:

U_p , the stress index for the primary member.

U_s , the stress index for the secondary member.

C_p , the stiffness index for the primary member.

C_s , the stiffness index for the secondary member.

C_p and C_s are as given in the *Specification* in Section K2.

U_p and U_s are given as:

$$(F_y - f_o) / f_o$$

$$(0.8F_y - f_o) / f_o$$

where f_o is the bending stress in the member (primary or secondary) at the initiation of ponding. In LRFD f_o is calculated using the factored load of $1.2D + 1.2R$, with D = the nominal dead load and R = the nominal rain/snow load.

Both the *LRFD Specification* Appendix and the *ASD Specification* Commentary present two figures K2.1 and K2.2. Figure K2.1 is used to find a maximum C_p when U_p and C_s are given. Figure K2.2 is used to find a maximum C_s when U_s and C_p are given. This procedure is thus a checking procedure since trial sections must be chosen to establish C_p , C_s , U_p , and U_s . Figures K2.1 and K2.2 are graphs representing combinations of stress and stiffness that control the increment of load (stress) and deflection at the initiation of ponding.

If one studies the relationships in these figures, it can be noted that the required stiffness is inversely related to initial stress. If the stress index associated with values of C_p and C_s that meet the stiffness limit of $C_p + 0.9C_s \leq 0.25$ is plotted, one can see that the stress index is very low, indicating that f_o is very near $0.9F_y$ (LRFD) or $0.6F_y$ (ASD). This is logical since the system is so rigid that the ponded accumulation is negligible. As one moves beyond the values of C_p and C_s that meet Equation K-2.1, it can be seen that the term $(F_y - f_o)$

(LRFD) or $(0.8F_y - f_o)$ (ASD) must increase to provide for the reduction in stiffness, e.g. the increase in C_p and/or C_s . Thus it can be seen that the accurate calculation of f_o is the essential element in using this procedure.

The LRFD Appendix and the ASD Commentary states that f_o is “the computed bending stress in the member due to the supported loading, neglecting the ponded effect.” The calculations for the increment of ponded water are a function of the initial deflection and stiffness of the primary and secondary members. The initial deflection and the initial stress are the result of the “initial loads,” which are those present at the “initiation of ponding.” This means that the “initial loads” may be and will probably be different from the design loads. The initial loads include all appropriate dead and collateral loads, such as:

1. Weight of structural system.
2. Weight of roofing and insulation system.
3. Weight of interior finishes.
4. Weight of mechanical and electrical systems.
5. Weight of roof top mechanical systems.

The initial loads also include some or all of the superimposed load. The requirements of the AISC *Specification* and Commentary point to the fact that the superimposed load must actually be present at the initiation of ponding. Thus the appropriate portion of design superimposed load is not necessarily 100 percent of the design superimposed load. The amount of superimposed load used is to a degree up to the judgment of the engineer.

The most significant loading in northern regions of the country is a prediction of the amount of snow present at the initiation of ponding. A significant factor in all regions is a judgment of the amount of water on the roof at the initiation of ponding. Also, consideration must be given to the combination of snow and water, where applicable. The AISC *Specification* (LRFD Appendix and ASD Commentary) demonstrate that the loading at the initiation of ponding does not include the water that produces the stresses due to ponding, but does include water trapped on the roof because the roof has not been “provided with sufficient slope towards points of free drainage or adequate individual drains to prevent the accumulation of rain water.” Also, as noted above, ASCE 7-02 Section 8.3 states that roofs with a slope of at least $1/4$ in. per ft need not be investigated for ponding stability. However, the superimposed load at the initiation of ponding could include water trapped by plugged internal roof drains.

ASCE 7-02 Section 8.3 requires that “each portion of a roof shall be designed to sustain the load of all rainwater that will accumulate on it if the primary drainage system for

that portion is blocked plus the uniform load caused by water that rises above the inlet of the secondary drainage system at its design flow.” Previous model codes included similar requirements.

