FIBERLAST EXPANSION BEARING PADS

In 1988 an extensive test program was conducted on FIBERLAST bearing pads to determine the performance characteristics of the pad material when used as ROF bearing pads. The results of these tests and the design recommendations are reported in the Voss Engineering Company brochure entitled, "FIBERLAST,"[1] which is available upon request. The test data and design considerations in this section relate to the use of FIBERLAST as a low-friction, expansion bearing pad material.

Uniform Compression
The 1988 test series on conventional FIBERLAST ROF pads with thicknesses of 1/4 to 1/2 in. and shape factors ranging from 2 to 7 resulted in design recommendations of 2000 psi maximum uniform compression stress. Under these uniform loading conditions, these various smaller and thinner pads for building construction exhibited 15 to 18 percent average compressive strains at the 2000 psi level. The 1991 tests evaluated thicker and larger conventional FIBERLAST pads for bridge and other heavy construction. These pads which were 7 x 14 in. in plan size with thicknesses of 1, 2, and 3 in. and 13x13x10 in., had shape factors of 2.3, 1.2, 0.8 and 0.3, respectfully. The test results from these smaller shape factor FIBERLAST pads, along with the test results from the small (larger shape factor) pads tested in 1988, are shown in Fig. 21. The stress/strain curves from the thicker and larger pads are very similar to those of the thinner and smaller FIBERLAST pads.

The measured compression strains for the thicker pads at a stress of 2000 psi are about 15, 17.5, 25 and 23.5 percent for shape factors of 2.3, 1.2, 0.8 and 0.3, respectively. The average compressive strain for these pads when loaded uniformly to 2000 psi is 20.3 percent. This compares with an average compressive strain of 17.3 percent for the 4 smaller pads with shape factors of 2 to 7 when loaded uniformly to 2000 psi. This new data reconfirms that FIBERLAST pads of all sizes and shape factors have substantially less sensitivity to bulging because of the reinforcing effect of the random oriented fibers.

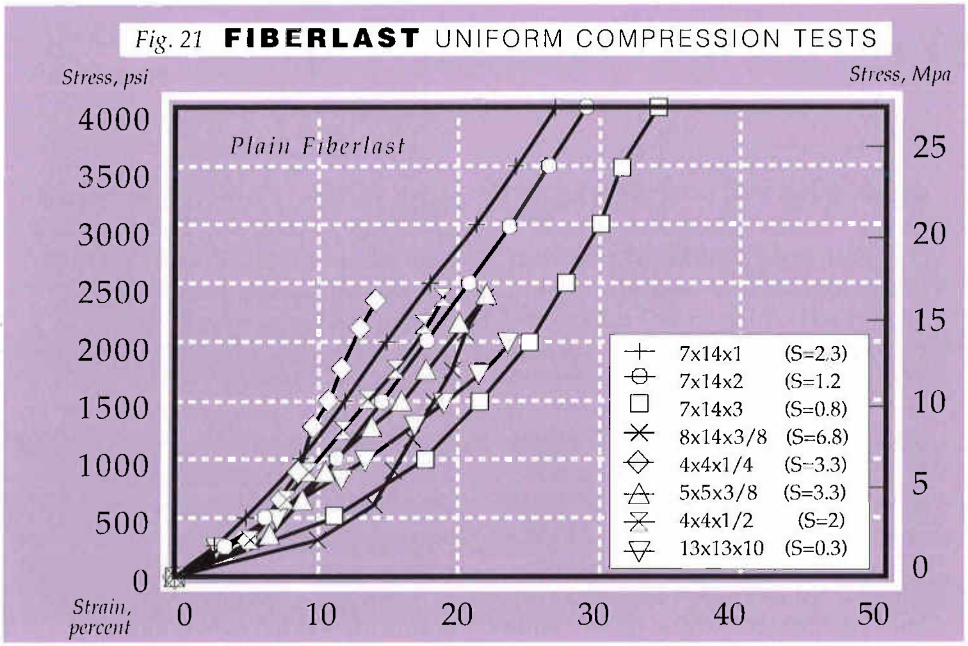
The stress/strain curves for FIBERLAST pads having shape factors from 0.3 to 7, shown in Fig. 21, are compared to 60 durometer steel - reinforced AASHTO grade Chloroprene having shape factors of 3 to 20 in Fig. 22.

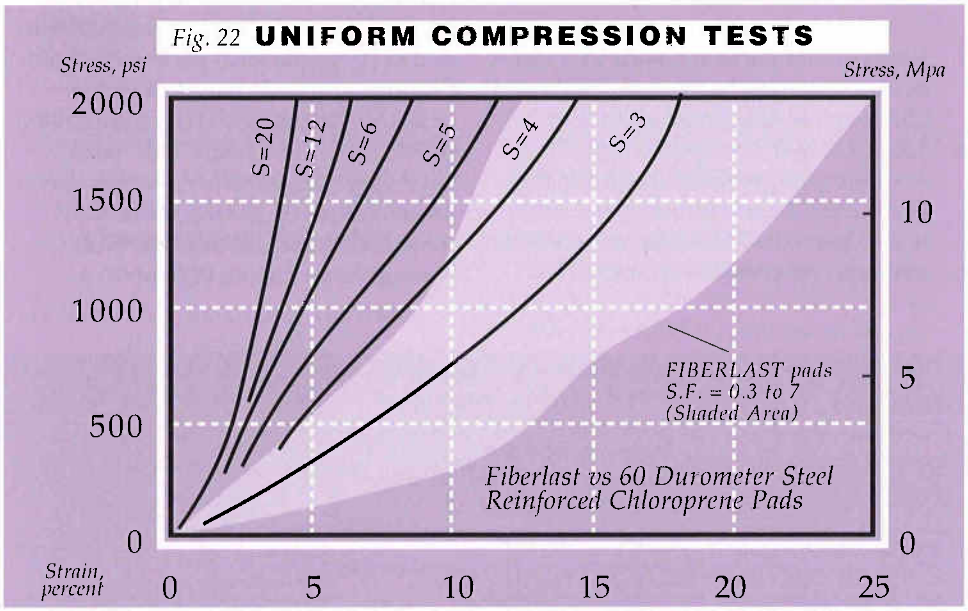
The stress/strain curves for uniformly-loaded conventional FIBERLAST ROF pads having shape factors from 1.2 to 6.8 are compared to AASHTO grade steel plate reinforced Chloroprene pads having a shape factor of 5 in Fig. 23. This comparison shows that FIBERLAST ROF pads have very similar stress / strain curves when compared to steel reinforced AASHTO grade Chloroprene pads having shape factors of 5, up to a

