| | |
|---|---|
| Test Type: | ASTM 1592 |
| Testing Authority: | ASTM |
| Test Name: | Flexural Moment Capacity |
| Test Date: | November 7, 2000 |
| Test Completed By: | Thomas M. Shingler, P.E.<br>Registered Structural Engineer |
| Testing Laboratory | Design Dynamics, Inc. |
| Panel Type: | 1 ½" Nail Strip Roof Panel |
| Panel Width: | 12.00 in. wide x 24 gage steel |
| Clip Spacing: | 2.0 tp 5.0 ft |
| Decking Construction: | Purlins |

**PURPOSE:** This series of metal roof panel testing is designed to establish the positive/negative flexural moment capacity, flexural stiffness index (Moment of Inertia) and the edge fastener tearout capacity of the Metalforming, Inc. 1 ½" Nailstrip product using the industry-accepted ASTM E-330 chamber procedure.

**METHOD:** The positive/negative flexural moment capacity and the flexural stiffness index of the panel was determined using a single span
(6 ft) test panel arrangement. There were four (4) full width test panels with male/female joint starter and terminal edges. The male/female joint starter and terminal edges were utilized to render continuity to the lay-up of the panel assembly and prevent the influence of so-called "edge effects".
For the positive flexural moment capacity and positive flexural stiffness index, the panels were installed with the rib configuration in an "up" position.
For the negative flexural moment capacity and the negative flexural stiffness index, the panels were installed with the rib configuration in a "down" position.
The positive/negative flexural stiffness indices were computed using load vs. deflection points at seven (7) levels of loading.
The edge fastener tear-out capacity was determined using a series of five (5) ASTM E-330 chamber tests.
The first three (3) tests had panel edge fastening spaced at 1.0 ft. o/c. The second two (2) tests had panel edge fastening spaced at 4.0 ft o/c.
There were seven (7) full width test panels with male/female joint starter and terminal edges.

The male/female joint started and terminal edges were utilized to render continuity and to the lay-up of the panel assembly and prevent the influence of so called "edge effects".
For the fastener edge tear-out capacity test, the panels were installed with the rib configuration in a "down" position.

Set-up: In-plan, the test chamber for the single span flexural moment capacity and flexural stiffness index evaluation was 6 ft. 5 ½" wide x 6 ft. 9" long. In-plan, the test chamber for the edge fastener tear-out capacity evaluation was 8 ft. 6" wide x 16 ft. long.

Relative to the positive/negative flexural moment capacity and the positive/negative flexural stiffness index, the ASTM E-330 testing procedure is designed to apply a uniform negative pressure to the roof panel specimen.

For the flexural moment capacity testing.....
A "rib up" orientation forces the top portion of the rib element into compression and the panel broad flat into tension..... emulating single curvature positive bending.
The net result of testing this panel orientation to buckling failure is the establishment of the positive flexural moment capacity.
A Factor-of-Safety of 2.00 applied to the positive flexural moment capacity determines the allowable positive flexural moment for the panel.

A "rib down" orientation forces the top portion of the rib element into tension and the panel broad flat into compression..... emulating single curvature negative bending.
The net result of testing this panel orientation to buckling failure is the establishment of the negative flexural moment capacity.
A Factor-of-Safety of 2.00 applied to the negative flexural moment capacity determines the allowable negative flexural moment for the panel.

The positive/negative flexural stiffness indices (positive/negative Moments of Inertia) were determined from single span rib up/ rib down load vs. deflection values inserted into the established single span maximum deflection equation and then solving for the applicable (+/-) Moment of Inertia value.
For extreme accuracy, a series of nine (9) load vs. deflection increments falling within the elastic range of the profile were incorporated into the testing procedure for determining flexural stiffness.

The fastener edge tear-out capacity testing involved the development of a high intensity edge fastener reaction forces through the application of ever-increasing test pressure.

The test pressure was gradually applied until fastener tear-out occurred, with the point of separation being defined as the edge fastener tear-out capacity value.
A Factor-of-Safety of 1.875 applied to the test-determined edge fastener tear-out value determines the allowable edge fastener reaction.

