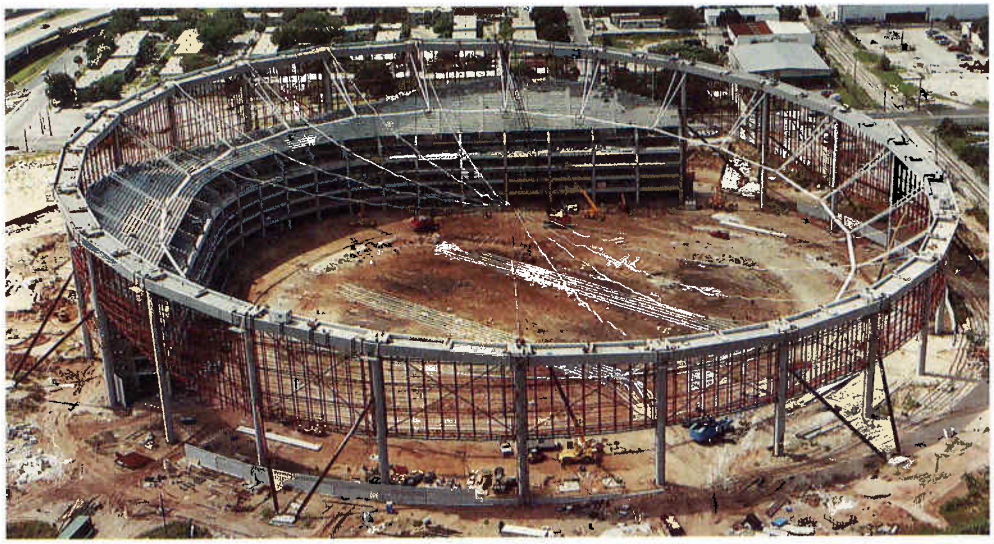
A beautiful prestressed precast concrete parking facility - one of the many parking garages that use Voss Bearing Pads.



Another new domed sports palace taking shape in the sun belt with Voss Bearing Pads in the plans.

A set of Voss Bearing pads will support each of these twin T's in the construction of this new parking garage in Chicagoland.

Marina Towers, a Chicago landmark, alive and well, resting on Voss Bearing Pads.

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Voss Engineering, producers of Bearing Pads for over thirty years, continues to research and develop the best available products in the industry.

In 1984 Voss Engineering recovered some 26 year-old pads for testing to determine long term strength qualities. They were Sorbtex™ duck layer fabric pads that came from a bridge under repair. Testing showed they retained 90% of their original strength properties. The pads had been supplied by Voss Engineering to the Illinois Tollway Authority in 1958. Since that time countless Voss bearings have gone into numerous projects ranging from parking structures and stadiums to bridges and commercial buildings. In fact, in many construction projects throughout the country where two structural elements are mated together harmoniously, you might just find a Voss bearing pad doing its job - pads such as our Sorbtex™ duck layer fabric pad, the Vossco™ ROF pad, the Neosorb™ unreinforced chloroprene pad, and Voss Slide Bearings (TEFLON®).

The Voss commitment to product quality and service to the customer continues uppermost in our corporate priorities. Our in-house test equipment allows us to simulate field conditions *(up to 105 KIPS compression and 25 KIPS lateral load)* and provide customers with solutions to their specific bearing problems. We are dedicated to continued research and development to keep the finest possible bearing pads available to the industry.

Such a product is **FIBERLAST**.

Bearing pads are commonly used in standard construction, precast and prestressed concrete bridges and buildings, as well as machinery and equipment foundations. They are designed to:

- distribute vertical loads uniformly over bearing areas to eliminate highly localized stresses and resulting structural damage
- allow horizontal and/or rotational movements at the bearing surfaces to reduce the effects of temperature, creep and shrinkage
- achieve a longer life than steel bearings which in the past have commonly failed due to corrosion
- isolate shock loads on structural members
- minimize vibrations between contacting surfaces.

Elastomeric Bearing Pad Types

Elastomeric bearing pads may be generally classified into two groups: plain pads (unreinforced) and reinforced pads. Plain pads are generally made in single layers from materials such as chloroprene, chloroprene formulated with other elastomers and natural rubber.

Reinforced elastomeric bearing pads are made by several different methods One example is duck reinforced pads made of closely spaced layers of woven fabric bonded with nitrile or chloroprene elastomers (Sorbtex™). These are commonly used for building or bridge applications as well as shock and vibration isolation. Random Oriented Fiber (ROF) is another reinforced pad (Vossco™) used extensively for bearings in the precast concrete industry and other construction applications including bridges.

FIBERLAST Bearing Pads

FIBERLAST bearing pads offer engineers and designers a new choice in ROF pads. With today's ever increasing structural needs and higher load requirements, a pad had to be developed that could meet these rigid demands and remain cost effective. FIBERLAST is such a product. Made of high quality ozone resistant virgin elastomer combined with synthetic fibers, FIBERLAST pads have been extensively tested to demonstrate that their performance characteristics are superior to comparable ROF or AASHTO grade unreinforced chloroprene pads.

FIBERLAST TEST PROGRAM

An extensive laboratory test program was undertaken to evaluate the structural performance properties of the new FIBERLAST ROF pad material. The tests were performed by Wiss, Janney, Elstner Associates, Inc., Northbrook, Illinois, under the direction of Donald W. Pfeifer, Vice President. The tests were designed and performed by Gilbert T. Blake, Senior Engineer, and Joseph Zachorowski, Specialist. Prior to undertaking the laboratory testing, a literature review [1,2,3,4,5] was made to establish the state-of-the-art in structural design considerations for elastomeric pads. Significant factors identified in the literature which need to be considered in the design process are as follows:

- Stress-strain behavior of uniformly loaded pads.
- Stress-strain behavior of nonuniformly loaded pads.
- Horizontal shear resistance behavior due to deformation and friction characteristics of uniformly loaded pads.
- Creep properties of uniformly loaded pads.
- Effective coefficient of friction.

In the test program compression tests were made on pads with sizes of 4 x 4 x 1/2 in., 4 x 4 x 1/4 in., 5 x 5 x 3/8 in. and 8 x 14 x 3/8 in. These four pad sizes have shape factors of 2, 4, 3.3 and 6.8, respectively. The pads were tested between steel-to-steel, steel-to-concrete and concrete-to-concrete bearing surfaces. Besides uniform loading tests, two nonuniformly loaded conditions were tested. All tests were conducted in triplicate making a total of 108 compression specimens.

Horizontal shear tests were made using uniform compressive stresses of 500, 1000 and 1500 psi on pads with sizes of 4 x 4 x 1/2 in. and 4 x 4 x 1/4 in. The pads were tested between steel-to-concrete and concrete-to-concrete bearing surfaces. A total of 36 shear tests were made.

Creep tests were also made in triplicate using a constant compressive stress of 1500 psi on pads with a size of 4 1/4 x 4 1/4 x 1/2 in. and a shape factor of about 2. The loads were maintained on these pads for 120 days using standard 50-ton creep frames in accord with ASTM C512 methods. Photographs of the various tests in progress are shown on the inside back cover.

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FIBERLAST SPECIFICATIONS

Made of high quality ozone resistant virgin elastomer combined with synthetic fiber.

Material properties of the new FIBERLAST bearing pads are tabulated below and discussed in detail in this catalog.

1. Hardness (Shore A)................................... 80 ± 5

   Heat Aging (per ASTM D573)
   70 hrs. @ 212°F in forced air oven
   Durometer, Point Change................10 pt. max

2. Compression

   minimum ultimate strength.....................8000 psi

3. Shear Modulus (G)......................... 230 ± 30 psi

   Based on tests conducted at 70° to 80°F under uniform compressive stresses of 500, 1000 and 1500 psi and at an applied horizontal shear plus slip strain of 50 percent. This value is applicable to both concrete-to-concrete and steel-to-concrete surfaces.
   G is constant in all directions parallel to the bearing plane.

4. Tensile Strength

   (ASTM D412, Die C).................... 1000 ± 100 psi

   Tensile strength for elastomeric materials is commonly related to the ability of the edges of plain nonreinforced bearing pads to withstand the tensile stresses induced by undesirable bulging of the pad during application of high compressive loads. Thus, nonreinforced chloroprene pads and some ROF pads must be designed to account for bulging and shape factor effects. Tests in 1988 on the new FIBERLAST pad material have demonstrated that this ROF material is relatively insensitive to bulging effects for shape factors ranging from 2 to 7. This performance is in contrast to the behavior reported in the June 1985 PCI Technical Report No. 4, "Criteria For Design of Bearing Pads," on a different ROF pad material.[1]

   Ozone Resistance (per ASTM D1149)
   Exposed 50 hrs. @ 100 pphm @ 100°F
   Tensile Strength.......................................725psi min.