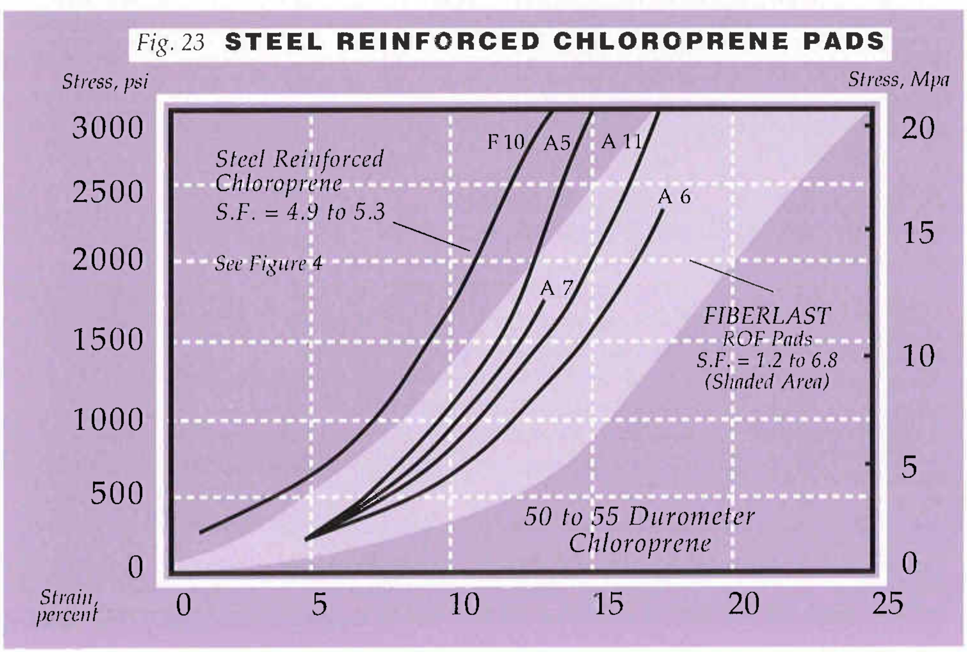
FIBERLAST Specifications
Made of high-quality ozone resistant virgin elastomer combined with synthetic fiber. Material properties of the new FIBERLAST bearing pads are tabulated below and discussed in detail in this manual.

1. Hardness (Shore A, ASTM D 2240)............ 80 ± 10%
   Heat Aging (ASTM D 573)
   70 hrs @ 212° F in forced air oven
   Durometer, Point Change. .... ± 10 pts. max.
2. Compression
   minimum ultimate strength.... .... 8000 psi
3. a. Shear Modulus (G)......................... 283 psi
   Based on tests conducted at 70° to 80° F according to ASTM D 4014-87, Annex A1 at a pure shear strain of 43 percent.
   b. Apparent Shear Modulus (G_A) .... 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. G_A is constant in all directions parallel to the bearing plane.
4. a. Tensile Strength
   (ASTM D 412, 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 Neoprene (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[1] that this ROF material has reduced sensitivity 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[8].
   b. Ozone Resistance (per ASTM D 1149)
   Exposed 50 hrs. @ 100 pphm @ 100° F
   Tensile Strength .... 725 psi min.
   c. Heat Aging (per ASTM D 573)
   70 hrs. @ 158° F in forced air oven
   Tensile, % Change .... +/- 25% max.
5. a. Elongation:
   Ultimate Elongation, % .... 40% min.
   b. Ozone Resistance (ASTM D 1149)
   Exposed 50 hrs. @ 100 pphm @ 100 F
   Elongation .... 40% min.
   c. Heat Aging (ASTM D 573)
   70 hrs. @ 212° F in forced air oven
   Elongation, % Change .... +/- 25% max.
6. Oil Immersion ASTM D 471
   70 hrs. @ 212° F in ASTM #3 oil
   Volume Change, % .... 125% max.
7. a. Tear Strength (ASTM D 624, Die B) ..... 400 Lb/in Min
   b. Ozone Resistance (ASTM D 518)
   Tear Strength 50 hrs. @ 80 PPMM @ 100°... 300 Lb/in Min
8. Dielectric Strength, ASTM D 149 (VDC/mil) 42
9. Surface Resistivity, ASTM D 257 (Ohm.cm x 10^6) .. 189.1
10. Volume Resistivity, ASTM D 257 (Ohm.cm x 10^6) .. 57.7
11. Thickness tolerance ± 1/16 in. or 15%, whichever is greater
12. Plan Size Tolerance ± 1/8 in.

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







stress of 2000 psi.

Uniform compression tests on FIBERLAST/polymer/PTFE pads and FIBERLAST/recessed steel/PTFE pads were also made in 1991 on larger size, thick pads suitable for bridge applications. These low friction FIBERLAST pads were 7x14x2 in. and 8x8x3 in. with shape factors of 1.2 and 0.7, respectively. The results of the tests shown in Figs. 24, and 25 indicate that the 7x14x2 in. conventional FIBERLAST and low-friction FIBERLAST pads with a shape factor of 1.2 when uniformly loaded to 2000 psi have uniform compression strains of about 17.5 percent (conventional) and 21 to 23 percent (low-friction pads). The conventional (7x14x3 in.) and low-friction (8x8x3 in.) FIBERLAST pads have essentially the same shape factors of 0.7 to 0.8. These conventional and low-friction pads when uniformly loaded to 2000 psi have compressive strain of about 25 percent (conventional) and 25 to 26 percent (low-friction).

These tests indicate that the tested low-friction pads with lower shape factors of 0.7 to 1.2 exhibit equal or slightly greater compressive strains when uniformly loaded to 2000 psi when compared to the conventional FIBERLAST pads with these same low shape factors of 0.7 to 1.2.