The applicable deflection equation is as follows.....

$$\text{deflection} = \frac{22.5 \times w \times L^{\wedge} 4}{E \times I}$$

deflection= recorded test deflection for a corresponding test pressure value, in.
w= test pressure value, psf
L= test span, ft.
L= 6.0 ft.
I= Moment of Inertia, in^4
E= Modulus of Elasticity of material, #/in^2
E= 29.5 x 10^6 #/in^2 (steel)

Rearranging terms and solving for the Moment of Inertia value, the equation becomes.....

$$I = \frac{22.5 \times w \times L^{\wedge} 4}{E \times \text{deflection}}$$

Test Results:
Positive Stiffness Index, (+) I Determination.....

| Test Pressure, psf | Test No. 1 (+) I | Test No. 2 (+) I | Test No. 3 (+) I | Test – Determined (+) I, in^4 (avg) |
|---|---|---|---|---|
| 15.0 | 0.029 | 0.028 | 0.030 | 0.029 |

(+) I (average) = 0.029 in^4

Positive Flexural Moment Capacity:

The applicable flexural moment equation is as follows.....

M (ultimate) = 1.50 x w (ultimate) x L ^ 2

$$\text{M (allowable)} = \frac{\text{M (ultimate)}}{\text{F.S.} = 2.00}$$

| Test No. | W (ultimate), #/ft^2 | M (ultimate), in-# | M (allowable), in-# |
|---|---|---|---|
| 1 | 41.22 | 2225 | 1115 |
| 2 | 41.86 | 2260 | 1130 |
| 3 | 41.83 | 2260 | 1130 |

(+) M (allowable, average) = 1125 in-#

Determine the (+) Section Modulus for the profile based on an allowable flexural stress level Fb of 30,000 #/in^2.....

$$(+)\ S = \frac{(+)\ M\ (allow)}{Fb} = \frac{1125\ in\text{-}\#}{30{,}000\ \#/in^2}$$

$$(+)\ S = 0.038\ in^3$$

Negative Stiffness Index, (-) I Determination.....

| Test Pressure, psf | Test No. 1 (-) I | Test No. 2 (-) I | Test No. 3 (-) I | Test –Determined (-) I, in^4 (avg) |
|---|---|---|---|---|
| 15.0 | 0.021 | 0.021 | 0.021 | 0.021 |

(-) I (average) = 0.021 in^4

Negative Flexural Moment Capacity:

| Test No. | W (ultimate), #/ft^2 | M (ultimate), in-# | M (allowable), in-# |
|---|---|---|---|
| 1 | 43.20 | 2330 | 1165 |
| 2 | 43.29 | 2340 | 1170 |
| 3 | 44.11 | 2380 | 1190 |

(-) M (allowable, average) = 1175 in-#

Determine the (-) Section Modulus of the profile based on an allowable flexural

stress level of 30,000 #/n^2.....

$$(-)\ S = \frac{(-)\ M\ (allow)}{Fb} = \frac{1175\ in\text{-}\#}{30{,}000\ \#/in^2}$$

$$(-)\ S = 0.039\ in^3$$

Edge Fastener Tear-out Capacity:

The applicable fastener reaction equation is as follows.....R = w x L

| Test No. | Span ft. | W (ultimate) #/ft^2 | R (ultimate) #/ft | R (allowable) #/ft |
|---|---|---|---|---|
| 1 | 1.00 | 114.80 | 114.80 | 61.2 |
| 2 | 1.00 | 129.42 | 129.42 | 69.0 |
| 3 | 1.00 | 131.25 | 131.25 | 70.0 |
| 4 | 4.00 | 49.28 | 197.12 | 105.1 |
| 5 | 4.00 | 50.03 | 200.12 | 106.7 |

R (allow, avg) @ 1.0 ft. = 66.7 #/ft
R (allow, avg) @ 1.0 ft. = 105.9 #/ft

Note: linear interpolation will be used to define intermediate values between the test extremes.

State Effective Section Properties for Profile.....

Profile: 1 ½" Nailstrip @ 12.00" wide x 24 gage steel

(+) I (eff) = [0.71 x 0.029] + [0.29 x 0.021] = 0.026 in^4

(+) S (eff) = $\frac{1125 \text{ in-\#}}{30{,}000 \text{ \#/in}^2}$ = 0.038 in^3

(-) I (eff) = [0.71 x 0.021] + [0.29 x 0.029] = 0.023 in^4

(-) S (eff) = $\frac{1175 \text{ in-\#}}{30{,}000 \text{ \#/in}^2}$ = 0.039 in^3

R (allow, avg) @ 1.0 ft = 66.7 #/ft

R (allow, avg) @ 4.0 ft = 105.9 #/ft

Note: Use (+) I (eff) for deflection considerations when the panel is experiencing downward (positive) loading normal to the plane of the roof.