   Heat Aging (per ASTM D1149)
   70 hrs. @ 212°F in forced air oven
   Tensile Strength, %Change........................-25% max.

5. Elongation:

   Ultimate Elongation, % ....40% min.

   Ozone Resistance (per ASTM D1149)
   Exposed 50 hrs @ 100 pphm @ 100°F
   Elongation...40% min.

   Heat Aging (per ASTM D573)
   70 hrs. @ 212°F in forced air oven
   Elongation, % Change...............................-25% max.

6. Oil Immersion

   Oil Immersion per ASTM D4711
   70 hrs. @ 212°F in ASTM #3 oil
   Volume Change, %.................................125% max.

7. Thickness tolerance ± 1/16" or 15%, whichever is greater.

ALL PRODUCT IS CERTIFIED TO ABOVE SPECIFICATIONS BY VOSS ENGINEERING, INC., CHICAGO, ILLINOIS

DESIGN CHARACTERISTICS

Bearing pad design procedures are usually based upon service loads. Design guidelines for bearing pads are available in the 1985 PCI Design Handbook.[4] The guidelines presented in this Manual are patterned after the PCI Design Handbook guidelines and proposed specifications included in the Oct. 1987 NCHRP Report 298.[2]

Compressive Stress

The allowable compressive stress, σ_C, for uniformly loaded, single layer ROF pads which are free to slip, suggested by the PCI[4], is as follows:

$$\sigma_C = 1000 + 100S \leq 1500 \qquad (1)$$

where:

σ_C = compressive stress on loaded area, psi

S = shape factor of actual loaded area

Shape factor is a nondimensional relationship associated with the bulging caused by compressing a bearing pad. It is an important factor in plain pad design where significant bulging of the pad can lead to failure.

Shape Factor is defined as:

$$S = \frac{l_1 w_1}{2t\,(l_1 + w_1)} \qquad (2)$$

where:

l_1 = loaded length of pad, in.

w_1 = loaded width of pad, in.

t = thickness of pad, in.

Equation (1) was based on extensive test data developed in 1984 from ROF pads with shape factors of 2 to 5. These pads were sensitive to shape factor variation when uniformly loaded to 1500 psi and compressive strains of 30 to 40 percent were developed.

The newly developed FIBERLAST pad was found to be relatively insensitive to shape factor (from 2 to 7). When uniformly loaded to 1500 psi, the compressive strains were 11 to 20 percent.

Compressive strains can also be influenced by the friction characteristics of the surfaces in contact with the pads. As a result, surfaces most commonly encountered in building or bridge construction were tested.

Typical FIBERLAST uniform compressive stress-strain curves averaged from three tests are shown in Figs. 1, 2 and 3 for various steel and concrete surface combinations and shape factors ranging from 2 to 7. These data from 36 tests indicate that the average compressive strain for a uniform 2000 psi stress level will be about 15 to 18 percent for these shape factors and surface loading conditions. A review of these data indicates that shape factor does not produce a consistent pattern nor significant detrimental effects on the strain behavior common to plain nonreinforced pads and other ROF pads.

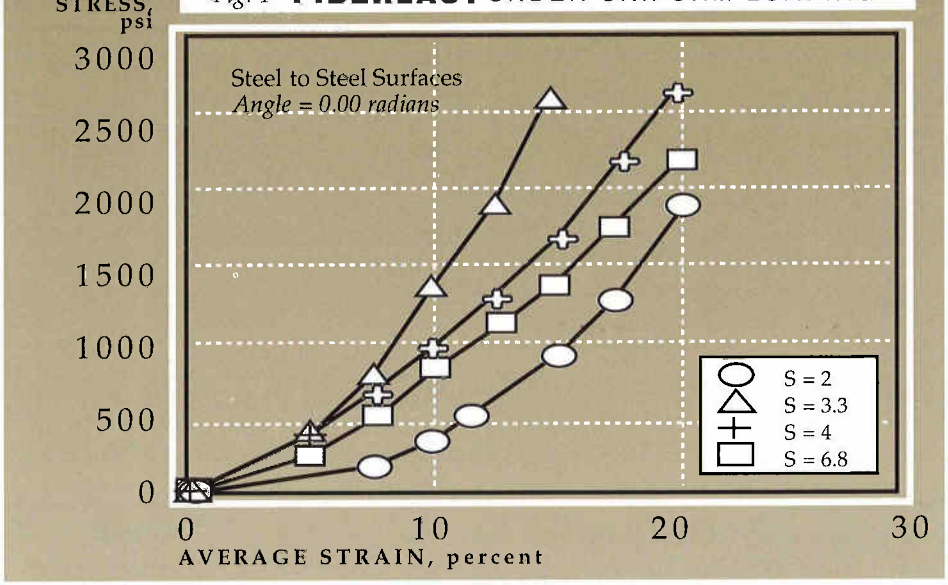

Fig. 1 **FIBERLAST** UNDER UNIFORM LOADING

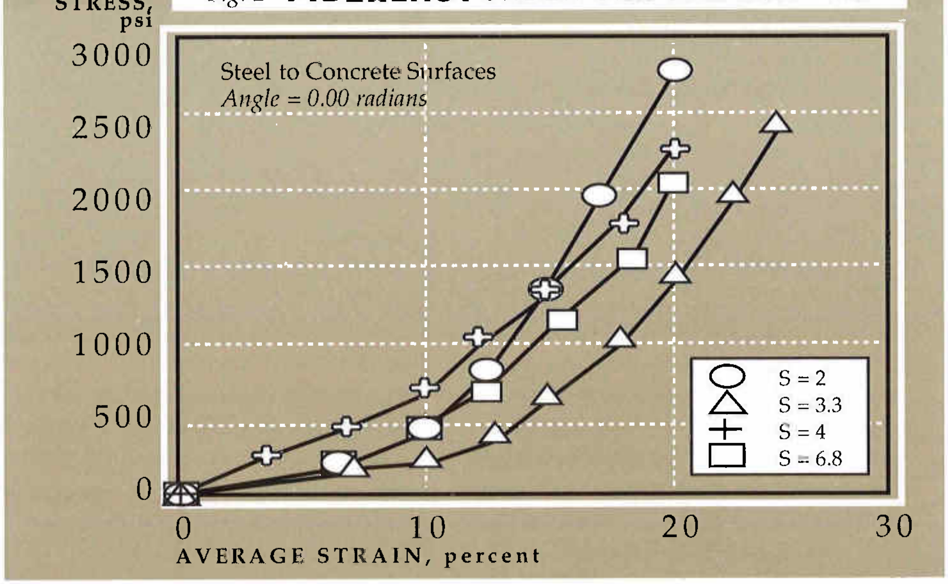

Fig. 2 **FIBERLAST** UNDER UNIFORM LOADING

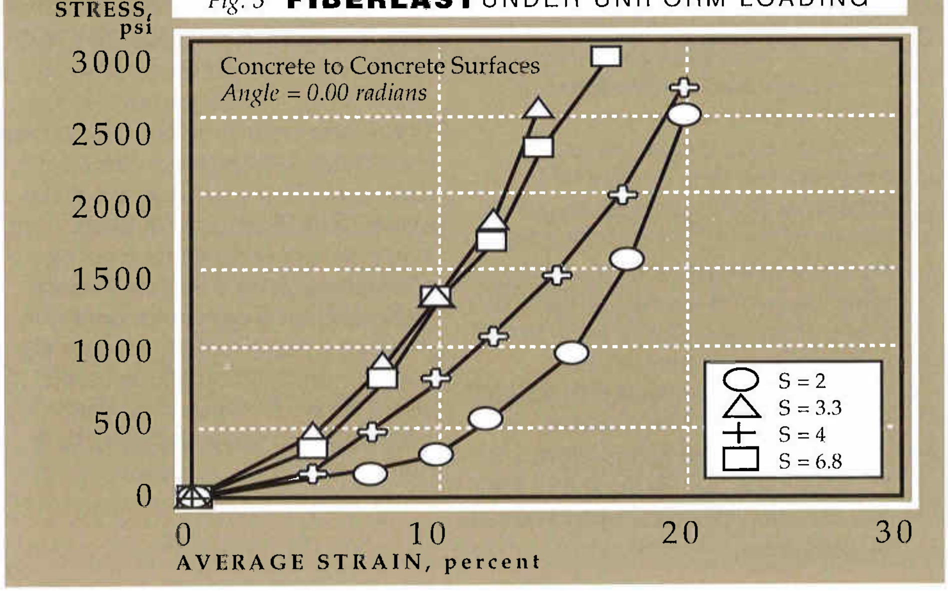

Fig. 3 **FIBERLAST** UNDER UNIFORM LOADING

Compressive Strain

Average compressive strain is defined as follows:

$$\varepsilon_c = \frac{\Delta_c}{t} \qquad (3)$$

where: ε_c = compressive strain, in./in.