Compressive Strain and Creep Behavior

As shown in Fig. 21, instantaneous compressive strain for FIBERLAST pads, when uniformly loaded to 2000 psi between steel surfaces, range from 13 to 25 percent for shape factors between 0.3 and 6.8. Long-term creep data for FIBER-LAST pads with a shape factor of 2 and uniformly loaded to 1500 psi are shown in Fig. A1 (on pg. 22). This creep data shows about 9 percent creep strain after 120 days of sustained loading. When combined with instantaneous strain, the total long-term shortening for FIBERLAST pads may range between 20 and 30 percent of the original pad thickness if loaded continuously to 1500 psi. If loaded to 2000 psi, the total long-term shortening would be somewhat greater than 20 to 30 percent. Since sustained loads are generally due to dead load only, the total long-term compressive strain will probably be less than the 20 to 30 percent range. During the uniform compression tests on FIBERLAST/polymer/PTFE system, it was noted that the transverse (shear) strain in the FIBERLAST material exceeded the ultimate tensile strain in the polymer. This resulted in cracking of the polymer laminate at a uniform compressive strain of about 30 percent, as noted in Fig. 24.

Nonuniformly Loaded Low-Friction FIBERLAST Bearing Pads in Compression (Rotation)

Since rotation effects at the bearings can cause high edge stresses in nonuniformly loaded pads, it is important to limit those stresses in design. The rotation limit suggested by PCI[5] is defined as follows:

$$\theta_L \text{ or } \theta_W = \frac{0.3t}{L \text{ or } W} \qquad (12)$$

When using 15 percent as the average compressive strain at the center of the loaded portion of the pad for FIBERLAST, the PCI rotation limits in Equation 12 and those suggested by AASHTO in Equation 4a are equivalent. A graphic representation of Equation 12 is shown in Fig. 26 and can be used in the same manner as described using Fig. 15 for SORBTEX. The curves in Fig. 26 show the relationships between rotation angle θ, the pad thickness t, and the maximum pad length or width which provides full contact or 100 percent utilization of the pad area during nonuniform loading while limiting the maximum edge strain to 30 percent.

Figures 27 and 28 show average FIBERLAST stress/strain behavior when loaded nonuniformly at an angle of 0.015 radians. Figures 29 and 30 show average stress / strain behavior for FIBERLAST when loaded nonuniformly at an angle of 0.025 radians.

As with the uniform tests, nonuniform tests on FIBERLAST / polymer / PTFE pads resulted in cracked polymer. For the nonuniform tests, cracking occurred at stresses of between 1600 and 1800 psi. This behavior is noted on Figs. 27 and 29. Although polymer