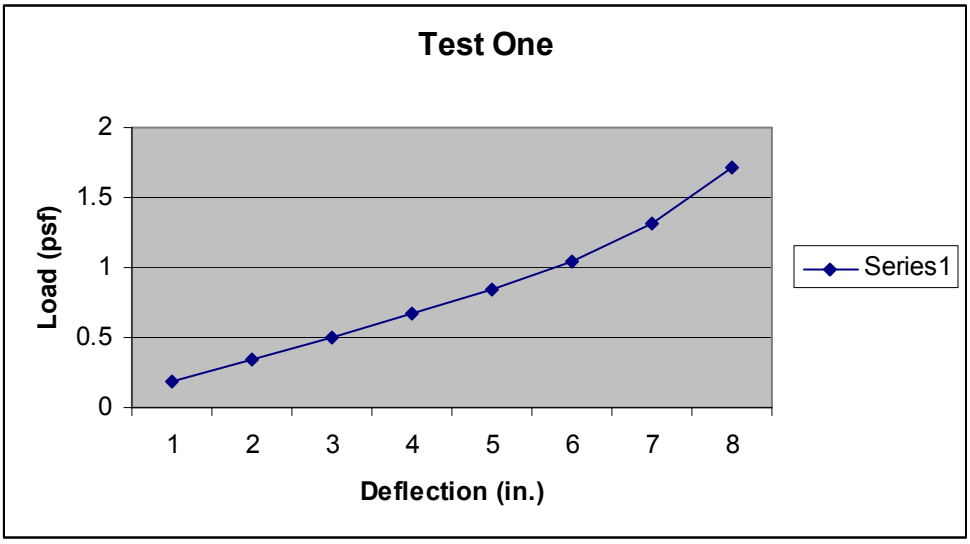
Use (-) I (eff) for deflection considerations when the panel is experiencing upward (negative) loading normal to the plane of the roof.

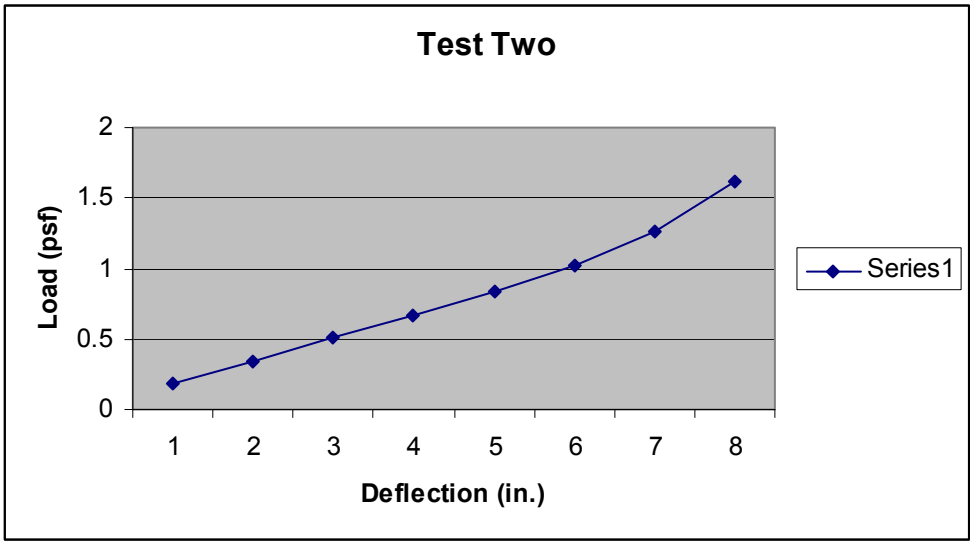
Use R (allowable) for the consideration of panel edge fastener tear-out under upward (negative) loading normal to the plane of the roof.