Δ_c = instantaneous compression shortening of pad, in.

t = original bearing pad thickness, in.

The total average compressive strain during the life of the pad is the sum of the initial compressive strain due to instantaneous dead and live loads, and the long-term compressive strain due to creep. Instantaneous compressive strains for FIBERLAST pads when loaded uniformly to 2000 psi between concrete and steel surface combinations range from 12 to 23 percent and average about 15 to 18 percent, irrespective of the bearing surface and shape factor. Long-term creep data for FIBERLAST pads uniformly loaded to 1500 psi with a shape factor of 2 are shown in Fig. 4. These creep data show about 9 percent creep strain after 120 days of sustained loading. Thus, the creep strain can vary from approximately 39 to 75 percent of the instantaneous compressive strain. The total long-term compressive strain can range between 21 to 32 percent of the original pad thickness if loaded continuously to the full service load design stress of 2000 psi. Since bearing pads are generally under sustained working stresses due to dead load only, the total long-term compressive strain of the pads would be less than the 21 to 32 percent range.

Nonuniformly Loaded Bearing Pads in Compression (Rotation)

Bearing pads are often loaded nonuniformly as shown in Fig. 5. The total angular difference θ, between the two structural member bearing surface planes is referred to as rotation.

Rotation is significant because it causes the load to be nonuniformly distributed over the bearing pad. Under some conditions, only a portion of the pad may be loaded as shown in Figs. 5, 6 and 7. This causes high stresses in the area where the load is in contact with the pad. For this reason, the amount of rotation must be accounted for in design.

The rotation limit suggested by PCI is given by the expression:

$$\theta_{max} = \frac{0.3t}{l \text{ or } l_1} = \frac{0.3t}{w \text{ or } w_1} \qquad (4)$$

where:

θ_{max} = maximum allowable rotation, radians

t = original bearing pad thickness, in.

l or l_1 = bearing pad length under actual load, in.

w or w_1 = bearing pad width under actual load, in.

The use of l or w depends on which surface dimension is affected by the rotation. If both dimensions are affected, the greater angle is used. Limiting rotation angles derived from Equation (4) for various pad thickness and dimension combinations are plotted in Fig. 8. The curves in Fig. 8 show the relationship between pad dimensions l or l_1 and w or w_1, pad thickness t, and allowable rotation θ_{max}, for nonuniform loading conditions which limit the maximum compressive strain of the nonuniformly loaded pad to 30 percent.

The latest bearing pad research presented in the October 1987 NCHRP Report 298[2] includes the following suggested specification for limiting the rotations of rectangular bearing pads used in bridge bearings:

$$L\theta_{TL,x} + W\theta_{TL,z} \leq 2\Delta_c \qquad (5)$$

where:

L = loaded bearing pad length, in.

W = loaded bearing pad width, in.

$\theta_{TL,x}$ = relative rotation of top and bottom surfaces of bearing about the transverse axis, radians

$\theta_{TL,z}$ = relative rotation of top and bottom surface of bearing about longitudinal axis, radians

Δ_c = instantaneous shortening of uniformly loaded pad, in.

When the proposed NCHRP rotation limits are utilized with the average compressive strain properties of uniformly loaded FIBERLAST (i.e., about 15 to 18 percent strain at uniform service load for all shape factors from 2 to 7), Equation (5) is comparable to the PCI equation (4) as shown:

$$L\theta_{TL,x} = 2\Delta_c \quad (\text{for } W\theta_{TL,z} = 0)$$
$$L\theta_{TL,x} = 2 \times 0.15t$$
$$L\theta_{TL,x} = 0.3t$$

and

$$\theta_{TL,x} = \frac{0.3t}{L} = \frac{0.3t}{W} \qquad (6)$$

Thus, the PCI and NCHRP rotation limits are comparable for FIBERLAST pads because the FIBERLAST material has an average uniformly-loaded compressive strain of about 15 percent at service load. Other ROF and plain pad materials would not exhibit equivalent behavior unless their stress-strain behavior produced the same 15 percent average compressive strain at service load stresses.

Figure 8 can be used to determine the proper pad thickness t for efficient utilization of the pad by maximizing the actual loaded area of the pad under nonuniform loading conditions. As an example, from Fig. 8 for an assumed design rotation of 0.025 radians, the maximum l_1 or w_1 dimension for a 1/4-in. pad will be about 3 in. However, these dimensions would increase to about 6 in. if a 1/2 in. thick pad was selected. When severe design rotations of 0.050 radians must be considered, Fig. 8 shows that pad efficiency declines rapidly. For example, only a 1-1/2 in. l_1 or w_1 dimension would be available for loading purposes with a 1/4 in. pad and only 3 in. would be available for loading purposes with a 1/2-in. thick pad.

When the actual rotation conditions of a project are unknown and the designer wishes to assume a reasonable angular rotation of 0.025 radians, the Fig. 8 chart shows that 1/4- to 1/2-in. thick pads can provide useable loaded dimensions l_1 or w_1 of about 3 to 6 in., respectively.

Designs based upon the data from

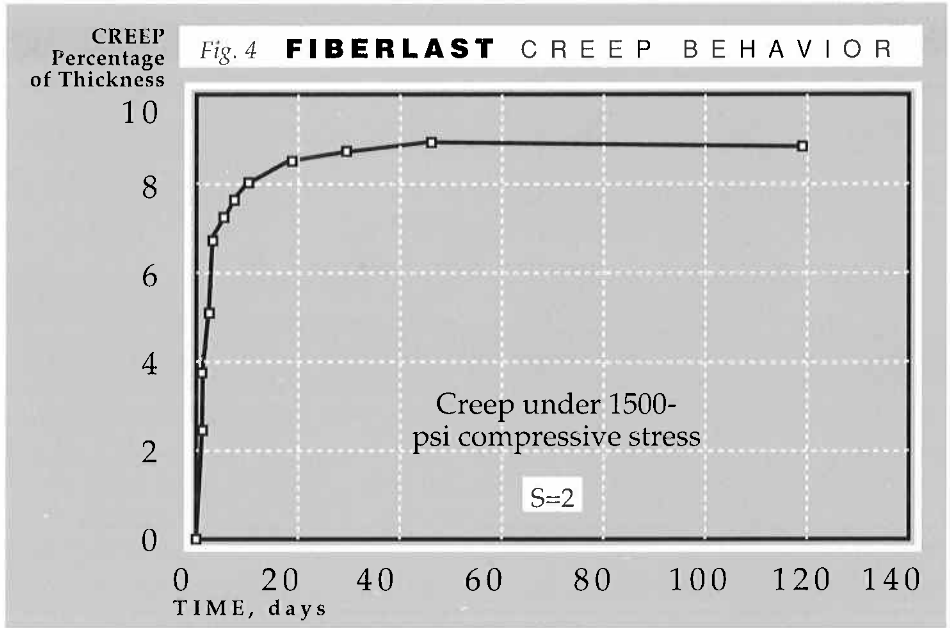

Fig. 4 **FIBERLAST** CREEP BEHAVIOR

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Fig. 5 **TYPICAL NONUNIFORM BEARING**
created by construction tolerances of both structural members