The use of the weight of trapped or impounded water is recommended in *SJI Technical Digest No. 3, Structural Design of Steel Joist Roofs to Resist Ponding Loads*. This reference also gives an approach for accounting for the potential for snow and water in combination. It recommends that “where ice and snow are the principal source of roof live load” 50 percent of the design live load be used up to 30 psf live load, and 100 percent of the design live load when the design live load is 40 psf and greater.” Presumably the percentage could be interpreted as varying linearly for loads between 30 and 40 psf. When these values are used to account for rain and snow, it is not necessary to add in the weight of potential trapped water described above unless the weight of impounded water would be greater than the reduced design live load. Model building codes require that roofs with a slope of less than $\frac{1}{2}$ in 12 be designed for rain on snow in accordance with ASCE 7-02 Section 1608.3.4. ASCE 7-02 requires a rain on snow load where p_g is 20 lb/ft² or less but not zero.

ASCE 7-02 requires that roofs with “controlled drainage” must be checked for ponding instability, as determined in the provisions for “ponding instability.” When these provisions apply, they require that “The larger of snow load or rain load shall be used in this analysis. The primary drainage system within an area subjected to ponding shall be considered to be blocked in this analysis.”

Note that the earlier discussion described two-way roof framing systems. There is a separate case where the secondary framing bears directly on walls. This case eliminates the primary member deflection and the AISC *Specification* (LRFD Appendix and ASD Commentary) procedures can be used by reference to Figures K2.1 and K2.2 for which C_s is calculated using the deck properties and C_p is calculated using the joist properties. Also the *SJI Technical Digest No. 3* gives a procedure for accounting for a reduction in the accumulated water weight due to camber. Logic suggests that concept could also be applied to the two-way system.

Neither AISC nor SJI procedures address the deflected geometry of a continuous primary framing system. All of the deflection and load calculations of both procedures are based on the half-sine wave shape of the deflected element. This shape is conservative with a continuous primary member, because it overestimates the volume in the deflected compound curve.

Thus,

1. Ponding stability is an important concern in roof design.
2. Using the stiffness criteria of the *Specification* can produce unnecessarily conservative designs.

3. Use of the design approach presented in the AISC Commentary is recommended.
4. Determination of the appropriate loading in the calculation of initial stress is absolutely critical for the method to produce an accurate result.

Roofing

The concerns for the integrity of the roofing lie in three main areas:

1. in the field of the roof
2. at the edges
3. at penetrations

Two types of roofing will be discussed here: membrane roofs and metal roofs on structure.

Membrane Roofs

The field of a membrane roof must be isolated from the differential thermal movement of membrane and structure. This is done by means of “area dividers” in the roof membrane. The spacing of these joints depends on the type of roofing and climate conditions. The *Roofing and Waterproofing Manual*, Fifth Edition, published by the National Roofing Contractors Association (NRCA, 2001) concedes that recent experience with newer materials indicates that area dividers can be spaced at greater intervals for certain types of membrane systems than had previously been the case. In fact the *Manual* uses the phrase “may not be required at all” in its presentation on the need for area dividers and their spacing requirements for certain membrane systems.

Area dividers are commonly required for attached or adhered systems and are generally spaced at intervals of 150-200 ft. Area dividers will, in all likelihood, be spaced at intervals smaller than the building expansion joints.

The integrity of the roofing field is affected by the underlying structure. Factory Mutual System in its *Approval Guide* gives maximum spans for various deck types and gages. The Steel Deck Institute provides different criteria:

1. A maximum deflection of span divided by 240 for uniform design live load; and,
2. a limit of span divided by 240 with a 200-lb concentrated load at midspan on a 1-ft 0-in. wide section of deck.

SDI also gives maximum recommended spans for decks subjected to maintenance and construction loads. These are repeated in the *NRCA Manual*.