Fig. 24 **FIBERLAST** UNIFORM COMPRESSION TESTS

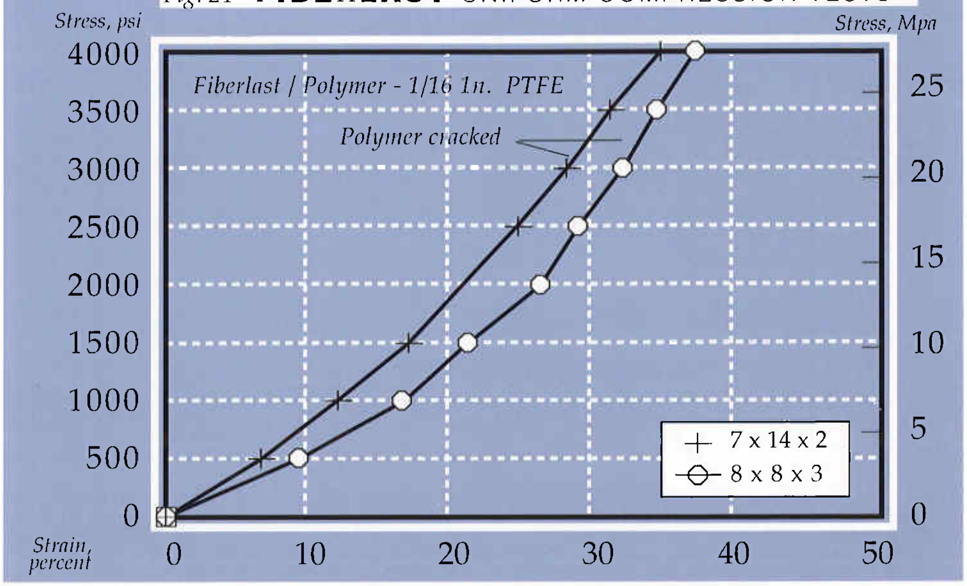


Fig. 25 **FIBERLAST** UNIFORM COMPRESSION TESTS

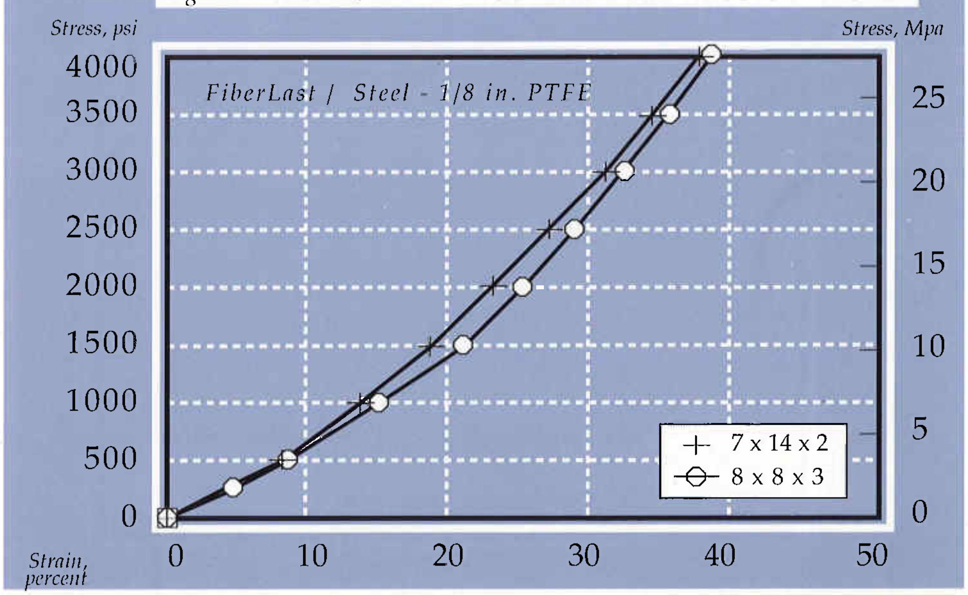
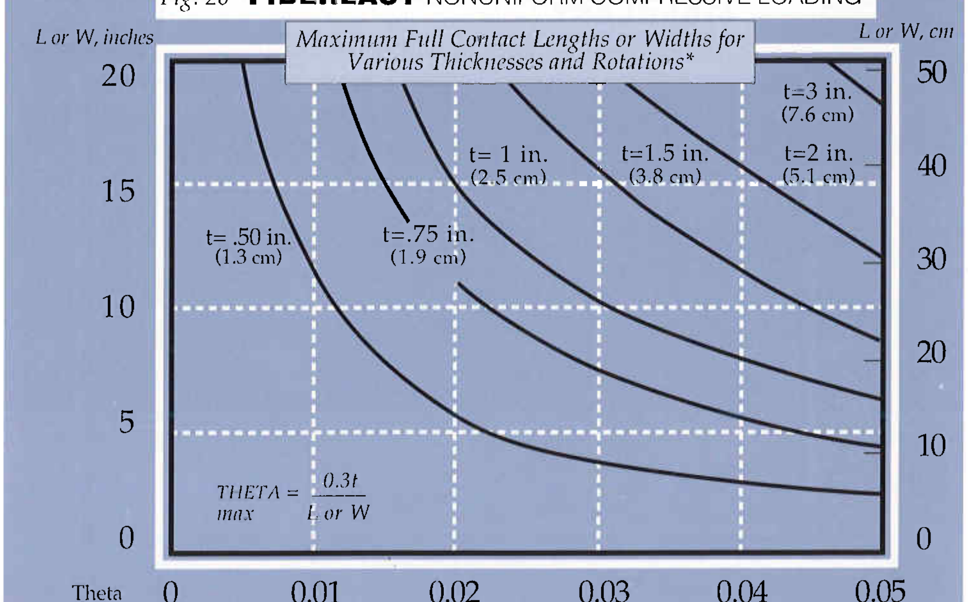
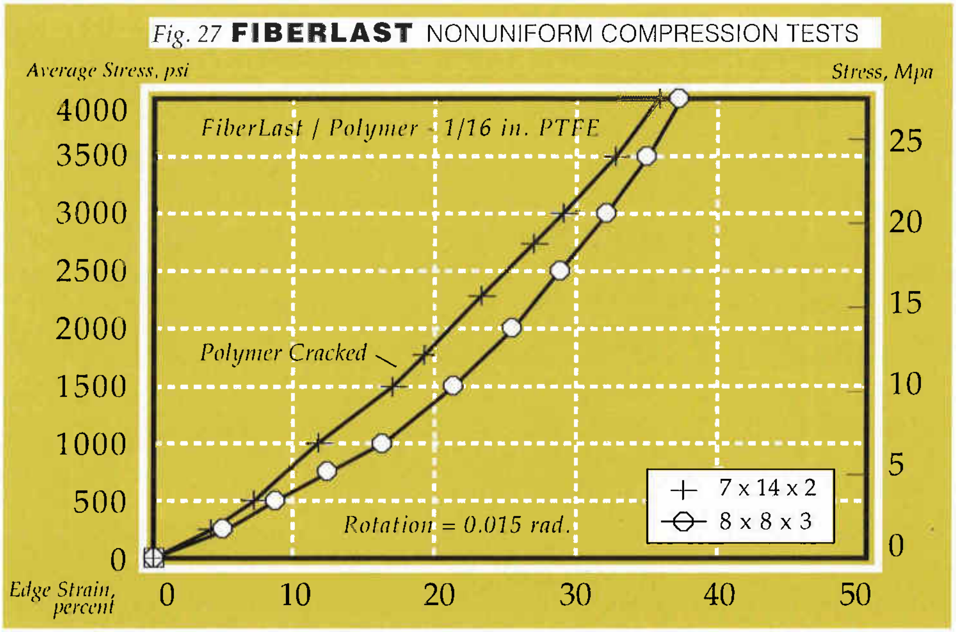
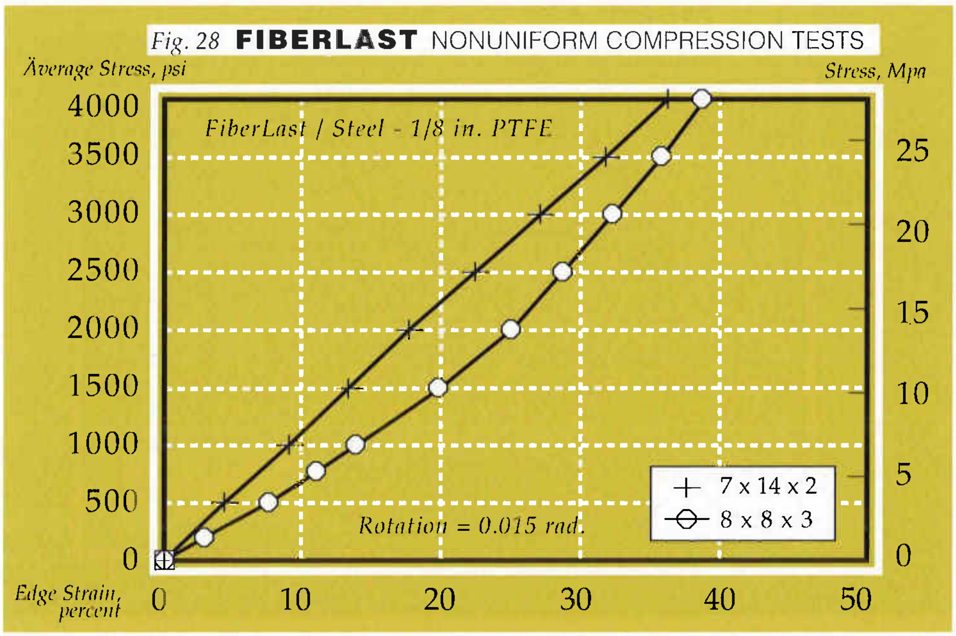