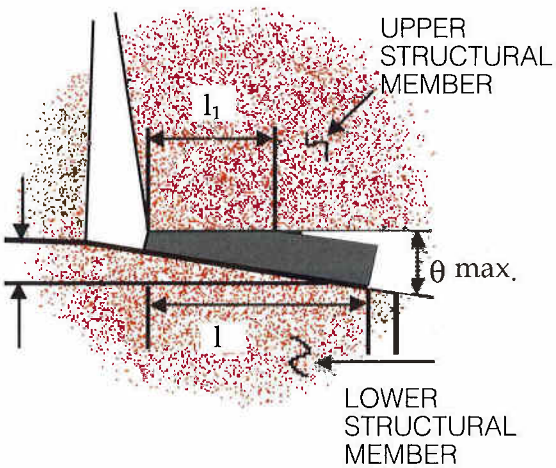
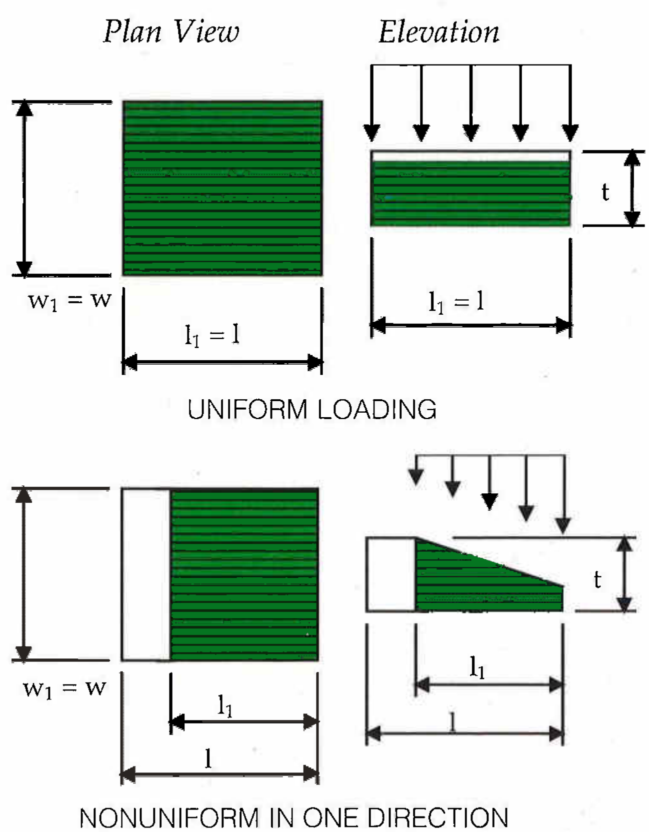
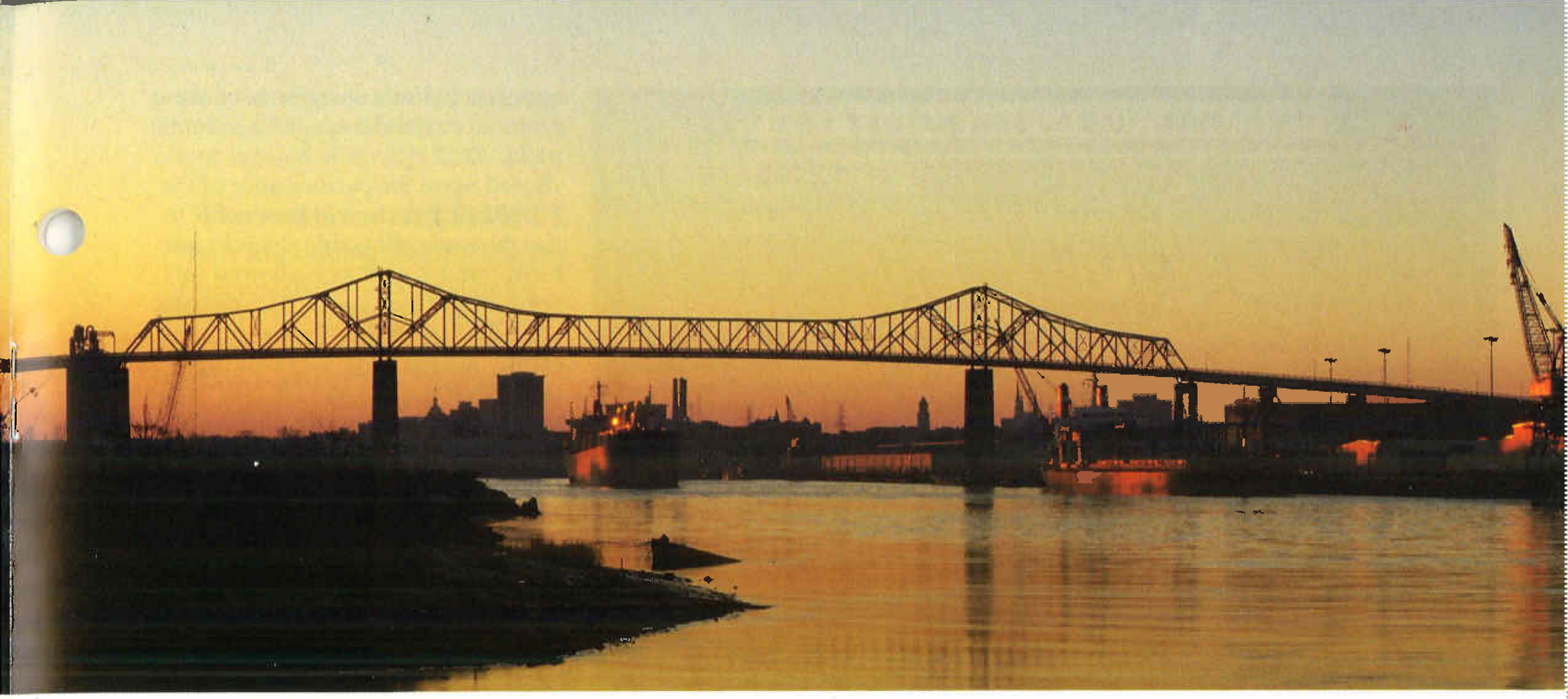


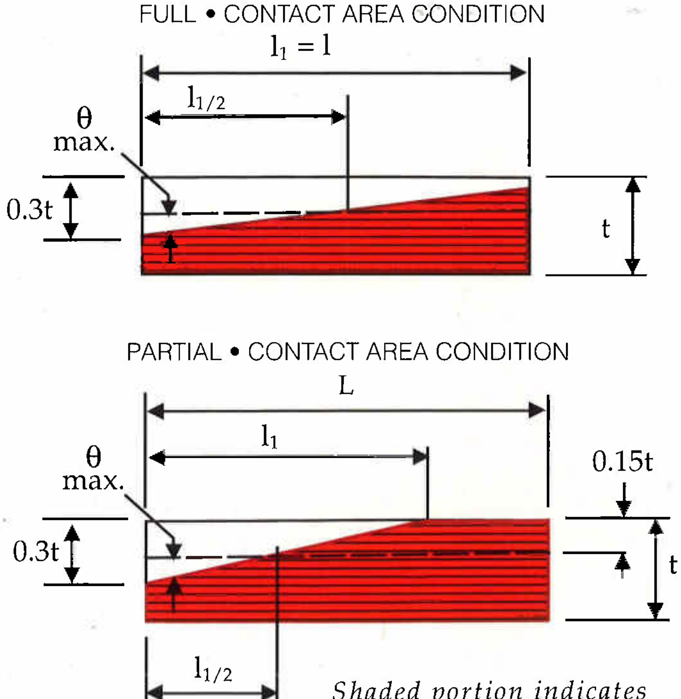
Fig. 6 **DESIGN LOADING CONDITIONS**





Voss Bearing Pads are a major component in bridges and other heavy construction.

Fig. 7 **PAD DEFORMATION SHAPES**
when nonuniformly loaded...Fiberlast Design Assumptions



Shaded portion indicates deformed, loaded shape.

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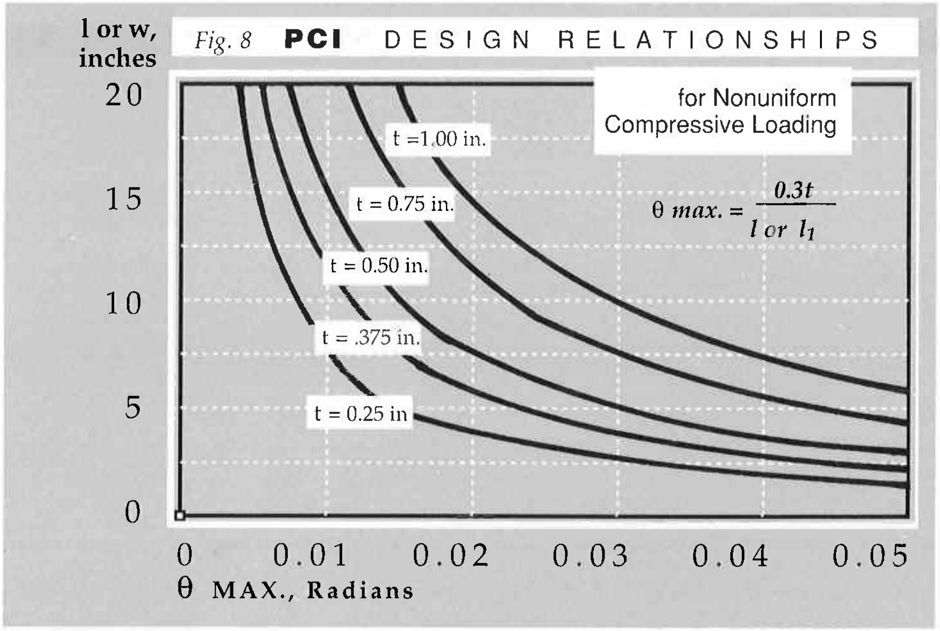

Fig. 8 result in producing average compressive strains at the center of gravity beneath the loaded area of a nonuniformly loaded FIBERLAST pad of about 15 percent while allowing 30 percent strain at the highly loaded edge.

