National Cooperative Highway Research Program

RESEARCH RESULTS DIGEST

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These Digests are issued in the interest of providing an early awareness of the research results emanating from projects in the NCHRP. By making these results known as they are developed and prior to publication of the project report in the regular NCHRP series, it is hoped that the potential users of the research findings will be encouraged toward their early implementation in operating practices. Persons wanting to pursue the project subject matter in greater depth may obtain, on a loan basis, an uncorrected draft copy of the agency's report by request to the NCHRP Program Director, Highway Research Board, 2101 Constitution Ave., N.W., Washington, D.C. 20418

EVALUATION OF PREFORMED ELASTOMERIC PAVEMENT JOINT SEALING SYSTEMS AND PRACTICES

An NCHRP staff digest of the essential findings from the final report on NCHRP Project 4-9, "Evaluation of Preformed Elastomeric Pavement Joint Sealing Systems and Practices," by G. M. Jones, D. E. Peterson, and R. K. Vyas, Utah State Highway Department, Salt Lake City, Utah.

THE PROBLEM AND ITS SOLUTION

The problem of sealing transverse joints in portland cement concrete pavements to prevent intrusion of objectionable materials is of prime importance to many state highway departments. Most existing specifications for extruded neoprene seals used to seal these joints consist of requirements pertaining to the elastomer used in fabricating the seal and the size, shape, and configuration of the fabricated product. The relation of these requirements to seal performance in service, or their significance as predictors of performance, has not been fully developed.

This project has reviewed previous research and experience; conducted an extensive laboratory testing program; and has achieved the objective of developing tentative performance criteria and guide specifications for preformed elastomeric joint seals for use in portland cement concrete pavement joints. A field evaluation program is to be conducted under a second project contract to verify or modify the tentative criteria and guide specifications. In the meantime, they are considered suitably verified for immediate trial use by highway departments as supplemental specifications. For this reason, highway design, materials, and specifications engineers will find the findings of the study of significant practical value.

FINDINGS

An extensive experimental program was conducted using sections of preformed elastomeric joint seals obtained from commercial producers. The program included (1) a theoretical and experimental study to determine kinematics of deformation and basic material properties, (2) laboratory studies relating seal properties to performance, and (3) a pilot field test. The theoretical study, conducted by the University of Utah under a subcontract with the Utah State Highway Department, indicates that preformed elastomeric seals offer good potential for sealing pavement joints effectively. An analytical technique for predicting load-deflection behavior of a given seal geometry has been developed that should be useful in the design of more effective seals. The pilot field study consisted of the placement and subsequent testing after two years of service of 5/16-in. and 7/16-in. nominal width seals in two experimental pavement sections with 13-, 18-, 17-, and 12-ft slab lengths. Although none of the seals performed entirely satisfactorily in the experimental sections for a variety of reasons, it was possible to develop relationships between force-deflection measurements of the seals removed from the sections and seals subjected to laboratory conditioning.

The laboratory studies involving environmental cycling, heat-aging, ozone resistance, oil resistance, tension, hardness, and watertightness testing of the commercially available seals produced the most meaningful findings. A number of thermal cycling procedures were used to simulate field conditions with force-deflection tests performed on the seals before and after the cycling to determine permanent set and loss in strength. As Figure 1 shows, there is generally a significant reduction in the strength of seals after exposure to environmental cycling, heat-aging, or field exposure. The heat-aging test (which consisted of aging the seal specimens in an oven for 70 hr at 212°F, followed by a 24-hr recovery period and the conduct of force-deflection measurements) produced the greatest detrimental effect on the seals; appeared to correlate with loss of strength of seals taken from the pilot field test; and is easy to perform. For these reasons, it was selected as the primary means for predicting field performance of seals.

Variations in cross-section geometry, material properties, and seal width of the same or different lots were found to be excessive at times. Variations in the width of the concrete joint were also experienced. When these variations are larger than the working range of the seal, adequate performance is impossible. The relationships between joint width, joint movement, seal working range, and seal force are shown in Figure 2. When a seal is compressed to one-half its nominal width, it is considered to be under 50 percent deflection--the upper limit of the working range. When a seal is compressed to 80 percent of its nominal width, it is considered to be under 20 percent deflection--the lower level of the working range. Some seals exhibit extremely high force at 50 percent deflection, indicating that a solid rubber mass has been achieved, resulting in web adhesion and seal failure. Therefore, it is desirable to specify a maximum allowable force at 50 percent deflection. It is also desirable that a seal be in compression at 20 percent deflection after a period of time in use.