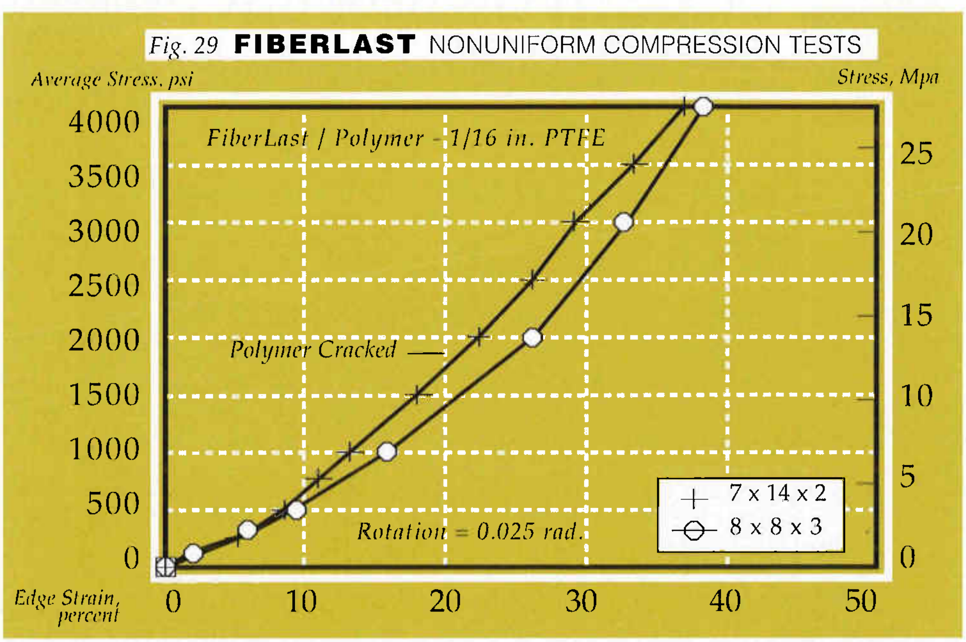
Fig. 26 **FIBERLAST** NONUNIFORM COMPRESSIVE LOADING



*Longer dimensions will not be loaded







cracking did not result in pad failure, it caused distortions in the bonded PTFE layer which would limit performance. Therefore, FIBERLAST bonded to polymer and PTFE is not recommended at service loads greater than 1000 psi. Instead, FIBERLAST bonded to steel and PTFE is preferred.

These load conditions and resulting stress/strain behavior allows up to 30 percent strain at the most highly stressed loaded edge and limits the average stress at the center of gravity of the loaded portion of the pad up to 15 percent. With the exception of polymer cracking, no detrimental effects from these loadings were apparent during tests of over 120 different pads.

Based on the test data for both uniformly and nonuniformly loaded low-friction expansion bearing pads, FIBERLAST can be loaded to an average stress of 2000 psi for rotations from 0 to 0.025 radians. For allowable stresses at larger rotation angles, please call the factory.

These recommended stress levels are also in accord with the AASHTO limitations on compressive stresses in layers of PTFE.

Pad Recovery

After testing FIBERLAST pads at 4000 psi, the pads were allowed to rest for 14 days. The pads were remeasured to determine elastic recovery. The average recovery of FIBERLAST was 98 percent ± 2 percent.

Planar (Horizontal) Shear

FIBERLAST has been extensively tested in shear. Figures 31 and 32 show the horizontal shear characteristics of FIBERLAST when tested under various compressive loads and surface conditions. These 33 tests show that the apparent shear modulus, G_A is relatively insensitive to the compressive stress variation from 500 to 1500 psi as well as the bearing surface conditions. The G_A values at 50 percent shear plus slip strain ranged from about 200 to 260 psi. In accordance with recent NCHRP Studies[3], it is recommended that FIBERLAST shear plus slip strain be limited to 50 percent.

Friction Properties of FIBERLAST Low-Friction Expansion Pads

Transverse movements in bridges and other structures impose shear forces on expansion bearings. The lower the friction between the upper and lower bearing elements, the smaller the shearing stress. However, since friction is never zero, there is always some stress on the bearings. Low durometer plain or reinforced bearings, such as NEOSORB, exhibit lateral shear displacement (shear strain). This results in higher apparent coefficients of friction between the bearing elements. Higher durometer expansion pads such as SORBTEX and FIBERLAST have less shear strain and exhibit lower apparent coefficients of friction when shear/slip strains are present.

Friction tests were conducted on specimens of FIBERLAST bonded to recessed steel plates with a bonded wearing surface layer of unfilled PTFE. The specimens were tested against a surface of 14 gage, Type 304 stainless steel with a surface roughness of about 18 microinches root mean square (rms). The friction tests were conducted at nominal compressive stresses of 500, 2000 and 3500 psi. The results of the tests are shown in Fig. A2 (on page 22) and tabulated in the following table.

FIBERLAST/Unfilled PTFE on Stainless Steel			
Friction Coefficients			
Performance	Bearing Pressure, psi		
	500	2000	3500
FIBERLAST	0.03	0.02	0.02
AASHTO[2]	0.08	0.06	0.04

Stability

Failure in highly-loaded, thick and narrow bearing pads is often caused by buckling rather than bulging and splitting. To ensure maximum stability, AASHTO specifications limit plain pad thickness to:

$$t \leq \frac{L}{5} \text{ or } \frac{W}{5} \qquad (13)$$

Where: t = pad thickness, in.
L = loaded length of pad, in.
W = loaded width of pad, in.

This specification is also recommended for FIBERLAST.