Figures 9, 10 and 11 show FIBERLAST average stress-strain behavior for various combinations of steel and concrete bearing surfaces when loaded nonuniformly at 0.025 radians. These data show that, for a rotation angle of 0.025 radians and a maximum compressive strain at the loaded edge of the pad of 30 percent, FIBERLAST pads will sustain actual average compressive stresses of about 2000 psi for concrete to concrete or concrete to steel surfaces and 1500 psi for steel to steel surfaces.

Figures 12, 13 and 14 show FIBERLAST average stress-strain behavior between the same bearing surfaces when loaded nonuniformly at 0.050 radians.

For the 0.050 radian test condition, these data show that the FIBERLAST pads will sustain average compressive stresses of about 1000 psi for all surface conditions.

While some of these stresses exceed the uniformly loaded pad stress of 1500 psi suggested by PCI, such higher stresses under nonuniform loading are explainable from the shape of the nonlinear stress-strain behavior of elastomeric materials. This condition allows for 30 percent strain on the most highly stressed portion of the nonuniformly loaded pad while still limiting the average strain to about 15 percent at the center of gravity of the loaded area of the pad. No detrimental effects were apparent at these stress levels during nonuniform load tests on 72 different pads.

Based upon the performance of the FIBERLAST pads, it is reasonable to use the same allowable stress in uniform compression as is allowed for nonuniform loading at 0.025 radians.

The data on uniformly and nonuniformly loaded pads, when incorporated with the PCI and NCHRP rotation limits and the stress-strain properties of FIBERLAST pads, result in the following suggested unfactored service load compressive stress limits:

FIBERLAST
allowable compressive stress, psi*

Bearing surface condition	*Rotation angle, radian* 0.00	0.025	0.050
Concrete-to-concrete	2000	2000	1000
Concrete-to-steel	2000	2000	1000
Steel-to-steel	2000	1500	1000

* Unfactored service stresses on actual loaded area of pad

As an example of the use of the above table and Fig. 8, the total design load P (unfactored service load) can be calculated for pads under different loading conditions. The calculations for a 6 in. x 6 in. x 3/8 in. pad loaded uniformly and nonuniformly between concrete surfaces are as follows:

for $\theta_{max} = 0.00$ radians

$P = lw\sigma_c$,
where $l = 6$ in. and $\sigma_c = 2000$ psi
$P = 6 \times 6 \times 2000 = 72{,}000$ lbs

for $\theta_{max} = 0.025$ radians

$P = l_1 w \ \sigma_c$,
where $l_1 = 4.50$ in. from Fig. 8
and $\sigma_c = 2000$ psi
$P = 6 \times 4.5 \times 2000 = 54{,}000$ lbs

for $\theta_{max} = 0.050$ radians

$P = l_1 w \ \sigma_c$,
where $l_1 = 2.25$ in. from Fig. 8
and $\sigma_c = 1000$ psi
$P = 6 \times 2.25 \times 1000 = 13{,}500$ lbs

Linear interpolation for other rotations to determine the maximum compressive stress appears appropriate. Severe rotations of greater than 0.050 radians should be avoided since pad capacity decreases rapidly

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with the decrease in loaded pad area. This causes the pad stresses to increase beyond allowable limits.

Planar (Horizontal) Shear

Shear in a bearing pad is related to the relative planar deformation between the top and bottom surfaces. This horizontal deformation is caused by forces being applied by the loading member or the reaction or both. These forces can be the result of vehicle acceleration and braking, thermal effects, prestressing effects and other factors.

Recent studies presented in the NCHRP Report 298[2] have shown that bearing pads with combined horizontal shear and vertical compressive loadings have maximum shear efficiency when the shear plus slip strain is limited to about 50 percent of the pad thickness. Strains beyond 50 percent caused the pad edges to be overstrained. This results in the rolling over of the edges, which can cause localized high stresses and debonding of the fiber from the elastomeric matrix. Although 70 percent shear plus slip strain has been recommended as a limit by PCI[4] and others, the NCHRP specification limits shear deformation to 50 percent of the pad thickness.

The maximum allowable shear stress utilizing the 50 percent shear plus slip strain limit can be expressed by the relationship:

$$\tau_S = \varepsilon_S G \qquad (7)$$

where:

τ_S = maximum allowable shear stress, psi

ε_S = maximum shear strain of 0.50, in./in.

G = shear modulus at shear plus slip strain of 0.50, psi

FIBERLAST has been extensively tested in shear. Figures 15 to 18 show the horizontal shear characteristics of FIBERLAST when tested under various compressive loads and surface conditions. These 33 tests show that the shear modulus G is relatively insensitive to the compressive stress variation from 500 to 1500 psi as well as the bearing surface conditions. The G values at 50 percent