Another important factor in seal performance is watertightness. Tests conducted during this study indicate that the high deflections required to maintain watertightness without an adhesive are not likely to be maintained throughout the life of a seal. Therefore, it is recommended that lubricant adhesives be used in all cases.

APPLICATIONS

Tentative guide specifications, divided into sections on materials, joint construction, and joint sealing, have been developed based on information obtained from states using preformed elastomeric seals and the findings of this study. The addition of the heat-aging performance related test to accepted materials tests and current practice should result in these tentative specifications being an improvement over those generally in use. Immediate trial implementation by highway

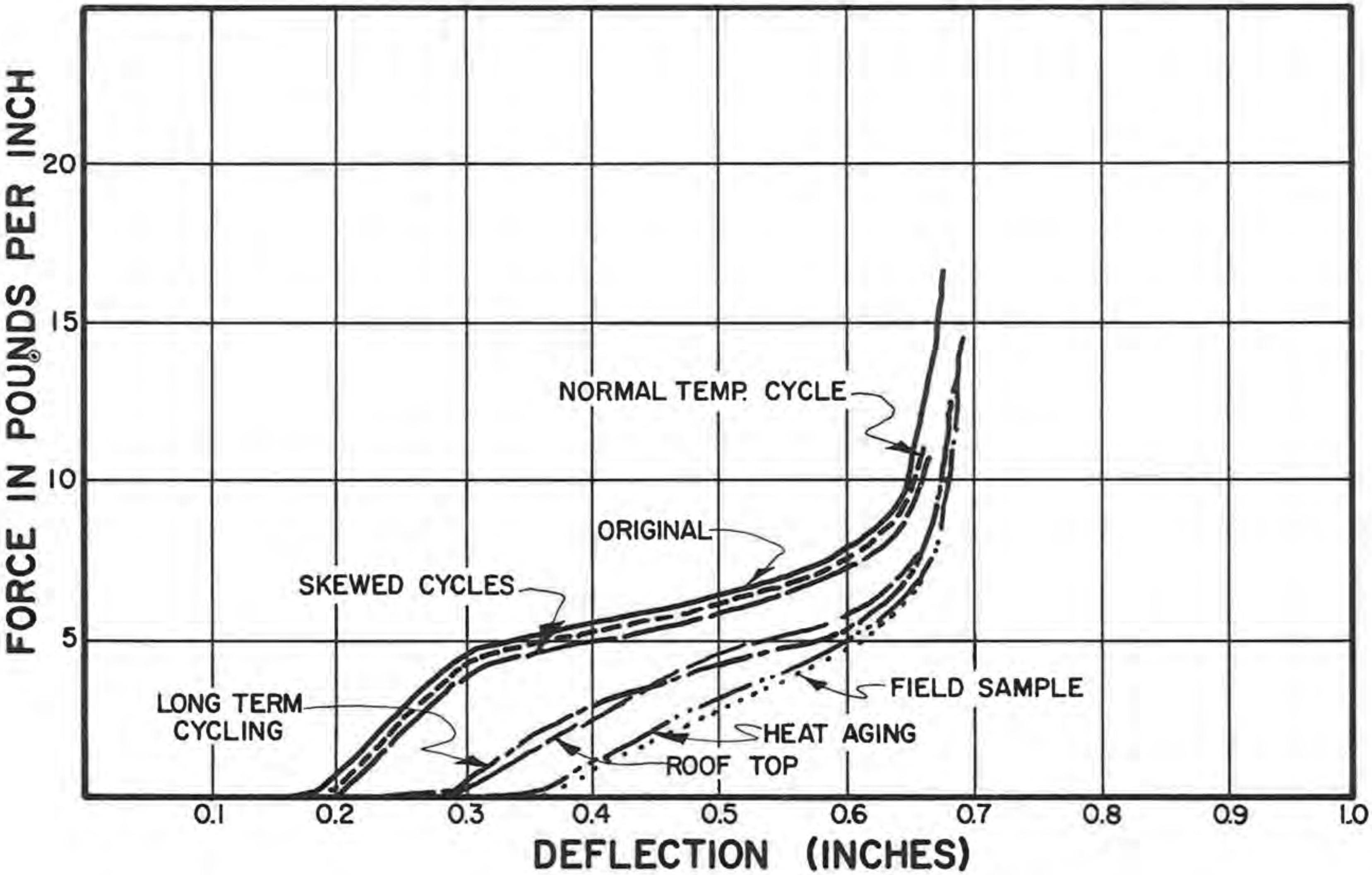

FIGURE 1 TYPICAL FORCE-DEFLECTION CURVES OF SEALERS BEFORE & AFTER CYCLING AND HEAT-AGING

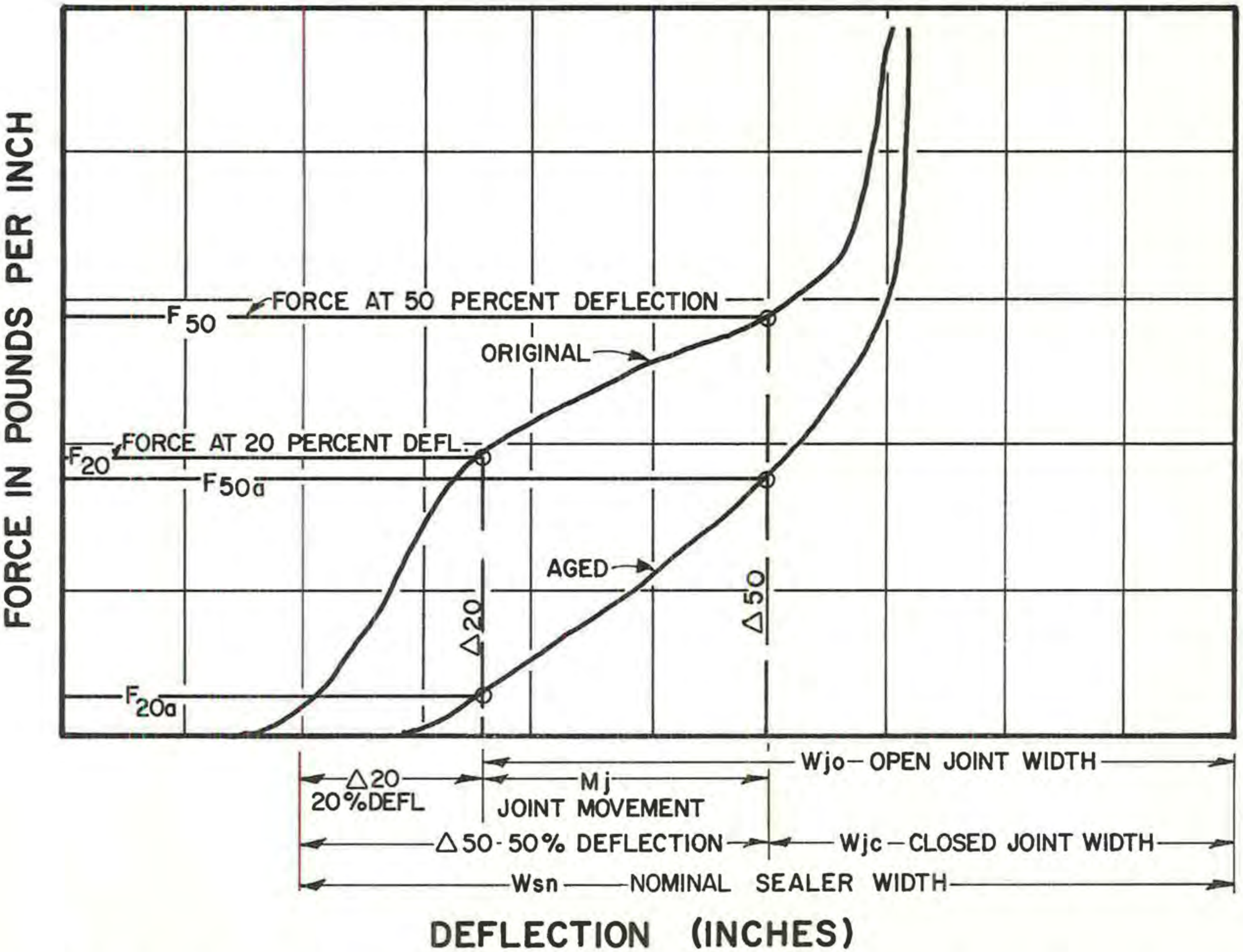

FIGURE 2 RELATIONSHIPS BETWEEN JOINT WIDTHS, JOINT MOVEMENTS, JOINT SEALER WORKING RANGES AND JOINT SEALER FORCES.

agencies using preformed elastomeric seals would seem appropriate. Following the field evaluation project, it is anticipated that the tentative specifications as verified or modified will provide the basis for revision of current materials and construction specifications for the sealing of transverse joints in portland cement concrete pavements.