Fig. 30 **FIBERLAST** NONUNIFORM COMPRESSION TESTS

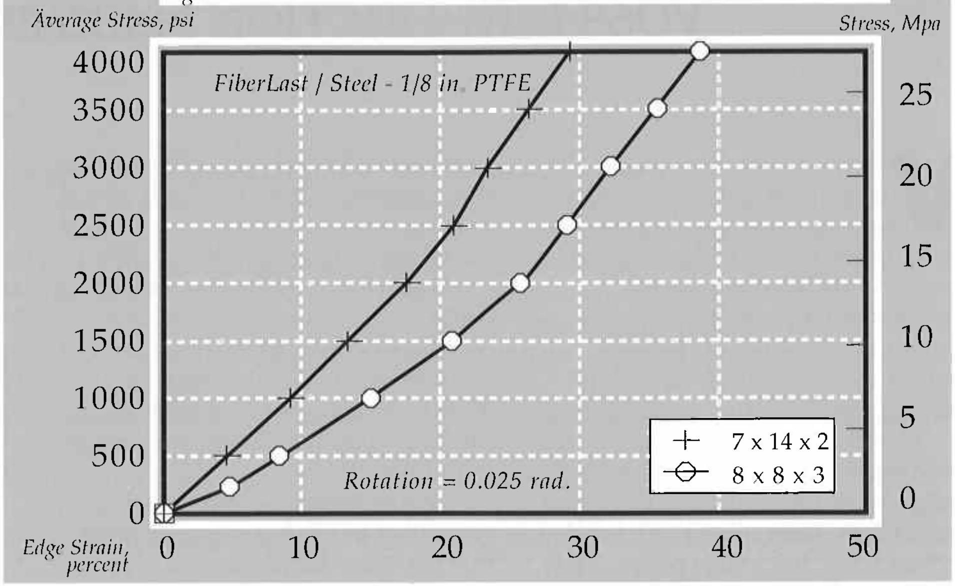


Fig. 31 **FIBERLAST** SHEAR-SLIP BEHAVIOR

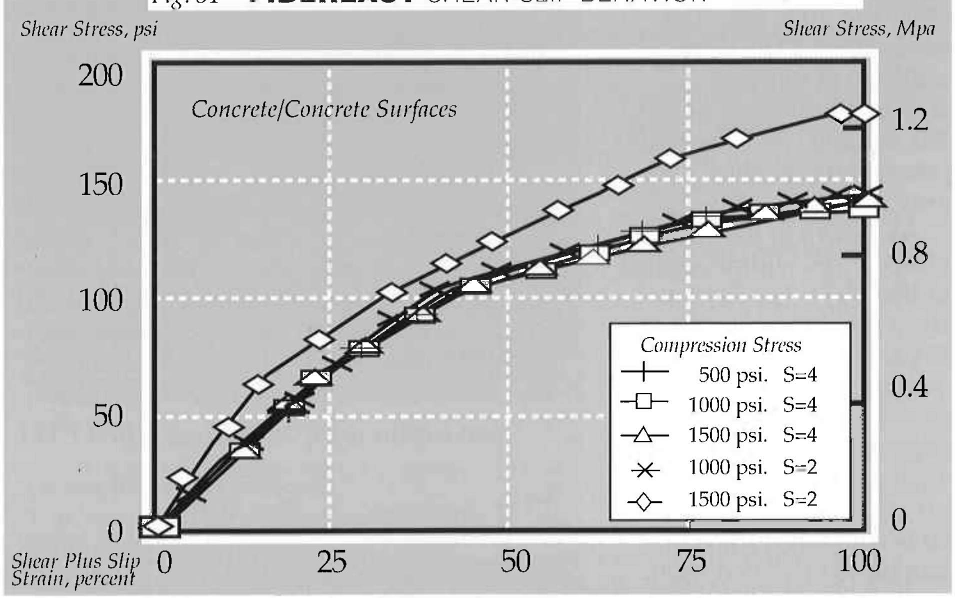
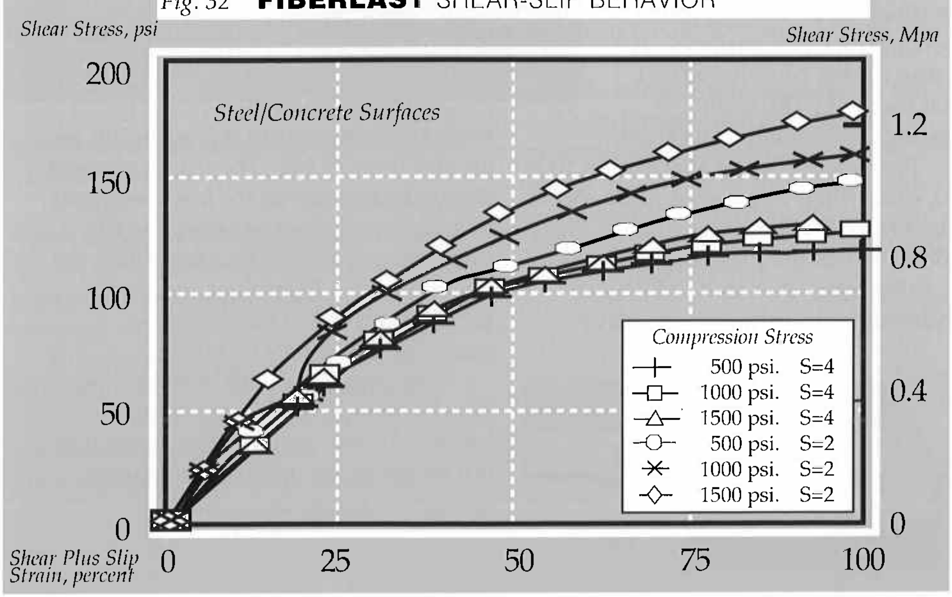


Fig. 32 **FIBERLAST** SHEAR-SLIP BEHAVIOR



BEARING INSTALLATION

Expansion and slide bearing assemblies generally consist of upper and lower components. The upper component contains a support element such as a steel plate and a contact element such as a sheet of stainless steel or layer of PTFE. The lower component usually consists of a steel support element, an ROF elastomeric or preformed fabric pad and a contact assembly. The contact assembly can be a bonded layer of PTFE, bonded laminations of polymer and PTFE or a bonded steel plate recessed to contain a layer of PTFE. These assemblies can be installed in concrete to concrete, steel to steel and concrete to steel construction.

Fig. 34, 35 and 36 illustrate some typical methods of bearing assembly attachment. Fig. 35 shows methods of attaching bearings in concrete to concrete construction while Fig. 34 shows methods used for steel to steel attachment. Some installations require bearings which limit movement to one direction. Examples of two such designs are shown in Fig. 36. Combinations of these methods and others can be used for steel to concrete applications.

Upper Bearing Assembly

Upper bearing pad support elements are usually fabricated from ASTM Type A36 steel. Stainless steel contact surfaces when used, are made from ASTM A240 or Type 304 stainless steel and shall be at least 14 gage (0.064 in.) with a surface finish less than 16.5 microinches R_a (20 microinches, root-mean-square.) In addition to the surface roughness requirement, other PTFE contact surfaces shall have minimum Brinell Hardness of 125 (~70 Rockwell B).

Stainless steel contact surfaces should be continuously welded to the support element to prevent infiltration of moisture between the sheet and plate. The bearing area of the contact surface should be sufficiently larger than the contact area of the lower element to allow for relative movement between the elements. Contact areas of both upper and lower elements should be protected from dirt, abrasion etc. during installation. Wherever possible, the contact surfaces shall be oriented so that sliding movements will cause dirt and dust accumulation to fall from the mating surface.