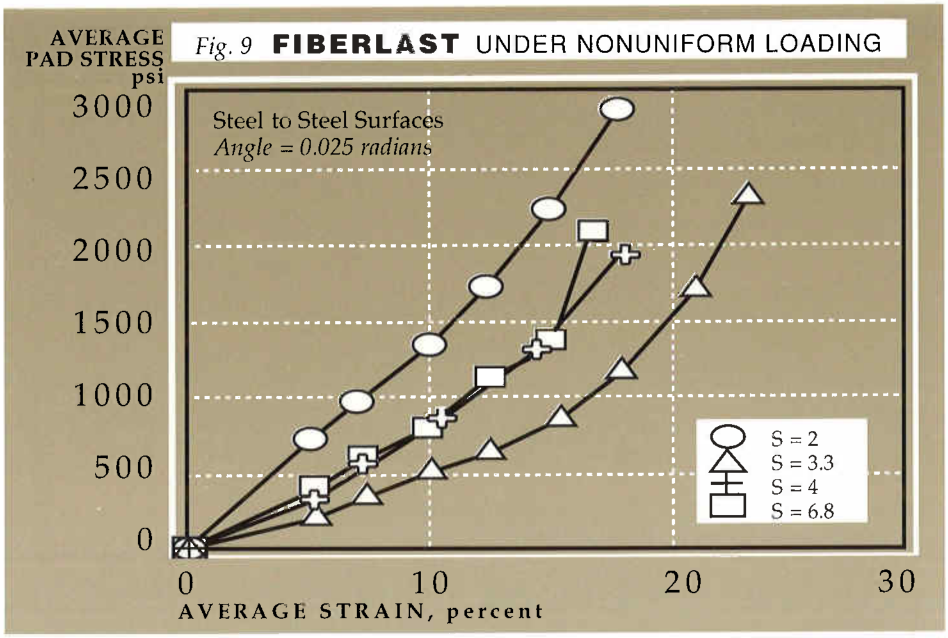


Fig. 9 **FIBERLAST** UNDER NONUNIFORM LOADING

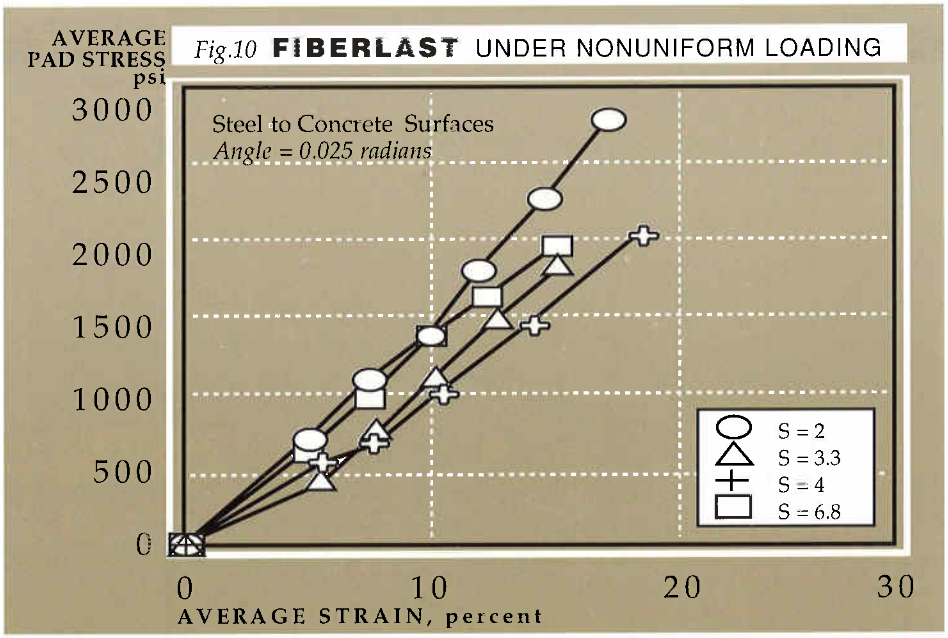


Fig.10 **FIBERLAST** UNDER NONUNIFORM LOADING

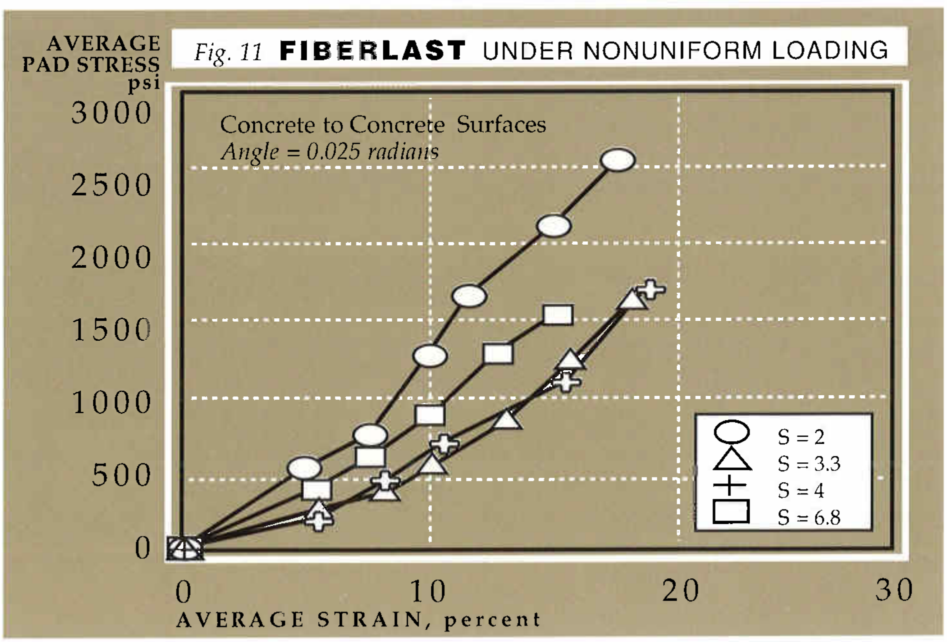


Fig. 11 **FIBERLAST** UNDER NONUNIFORM LOADING

Fig. 12 **FIBERLAST** UNDER NONUNIFORM LOADING

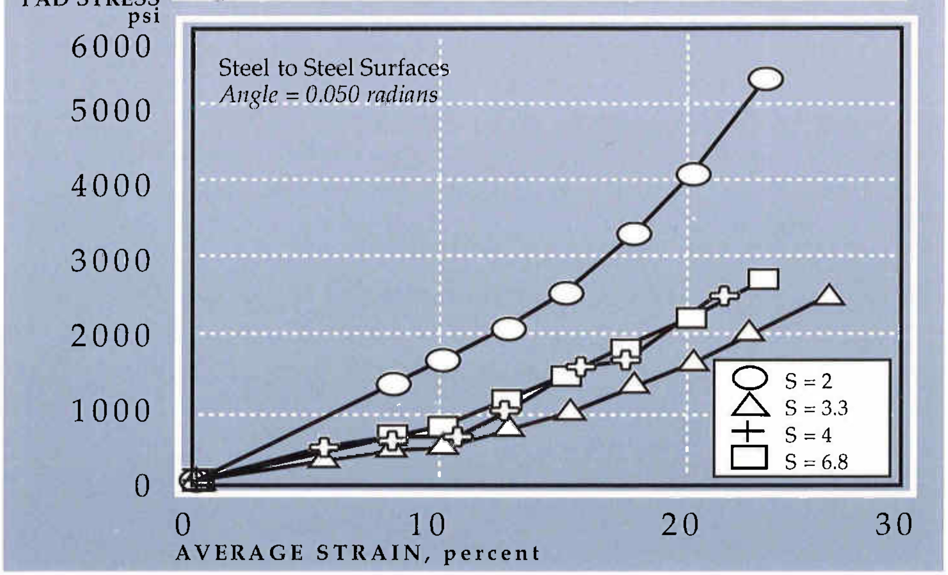


Fig. 13 **FIBERLAST** UNDER NONUNIFORM LOADING

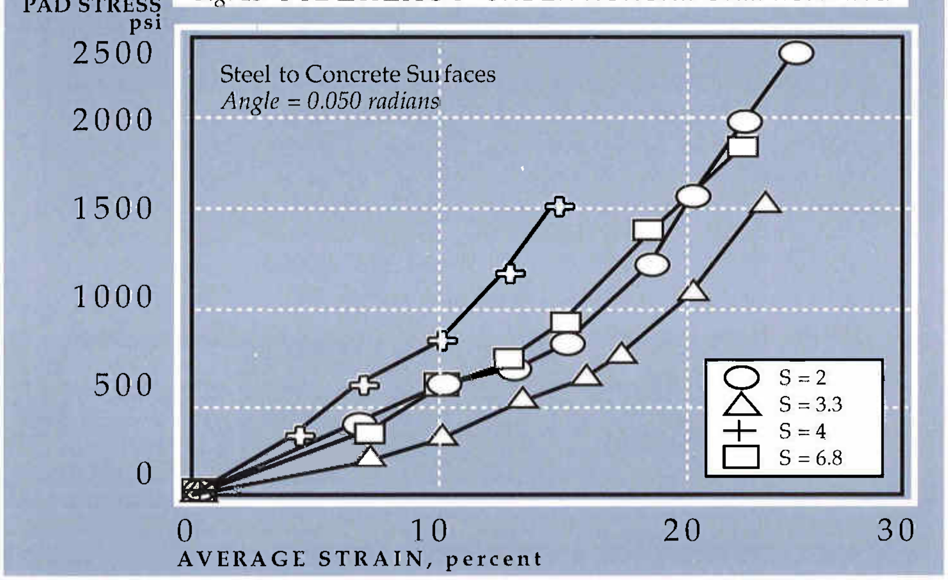
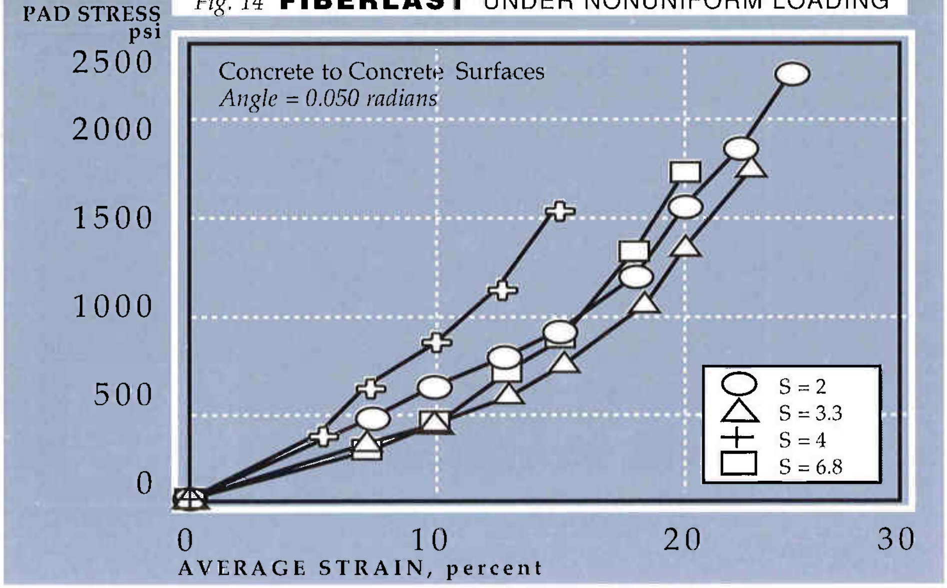


Fig. 14 **FIBERLAST** UNDER NONUNIFORM LOADING



shear plus slip strain ranged from about 200 to 260 psi.

Effective Friction Properties of FIBERLAST

The effective coefficient of friction of the FIBERLAST pads may be estimated as follows:

$$\mu = \frac{\tau_s}{\sigma_c} \qquad (8)$$

where:

μ = effective coefficient of friction

τ_s = shear stress at a shear plus slip strain of 50 per cent of pad thickness, psi

σ_c = uniform compressive stress on pad, psi

The data in Fig. 19 show the effective coefficient of friction at a horizontal shear plus slip strain of 50 percent of the pad thickness. The coefficients are relatively insensitive to shape factor and bearing surface conditions, but they are influenced by the magnitude of the compressive stress on the pad. The values range from about 0.23 down to 0.06.