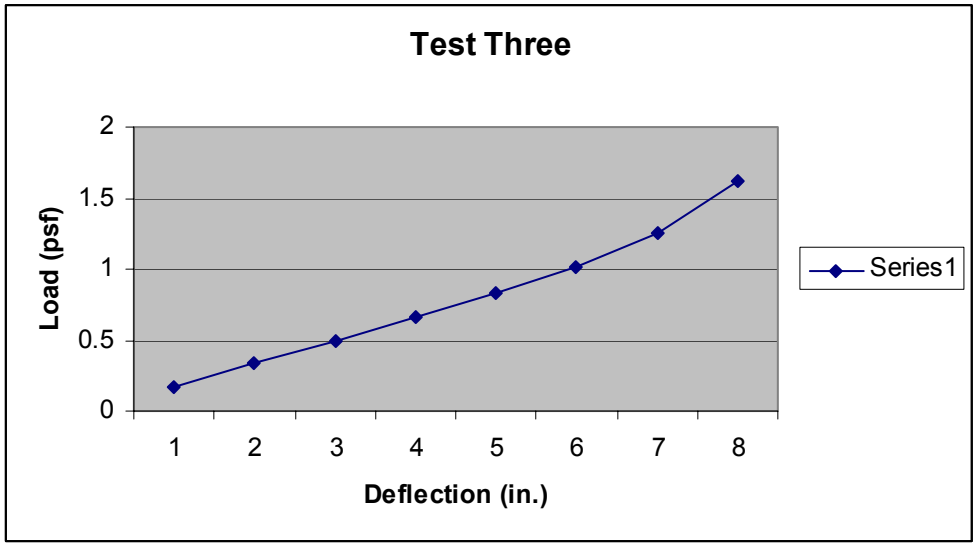
| | | | | | |
|---|---|---|---|---|---|
| @ | 1.00 : | R (allow) | = | 66.7 #/ft | |
| | 1.25 : | | = | 69.9 | |
| | 1.50 : | | = | 73.2 | 71.6 #/ft (avg) |
| | 1.75 : | | = | 76.4 | |
| | 2.00 : | | = | 79.7 #/ft | |
| | 2.25 : | | = | 82.9 | |
| | 2.50 : | | = | 86.2 | 84.5 #/ft (avg) |
| | 2.75 : | | = | 89.5 | |
| | 3.00 : | | = | 92.8 #/ft | |
| | 3.25 : | | = | 96.0 | |
| | 3.50 : | | = | 99.3 | 99.3 #/ft (avg) |
| | 3.75 : | | = | 102.6 | |
| | 4.00 : | | = | 105.9 #/ft | |

| Metalforming, Inc. - 1 ½" Nailstrip Snap Seam Profile<br>24 gage steel - 12.0" wide x 6'-6" long<br>Rib: UP - Test Span: 6 ft | | | |
|---|---|---|---|
| E-330 | Deflection Values @ Key Panel Location | | |
| Load | Test No. 1 | Test No. 2 | Test No. 3 |
| 5.00 | 0.190 | 0.183 | 0.173 |
| 10.00 | 0.343 | 0.338 | 0.332 |
| 15.00 | 0.500 | 0.515 | 0.494 |
| 20.00 | 0.670 | 0.665 | 0.660 |
| 25.00 | 0.845 | 0.830 | 0.825 |
| 30.00 | 1.050 | 1.025 | 1.020 |
| 35.00 | 1.310 | 1.265 | 1.260 |
| 40.00 | 1.710 | 1.615 | 1.620 |
| W(ult) psf | 41.22 | 41.86 | 41.83 |

**Load vs. Deflection**
**1 ½" Nailstrip Span Seam - 24 gage**
**Metalforming, Inc.**
Design Dynamics, Inc
Drawn by: CCN 10-26-00