Lower Bearing Assembly

The lower bearing assembly usually rests on a steel plate cast in concrete or is attached to a steel structural element. Support elements of the bearing are usually ASTM Type A36 steel, welded or bolted to the steel plate or structural element. The bearing pad/contact surface element can be either unrestrained free standing, restrained free standing, or bonded to the support element, if used.

If welding is used to attach elements with bonded PTFE surfaces, provisions must be made to ensure that the temperature in the bond area does not exceed 300°F (150°C).

When designing retainers for the lower assembly, consideration must be given to bulge and long-term creep shortening characteristics of the bearing pad. Retainers must be positioned so that there is sufficient vertical and horizontal clearances between the pad and the retainer to allow for pad lateral expansion and long-term creep shortening.

All exposed carbon steel should be painted to retard corrosion.

Lateral Cold Flow of PTFE With Laminated Expansion Bearing Pads

As elastomeric pads compress from applied vertical loads, the pads expand laterally. When the elastomeric material is laminated to a low-friction PTFE system, the PTFE material also expands laterally unless a special polymeric material separates the elastomeric pad from the PTFE material. This cold flow within the PTFE can create long-term durability problems, particularly when the PTFE does not recover its lateral cold flow strain. During the test program, the lateral cold flow characteristics of PTFE bonded to plain SORBTEX, to SORBTEX with a polymer, to FIBER-LAST and to FIBERLAST with a polymer were measured. The results of these uniform compression tests are shown in Fig. A4 (on Pag 22). The test data indicate that the polymer layer dramatically reduces the lateral cold flow behavior of the PTFE when bonded to SORBTEX or FIBERLAST.

The design engineer should consider the expected lateral strain in the design bearing when considering the use of a polymer substrate. If the edge strain of a FIBERLAST / Polymer / PTFE pad under rotation exceeds about 15 percent, a piece of 10 gage stainless steel should be used in place of the polymer.

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ENGINEERING

Fig. A1 **CREEP BEHAVIOR**

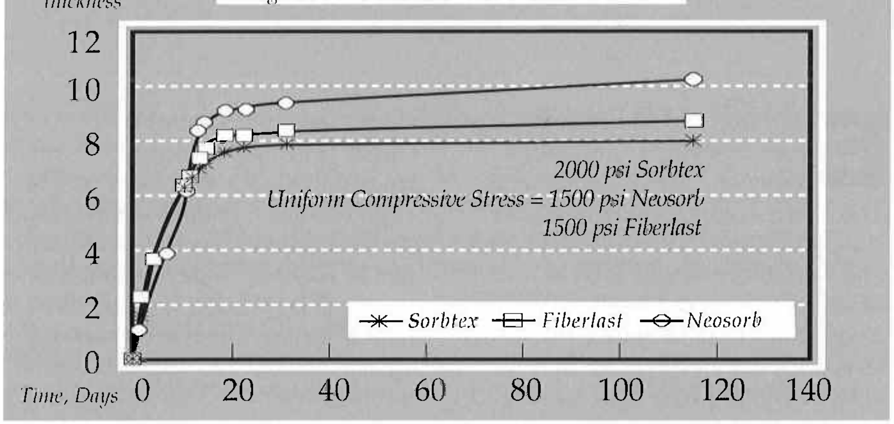


Fig. A2 **COEFFICIENT OF FRICTION TESTS**

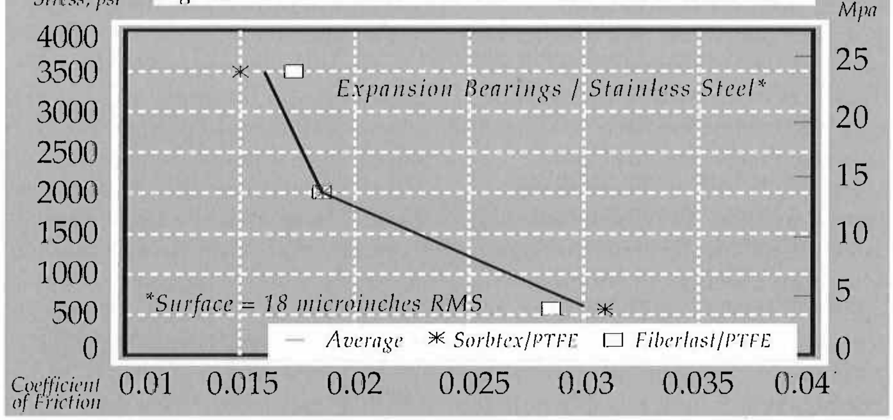


Fig. A3 **SLIDE BEARING FRICTION TESTS**

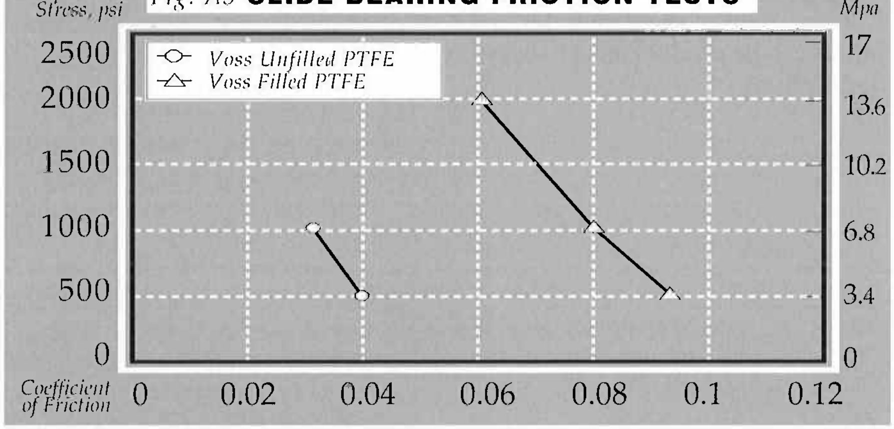
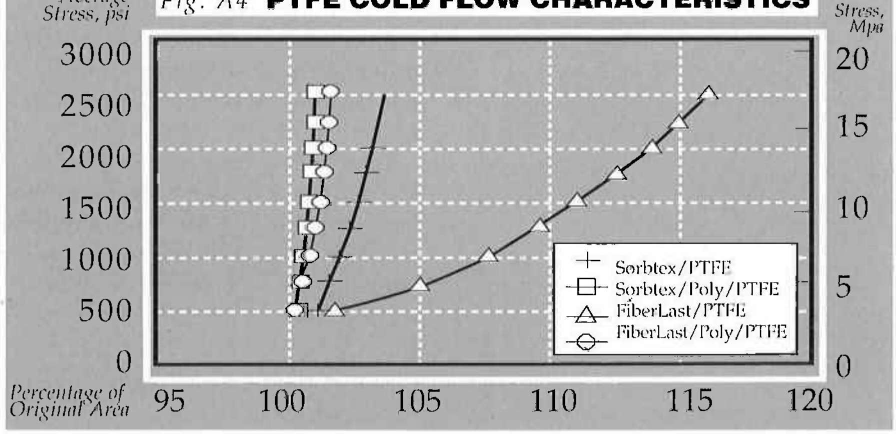