Stability

Failure in highly-loaded, thick and narrow bearing pads is often caused by buckling rather than bulging and splitting. To ensure maximum stability, the NCHRP specifications recommend that plain pad thickness, t, should relate to pad length and width as follows:

$$t \leq \frac{l_1}{5} \text{ or } \frac{w_1}{5} \qquad (9)$$

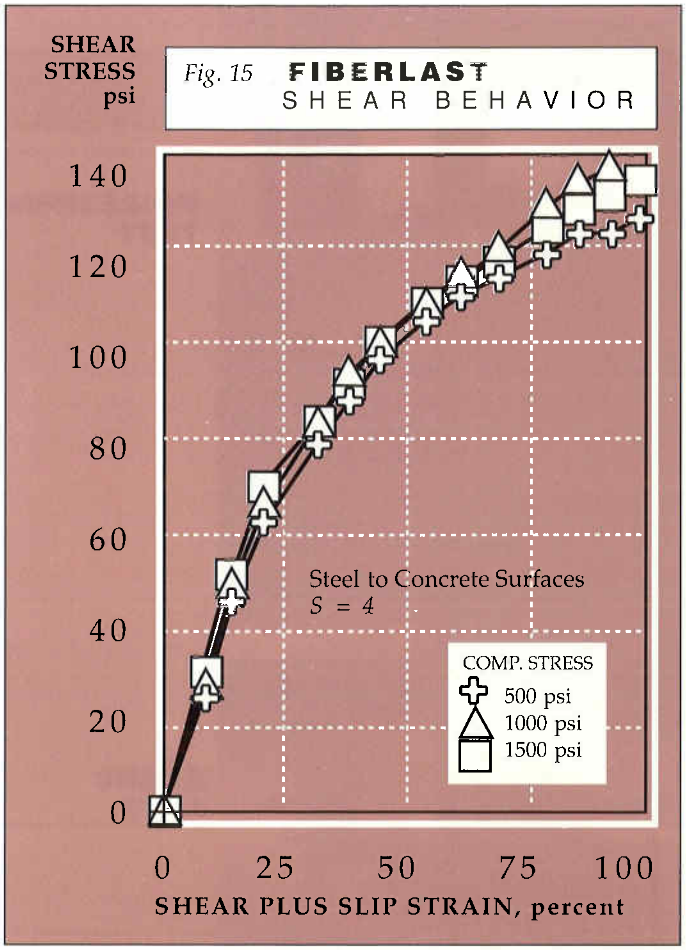
where:

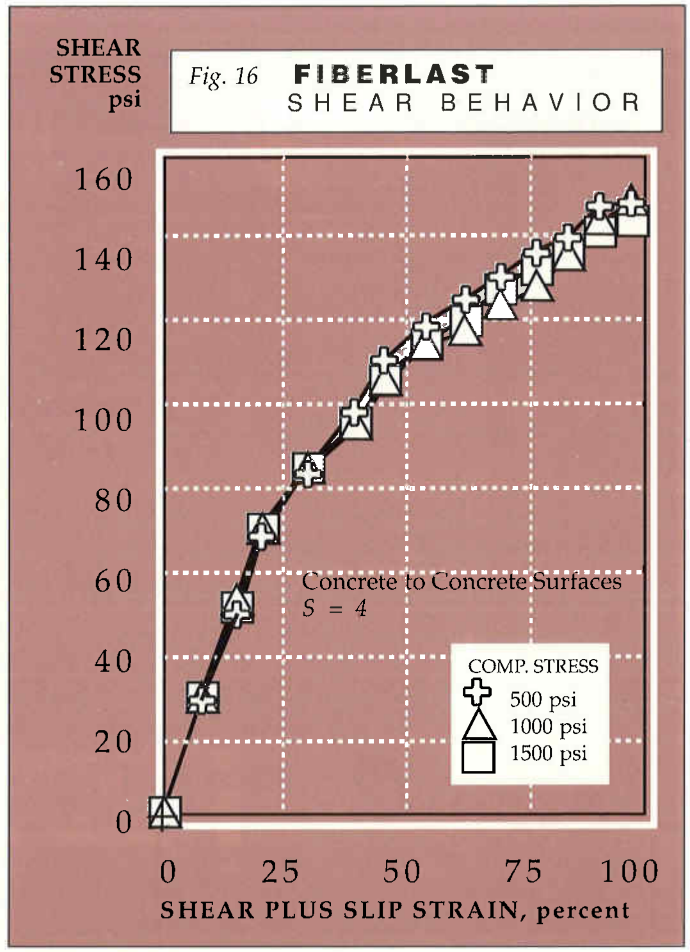
t = pad thickness, in.

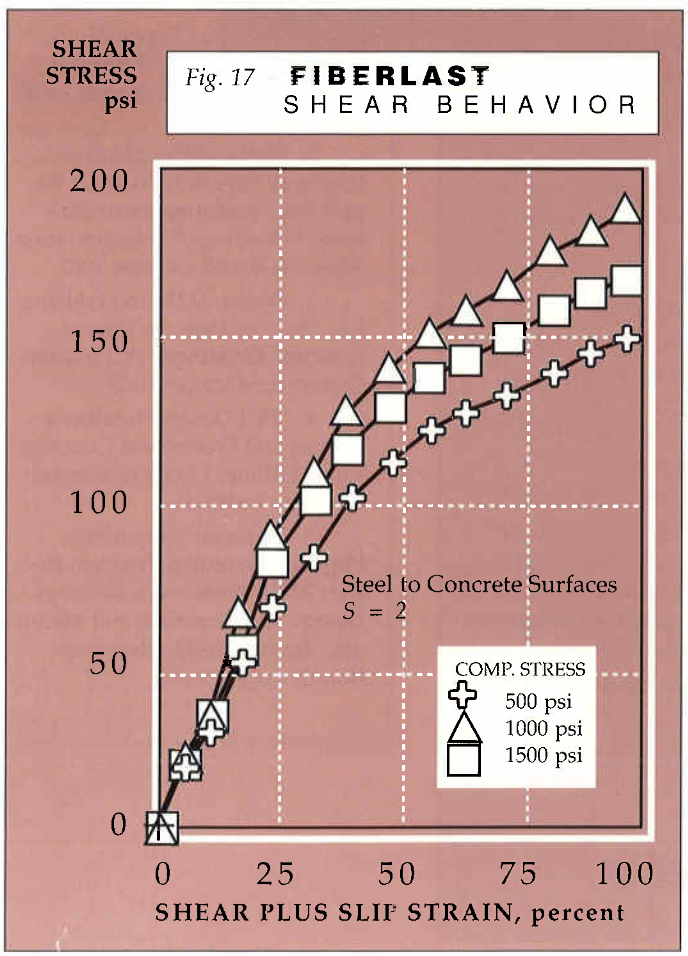
l_1 = loaded length of pad, in.

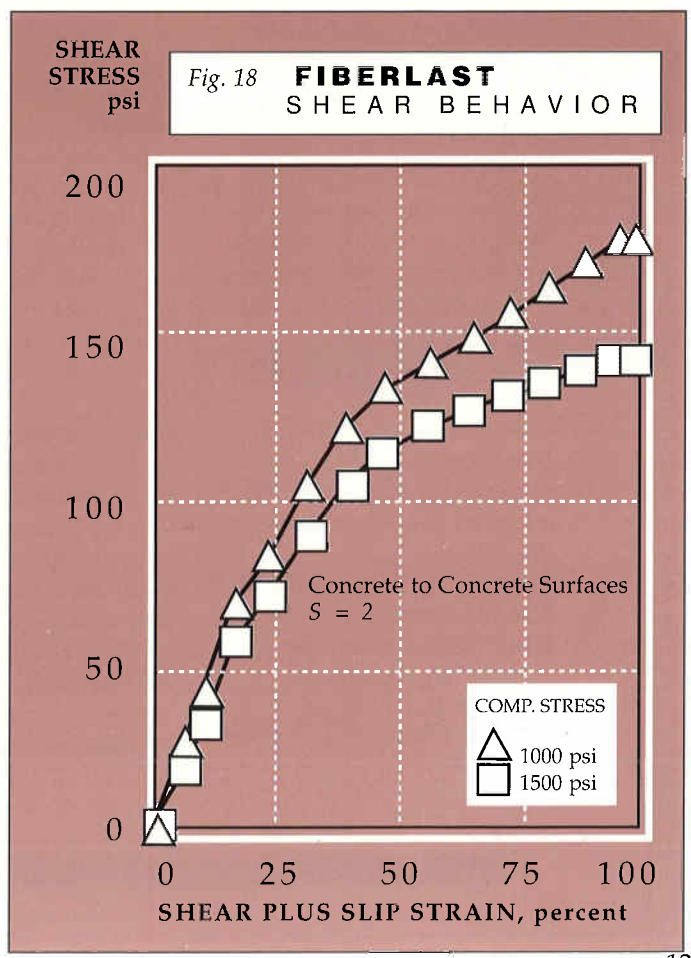
w_1 = loaded width of pad, in.

