

METAL BAR GRATING
ENGINEERING
DESIGN
MANUAL

SECOND EDITION



MBG
Metal Bar Grating



A Division of
NAAMM

NATIONAL ASSOCIATION OF
ARCHITECTURAL METAL MANUFACTURERS



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This manual was developed by representative members of the Metal Bar Grating Division (MBG) of the National Association of Architectural Metal Manufacturers (NAAMM) to provide their opinion and guidance on the procedures used in design calculations for metal bar grating. This manual contains advisory information only and is published as a public service by NAAMM. NAAMM disclaims all liability of any kind for the use, application or adaptation of material published in this manual.

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METAL BAR GRATING

This manual sets forth procedures used in design calculations for metal bar grating. The load bearing capabilities and deflections of grating are based on the structural properties of the bearing bars and the number of bearing bars supporting the load. Grating is designed so that the allowable stresses of the metals used are not exceeded when the design loads are applied or, if deflection governs, the specified allowances for deflection are not exceeded. Metric properties, with sample calculations, are included for metric conversions. All calculations are based on the *AISC Manual of Steel construction*, 15th edition. All spans are designed as simple spans.

The concentrated, uniform and partially distributed uniform loads used in the calculations are modeled as static loads. Static loads are typically used to evaluate the functionality for live loading pedestrian load applications. Examples 1 – 5 on the following pages present the formulas used for calculating the load and deflection values of static loads.

Heavy rolling loads are defined as Vehicular Loads. Examples 6 – 7 present the formulas used to calculate the values for welded and pressure locked gratings when subjected to vehicular loads. Example 8 presents the formulas used to calculate the values for riveted gratings subjected to vehicular loads.

The Load Criteria presented for Vehicular Loads on page 12 is intended to serve as a guide for common vehicular applications. This criteria is not intended to be all-inclusive and if your application is not clearly represented by one of these options, contact NAAMM or your nearest NAAMM MBG member company for assistance in evaluating your specific application.

NOMENCLATURE

- a = length of partially distributed uniform load or vehicular load, parallel with bearing bars, in.
- b = thickness of rectangular bearing bar, in.
- c = width of partially distributed uniform load or vehicular load, perpendicular to bearing bars, in.
- d = depth of rectangular bearing bar, in.
- A_c = distance center to center of main bars, riveted grating, in.
- A_r = face to face distance between bearing bars in riveted grating, in.
- A_w = center to center distance between bearing bars in welded and pressure locked gratings, in.
- C = concentrated load at midspan, pfw
- D_c = deflection under concentrated load, in.
- D_u = deflection under uniform load, in.
- E = modulus of elasticity, psi
- F = allowable stress, psi
- I = moment of inertia, in⁴
- I_{H20} = moment of inertia of grating under H20 loading, in⁴
- I_b = I of bearing bar, in⁴
- I_g = I of grating per foot of width, in⁴
- I_n = moment of inertia of nosing, in⁴
- K = number of bars per foot of grating width, 12"/ A_w
- L = clear span of grating, in. (simply supported)

M = bending moment, lb-in
 M_b = maximum M of bearing bar, lb-in
 M_g = maximum M of grating per foot of width, lb-in
 N = number of bearing bars in grating assumed to carry load
 N_{bH20} = number of main bearing bars under load H20
 N_{cH20} = number of connecting bearing bars under load H20
 P_b = load per bar, lb
 P_u = total partially distributed uniform load, lb
 P_{uH20} = wheel load, H20, lb
 P_w = wheel load, lb
 S = section modulus, in³
 S_b = S of bearing bar, in³
 S_g = S of grating per foot of width, in³
 S_{H20b} = section modulus at bottom of grating under H20 loading, in³
 S_n = section modulus of nosing, in³
 U = uniform load, psf

ABBREVIATIONS

in. = inch
ft = foot
lb = pounds
lb-in = pound-inches
pftw = pounds per foot of grating width
psf = pounds per square foot
psi = pounds per square inch