TENTATIVE GUIDE SPECIFICATIONS FOR SEALING JOINTS IN PORTLAND CEMENT CONCRETE PAVEMENTS

These guide specifications are separated into sections of (A) materials, (B) joint construction, and (C) joint sealing.

A. Materials--The preformed elastomeric joint sealer shall be made by extrusion of a vulcanized elastomeric polymer such as chloroprene as the basic constituent. Any sealer that is proposed for use shall be tested to determine acceptability. A 15-ft length of the sealer shall be submitted for testing for compliance with these specifications. If the sealer meets these requirements, it will be approved for use. However, the sealers will be sampled and tested on delivery to the project to determine uniformity and compliance. Three 6-ft samples will be obtained from each lot on a random basis and tested. All three samples shall comply with the specifications in order for the lot to be accepted.

The sealer shall have vertical sidewalls equal in length to one-half of the nominal width when the sealer is compressed to 20 percent deflection. The over-all depth of the sealer shall not exceed 2 in. when the sealer is compressed to 50 percent deflection. The sealers shall be marked at 1-ft intervals $\pm 1/16$ in. on the top surface at the time of manufacture.

The joint sealer material shall comply with the following physical requirements:

Property	ASTM Test Procedure	Requirement
Elongation at break, %, min.	D412	250
Hardness, Type A Durometer	D2240 (modified)	55 ± 5
Oven aging, 70 hr, 212°F:	D573	
Tensile strength change, %, max.	D412	-20
Elongation change, %, max.		-20
Hardness change, points		+10
Ozone resistance, 20% strain, 300 pphm in air, 70 hr, 104°F	D1149	No cracks
Preformed polychloroprene elastomeric joint seals for concrete pavements:	D2628-67T	
72 hr @ 14°F, 50% deflection		Min. recov. 88%
22 hr @ -20°F, 50% deflection		Min. recov. 83%
70 hr @ 212°F, 50% deflection		Min. recov. 85%

The preformed elastomeric joint sealer shall comply with the following force-deflection requirements:

Deflection Based on Nominal Width (%)	Required Force
7/16-in. and smaller joint sealer:	
20	2 lb/lin. in., min.
50	12 lb/lin. in., max.
1/2-in. and larger joint sealer:	
20	3 lb/lin. in., min.
50	12 lb/lin. in., max.

The force-deflection relationship will be determined in accordance with the procedure described in a later section.

The specimens used for determining the original force-deflection relationship will then be heat-aged in an oven for 70 hr at 212°F under 50 percent deflection. After heat-aging the specimens will again be subjected to force-deflection testing and shall comply with the following additional requirements:

Deflection Based on Nominal Width (%)	Required Force
7/16-in. and smaller sealer:	
20	1 lb/lin. in., min.
50	12 lb/lin. in., max.
1/2-in. and larger sealer:	
20	1.5 lb/lin. in., min.
50	12 lb/lin. in., max.

The lubricant-adhesive shall be a compound of the same base polymer as the preformed joint sealer, blended with suitable volatile solvents. It shall have the following additional physical properties:

Average net weight per gallon . . . . 7.84% $\pm$ 5%
Solids content % by weight. 25 $\pm$ 3.0 (ASTM D553)

The viscosity of the lubricant-adhesive shall be such that it will perform suitably with the installation equipment.

Film strength: 2,300-psi min. tensile strength, 750 percent min. elongation before breaking.

Any lubricant-adhesive not used within nine months of manufacture shall be rejected.

(A bonding strength test using the actual joint sealer and the lubricant-adhesive with two concrete blocks is desirable. Work done with this procedure on this study did not produce definable levels of acceptance. This could be determined as part of the proposed field evaluation program.)