A description of the test methods and results of the test program, which included all of the Voss Engineering product line as well as other commercial products, will be available upon request.


SHEAR STRESS psi
Fig. 15 FIBERLAST SHEAR BEHAVIOR
140
120
100
80
60
40
20
0
Steel to Concrete Surfaces
S = 4
COMP. STRESS
500 psi
1000 psi
1500 psi
0 25 50 75 100
SHEAR PLUS SLIP STRAIN, percent


SHEAR STRESS psi
Fig. 16 FIBERLAST SHEAR BEHAVIOR
160
140
120
100
80
60
40
20
0
Concrete to Concrete Surfaces
S = 4
COMP. STRESS
500 psi
1000 psi
1500 psi
0 25 50 75 100
SHEAR PLUS SLIP STRAIN, percent


SHEAR STRESS psi
Fig. 17 FIBERLAST SHEAR BEHAVIOR
200
150
100
50
0
Steel to Concrete Surfaces
S = 2
COMP. STRESS
500 psi
1000 psi
1500 psi
0 25 50 75 100
SHEAR PLUS SLIP STRAIN, percent


SHEAR STRESS psi
Fig. 18 FIBERLAST SHEAR BEHAVIOR
200
150
100
50
0
Concrete to Concrete Surfaces
S = 2
COMP. STRESS
1000 psi
1500 psi
0 25 50 75 100
SHEAR PLUS SLIP STRAIN, percent

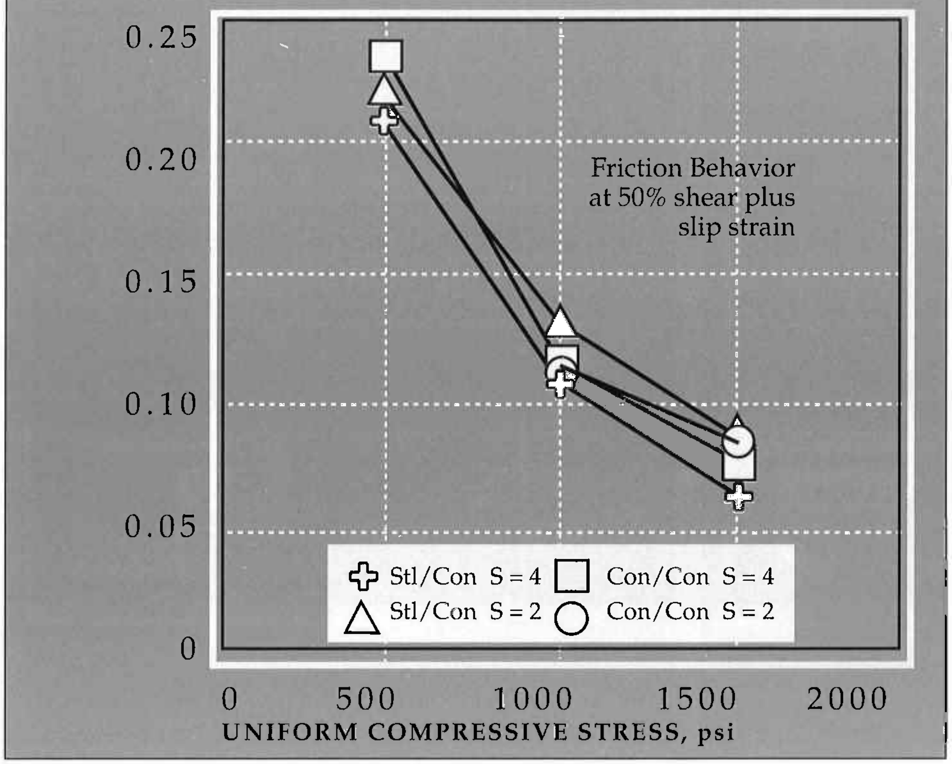


Fig. 19 **FIBERLAST** FRICTION BEHAVIOR

DEFINITION OF TERMS

l = gross length of bearing pad. Usually parallel to the longitudinal axis of the supported structural member, in.

l_1 = length of bearing pad under load, in.

G = shear modulus of elastomer, psi (at 70° to 80°F).

P = unfactored service load on bearing pad, lbs.

S = shape factor of loaded area.

t = unloaded bearing pad thickness, in.

w = gross width of bearing pad. Usually perpendicular to the longitudinal axis of the supported structural member, in.

w_1 = width of bearing pad under load, in.

θ = relative rotation of top and bottom surfaces of bearing, radians:

Subscripts:

TL = total service load

x = about transverse axis

z = about longitudinal axis

θ_{max} = maximum allowable rotation, radians

Δ_c = instantaneous compressive deflection of bearing pad, in.

ε_c = compressive strain, in./in.

ε_s = shear plus slip strain, in./in.

σ_c = average compressive stress on loaded area, psi

τ_s = average shear plus slip stress, psi

μ = effective coefficient of friction

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3. Pfeifer, D.W. and Iverson, J.F., "Bearing Pads for Precast Concrete Buildings," PCI Journal, September-October 1985.
4. "PCI Design Handbook - Precast and Prestressed Concrete," Third Edition, 1985, Prestressed Concrete Institute.
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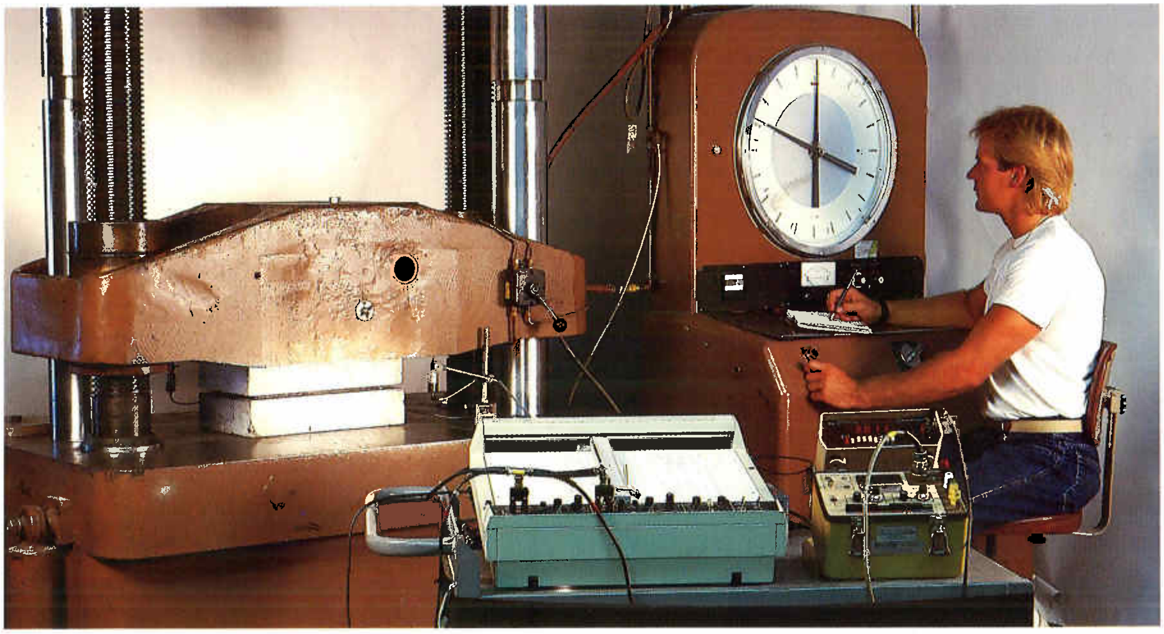
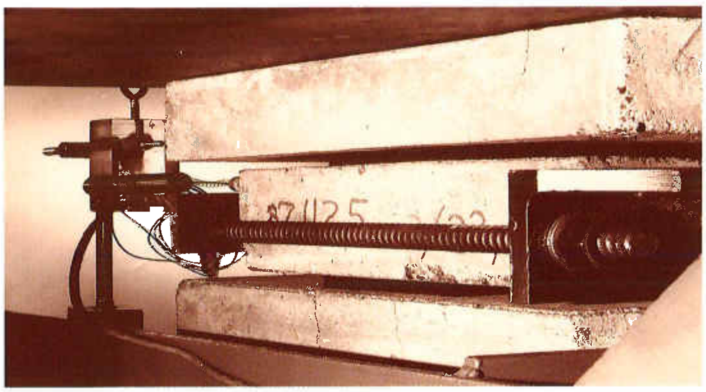
COMPRESSION TEST



SHEAR TEST



CREEP TEST

Voss

ENGINEERING