METAL PROPERTIES

ENGLISH

<u>Material</u>	Allowable Design Stress F psi	Yield Strength F _y psi	Tensile Strength F _u psi	Modulus of Elasticity E psi
<u>Steel</u>				
ASTM A1011 CS Type B	18,000	30,000(1)		29,000,000
ASTM A1011 SS GR36	20,000	36,000	53,000	29,000,000
ASTM A36	20,000	36,000	58,000	29,000,000
<u>Stainless Steel</u>				
ASTM A666 Type 304	20,000	30,000	75,000	28,000,000
ASTM A666 Type 304L	16,500	25,000	70,000	28,000,000
ASTM A666 Type 316	20,000	30,000	75,000	28,000,000
ASTM A666 Type 316L	16,500	25,000	70,000	28,000,000
<u>Aluminum*</u>				
ASTM B221 6061-T6	12,000	35,000	38,000	10,000,000
ASTM B221 6063-T6	12,000	25,000	30,000	10,000,000
ASTM B221 6005A-T61	12,000	35,000	38,000	10,000,000
ASTM B221 6105-T5	12,000	35,000	38,000	10,000,000

- None of the designs for MBG grating are for welded aluminum construction. The allowable stresses listed may be below the values recommended by the Aluminum Association to assure acceptable serviceability and performance

METRIC

<u>Material</u>	Allowable Design Stress F MPa	Yield Strength F _y MPa	Tensile Strength F _u MPa	Modulus of Elasticity E MPa
<u>Steel</u>				
ASTM A1011M CS Type B	124.11	205(1)		200,000
ASTM A1011M SS GR250	137.90	250	365	200,000
ASTM A36M	137.90	250	400	200,000
<u>Stainless Steel</u>				
ASTM A666 Type 304	137.90	205	515	193,000
ASTM A666 Type 304L	113.77	170	485	193,000
ASTM A666 Type 316	137.90	205	515	193,000
ASTM A666 Type 316L	113.77	170	485	193,000
<u>Aluminum</u>				
ASTM B221M 6061-T6	82.74	240	260	69,000
ASTM B221M 6063-T6	82.74	170	205	69,000
ASTM B221M 6005-T61	82.74	240	260	69,000
ASTM B221M 6105-T5	82.74	240	260	69,000

(1) Per ASTM A-1011 the typical (nonmandatory) range for yield strength for ASTM A 1011 CS Type B is 30 to 50 psi, or 205 to 344 MPa

FORMULAS

1. Number of bearing bars per foot of width for welded grating, $K = 12/A_w$
2. Section modulus of rectangular bearing bar, $S_b = bd^2/6 \text{ in}^3$.
3. Section modulus of grating per foot of width, $S_g = Kbd^2/6 \text{ in}^3 = KS_b \text{ in}^3$
4. Section modulus required for given moment and allowable stress, $S = M/F \text{ in}^3$
5. Moment of inertia of rectangular bearing bar, $I_b = bd^3/12 \text{ in}^4 = S_b d/2 \text{ in}^4$
6. Moment of inertia of grating per foot of width, $I_g = Kbd^3/12 \text{ in}^4 = KI_b \text{ in}^4$
7. Bending moment for given allowable stress and section modulus, $M = SF \text{ lb-in}$

The following formulas are for simply supported beams with maximum moments and deflections occurring at mid-span.

8. Maximum bending moment under concentrated load
 $M = CL/4 \text{ lb-in per foot of grating width}$
9. Concentrated load to produce maximum bending moment
 $C = 4M/L \text{ lb per foot of grating width}$
10. Maximum bending moment under uniform load
 $M = UL^2/(8 \times 12) = UL^2/96 \text{ lb-in per foot of grating width}$
11. Uniform load to produce maximum bending moment
 $U = 96M/L^2 \text{ psf}$
12. Maximum bending moment due to partially distributed uniform load
 $M = P_u (2L - a)/8 \text{ lb-in}$
13. Maximum deflection under concentrated load
 $D_c = CL^3/48EI_g \text{ in.}$
14. Moment of inertia for given deflection under concentrated load
 $I_g = CL^3/48ED_c \text{ in}^4$
15. Maximum deflection under uniform load
 $D_u = 5UL^4/(384 \times 12EI_g) = 5UL^4/4608EI_g \text{ in.}$
16. Moment of inertia for given deflection under uniform load
 $I_g = 5UL^4/4608ED_u \text{ in}^4$
17. Maximum deflection under partially distributed uniform load
 $D_u = P_u((a/2)^3 + L^3 - a^2 L/2)/48EI_b \text{ in.}$