Fig. A4 **PTFE COLD FLOW CHARACTERISTICS**



EXPANSION BEARING CONCEPTUAL DESIGN DETAILS

Fig.34 STEEL TO STEEL

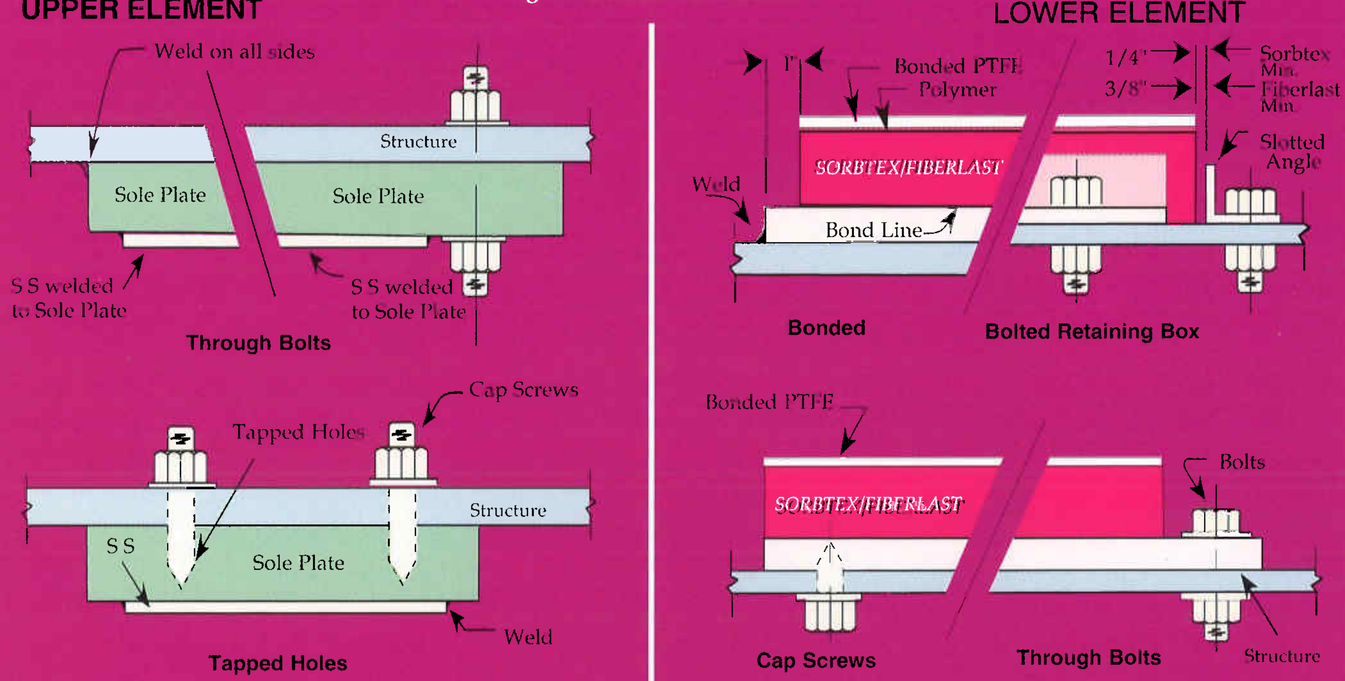


Fig.35 CONCRETE TO CONCRETE

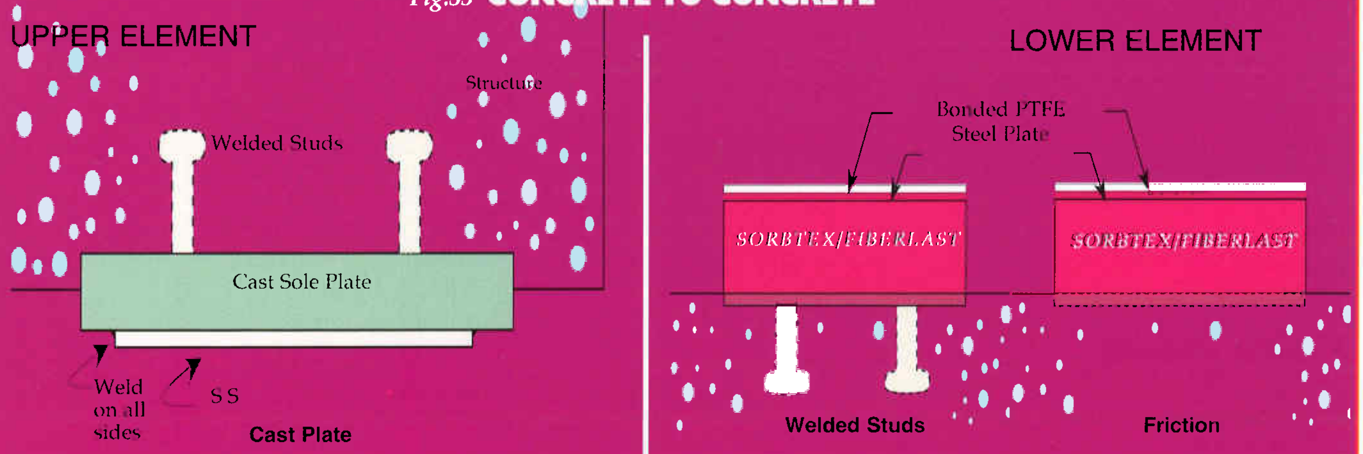


Fig.36 LATERAL RESTRAINT