B. Joint construction--All construction joints shall be constructed in two stages. The first stage shall consist of sawing or forming the joint to prevent random cracking. This relief cut or the first stage shall be 1/8 in. maximum in width for short joint spacings (those 39 ft or less) and they shall be 1/4 in. maximum in width for long joint spacings (those 40 ft or greater). The relief cut shall be 2 1/2 in. in depth. The second stage cut shall be no earlier than 72 hr after the concrete is placed. It shall be cut to a width equal to 50 percent of the nominal joint sealer width planned for use. The width shall be approximately adjusted for temperature extremes. A rule of thumb for adjusting width would be to add the amount of edge cracking in excess of the first stage cut width to the specified joint width. The width tolerance shall be ± 5 percent of the nominal joint sealer width. The joints may be beveled with a 1/4-in. bevel on 45°. (There is a question as to the value of beveled joints on performance.)

After the joints have been sawed and cleaned they shall be inspected for voids and spalls. Any voids or spalls in excess of the specified width plus tolerance shall be corrected. All loose, unsound, or damaged concrete shall be removed and the area shall be thoroughly cleaned by sandblasting or wire brushing. The area shall then be blown clean with use of compressed air. A heavy polyethylene sheet, or other rigid material covered with polyethylene film, shall be inserted into the joint groove and held tightly against the joint face that is to be patched. The concrete surface shall be clean and dry at the time of placing the epoxy resin mortar. The epoxy resin mortar shall normally consist of a mixture of two parts epoxy resin to one part curing agent for the epoxy binder. One part epoxy binder to 3.5 parts dry sand will be the normal mix. Some epoxy binder shall be used to prime the surface being repaired prior to placing the mortar mix. The mix shall be shaped to the original proper joint configuration.

Longitudinal joints shall be sawed in one stage to the proper width and depth. Normally a 7/16-in. preformed joint seal will be used for longitudinal joints so the saw cut would be 7/32 in. in width and 2 1/2 in. in depth. The tolerances and repairs shall be as described for transverse contraction joints.

C. Joint sealing--All joints shall be sealed prior to traffic using the roadway. The joints shall be clean and dry at the time the joint sealer is installed. All joint sealers shall be machine-installed. The installation equipment shall be approved by the Engineer prior to use. The joint sealers shall be installed in such a manner that elongation shall not exceed 5 percent and compression shall not exceed 2 percent. Lubricant-adhesive shall be used and it shall be properly placed by the installation equipment at the time the joint sealer is placed. A sufficient quantity of lubricant-adhesive will be used to ensure adequate coating of the sealer surface being bonded to the concrete. Any lubricant-adhesive that gets on top of the sealer shall be removed. The installed joint sealer shall be free of twisting, warping, and other defects. All improperly installed sealers shall be removed and replaced. The joint sealers shall be placed to a depth of 1/4 in. $\pm 1/16$ in. below the pavement surface.

The longitudinal joint sealers shall be placed first and they shall not have pieces installed shorter than 200 ft in length. After the longitudinal sealer is placed, it shall be notched and sealed with the lubricant-adhesive at the intersections with the transverse joints. The transverse joint sealers shall then be installed.

Force-Deflection Test Procedures

A. Apparatus for force deflection test--A universal test machine with an attached automatic recorder will be used to determine the force-deflection relationship of the sealers.

B. Specimens--The samples of sealers will be cut from stock of the various sizes and types. They shall be 6 in. in length.

The 6-in. specimens will be placed on their sides between the top and base plates of the universal testing machine. The spacing between the two plates will be set at 1.4 in. for specimens less than 1.4 in. and greater than or equal to 1.0 in. in width. For specimens less than 1.0 in. in width the spacing will be set at 1.0 in. As the load is applied (at the rate of 0.5 in. per minute) the automatic recorder describes the force-deflection curve. Figure 1 is a typical example of force-deflection curves as obtained from the automatic recorder. The origin of the graph represents 1.0 or 1.4 in. in elongation-compression, depending on the width of the specimen. The point where the load is first applied to the specimen and contact is made with the top plate is where the curve begins moving up and to the right. The original specimen width is then equal to the difference between the original spacing width or the origin and the point where the curve begins to ascend. The curve then represents the load in pounds necessary to obtain the deflection in inches. The loss in strength or width of a specimen through aging or cycling will show up as a different curve with a different point of load contact. The difference between the load contact points for the first and second curves represents the permanent set of the specimen.

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