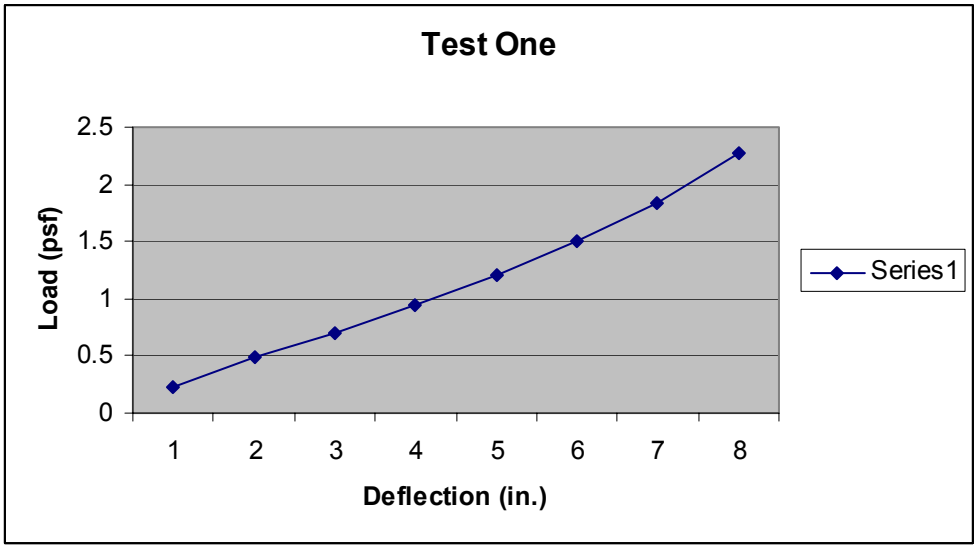


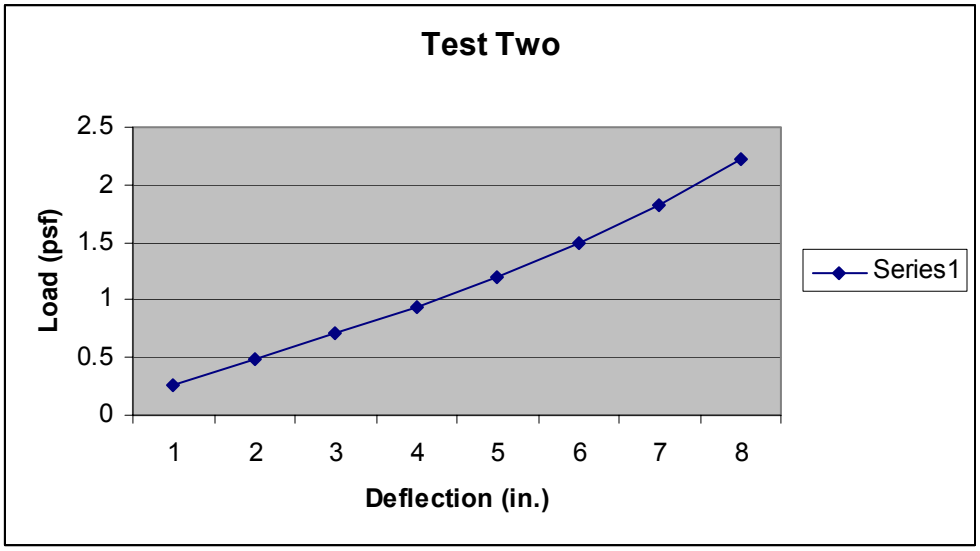



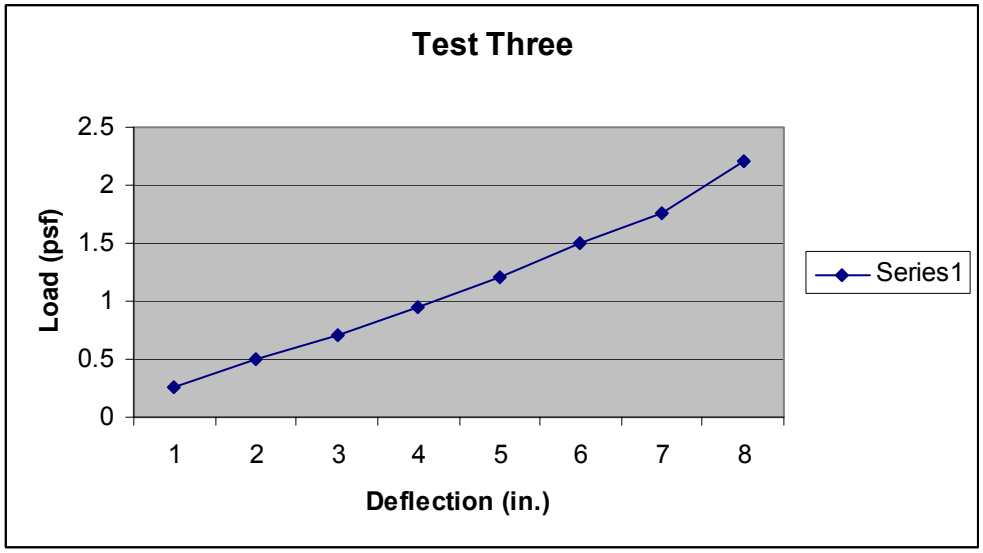



| METALFORMING, INC. - 1 ½" NAILSTRIP SNAP SEAM PROFILE<br>24 GAGE STEEL - 12.0" WIDE X 6'-6" LONG<br>RIB: DOWN - TEST SPAN: 6 FT | | | |
|---|---|---|---|
| E-330 | DEFLECTION VALUES @ KEY PANEL LOCATION | | |
| LOAD | TEST NO. 1 | TEST NO. 2 | TEST NO. 3 |
| 5.00 | 0.225 | 0.253 | 0.264 |
| 10.00 | 0.481 | 0.481 | 0.493 |
| 15.00 | 0.705 | 0.705 | 0.705 |
| 20.00 | 0.945 | 0.940 | 0.940 |
| 25.00 | 1.205 | 1.195 | 1.200 |
| 30.00 | 1.500 | 1.490 | 1.495 |
| 35.00 | 1.840 | 1.815 | 1.760 |
| 40.00 | 2.280 | 2.230 | 2.215 |
| W(ULT) PSF | 43.20 | 43.29 | 44.11 |

LOAD VS. DEFLECTION
1 ½" NAILSTRIP SPAN SEAM - 24 GAGE
METALFORMING, INC.
DESIGN DYNAMICS, INC
DRAWN BY: CCN 10-26-00






## DESIGN INPUT DATA FOR 1 ½" NAILSTRIP @ 12 X 24 GA.

PRODUCT PROPERTIES:
E = 29500. KSI
I = .0230 IN4/FT S = .0380 IN3/FT

DESIGN PARAMETERS:

DEFLECTION = L/180

| | | |
|---|---|---|
| ALLOW. BENDING STRESS (PSI) | = | 30000.00 |
| ALLOW. END SUPPORT REACTION (#/FT) | = | 71.6 |
| ALLOW. INTERMEDIATE SUPPORT REACTION | = | 71.6 |

## LOAD SPAN TABLE FOR 1 ½" NAILSTRIP @ 12 X 24 GA.

DEFLECTION = L/180.

| Span | Three Equal Span | | |
|---|---|---|---|
| (FT) | W(PSF) | RE | RI |
| 1.00 | 65.09 | 26.0 | 71.6 |
| 1.25 | 52.07 | 26.0 | 71.6 |
| 1.50 | 43.39 | 26.0 | 71.6 |
| 1.75 | 37.19 | 26.0 | 71.6 |

W = ALLOWABLE UNIFORM LOAD
RE = END SUPPORT REACTION AT ALLOW. LOAD (#/FT)
RI = INTERMEDIATE SUPPORT REACTION AT ALLOW. LOAD (#/FT)

DESIGN INPUT DATA FOR 1 ½" NAILSTRIP @ 12 X 24 GA.

PRODUCT PROPERTIES:
E = 29500. KSI
I = .0230 IN4/FT
S = .0380 IN3/FT

DESIGN PARAMETERS:
DEFLECTION = L/180

ALLOW. BENDING STRESS (PSI) = 30000.0
ALLOW. END SUPPORT REACTION = 84.5
ALLOW. INTERMEDIATE SUPPORT REACTION = 84.5

LOAD SPAN TABLE FOR 1 ½" NAILSTRIP @ 12 X 24 GA.
DEFLECTION = L/180

| SPAN | THREE EQUAL SPAN | | |
|---|---|---|---|
| FT | W(PSF) | RE | RI |
| 2.00 | 38.41 | 30.7 | 84.5 |
| 2.25 | 34.14 | 30.7 | 84.5 |
| 2.50 | 30.73 | 30.7 | 84.5 |
| 2.75 | 27.93 | 30.7 | 84.5 |

W = ALLOWABLE UNIFORM LOAD
RE = END SUPPORT REACTION AT ALLOW. LOAD (#/FT)
RI = INTERMEDIATE SUPPORT REACTION AT ALLOW. LOAD

DESIGN INPUT DATA FOR 1 ½" NAILSTRIP @ 12 X 24 GA.

PRODUCT PROPERTIES:

E = 29500. KSI
I = .0230 IN4/FT
S = .0380 IN3/FT

DESIGN PARAMETERS:
DEFLECTION = L/180.

ALLOW. BENDING STRESS (PSI) = 30000.0
ALLOW. END SUPPORT REACTION (#/FT) = 99.3
ALLOW. INTERMEDIATE SUPPORT REACTION = 99.3

## LOAD-SPAN TABLE FOR 1 ½" NAILSTRIP @ 12 X 24 GA.

### DEFLECTION = L/180

| SPAN | THREE EQUAL SPAN | | |
|---|---|---|---|
| FT | W(PSF) | RE | RI |
| 3.00 | 30.09 | 36.1 | 99.3 |
| 3.25 | 27.78 | 36.1 | 99.3 |
| 3.50 | 25.79 | 36.1 | 99.3 |
| 3.75 | 24.07 | 36.1 | 99.3 |
| 4.00 | 22.57 | 36.1 | 99.3 |