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TEXAS UTILITIES GENERATING COMPANY

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February 27, 1986

WILLIAM G. COUNSIL
EXECUTIVE VICE PRESIDENT

Director of Nuclear Reactor Regulation
Attention: Mr. Vince S. Noonan, Director
Comanche Peak Project
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

SUBJECT: COMANCHE PEAK STEAM ELECTRIC STATION
DOCKET NOS. 50-445 AND 50-446
STEAM GENERATOR UPPER/LOWER LATERAL RESTRAINT ANALYSES

Dear Mr. Noonan:

During a recent CPSES meeting with members of NRC Technical Review Team (TRT) concerning analyses performed for the steam generator upper/lower restraints, information was requested as to the limitations of the Ebasco Nastran program utilized in the analyses.

Attached is a summary of the investigations performed by Ebasco to determine these limitations.

All calculations, computer models and output, etc. in support of the Ebasco investigation can be provided upon request.

Very truly yours,

W. G. Counsil

BSD/arm
Attachment

Original plus 40 copies

c - A. Vietti-Cook
D. Jeng
C. Constantino
C. Hoffmeyer

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EBASCO/NASTRAN CRACKING ELEMENT EVALUATION

Investigations of the performance of the EBASCO/NASTRAN program to determine the validity of solutions have been done. Of particular interest is the comparison of EBASCO/NASTRAN solutions to actual laboratory tests. Such comparisons have been made utilizing beam tests and comparing the load displacement curves from the test to those from the calculations.

Two of the tests were from U. S. Naval Civil Engineering Laboratory Beam Tests (Figures 1 and 2). One was from a Brookhaven National Laboratories Beam Test (Figure 3). The comparisons of the results between EBASCO/NASTRAN predictions and the laboratory tests are presented in Figures 1, 2 and 3.

Figure 1 shows the results of a shallow beam test (span/depth = 17.3). The flexural deformation dominates the load displacement curve. Figure 2 is for a beam with span/depth ratio of 9.6. The beam has flexural deformation when the load is small. As load increases, the diagonal tension cracking causes additional displacement above the flexural displacement. Figure 3 is for a span/depth ratio of 5.7. The load-displacement character of this beam is highly influenced by the diagonal tension cracking.

These laboratory tests showed that reinforced concrete beam load displacement performance actually occurs in four distinct stages which follow each other when tested to destruction. These four stages appear as:

1. flexural deformation with no concrete cracking,

2. flexural deformation with concrete cracking due to flexural stresses,

3. flexural and shear deformation with concrete cracking due to flexural stresses and diagonal tension stresses resulting from shear,

4. plastic deformation due to flexural and/or shear stresses exceeding the yield point of the material; this finally leads to collapse.

An idealized load/displacement curve is shown in Figure 4. These studies have shown that EBASCO/NASTRAN, when run using a value for the tensile strength of concrete of 7.5 $\sqrt{f'c}$, yields a load displacement curve which matches the flexural deformation part of the full curve. It departs from the actual load displacement curve at the point or region where diagonal tension cracking starts to occur. This is when the shear stress approaches a value of 2 $\sqrt{f'c}$ which is the ACI 318 code value for shear strength provided by concrete alone. Beyond this point EBASCO/NASTRAN underestimates the amount of displacement.

Generally, if a value of zero for the tensile strength of concrete is used in EBASCO/NASTRAN, the displacements will be overestimated in the region above a shear stress of 2 $\sqrt{f'c}$.

Presently, use of EBASCO/NASTRAN with the cracking element with the shear stress in the concrete below 2 $\sqrt{f'c}$ should result in accurate predictions of load-displacement behavior. If the shear stress is greater than 2 $\sqrt{f'c}$, diagonal tension cracking will occur and a dual analysis by EBASCO/NASTRAN is necessary, one using a high tensile strength and one using zero as the tensile strength, to properly bracket the actual performance of the member. From these studies the tensile strength of concrete to be utilized with the EBASCO/NASTRAN should be about 7.5 $\sqrt{f'c}$.

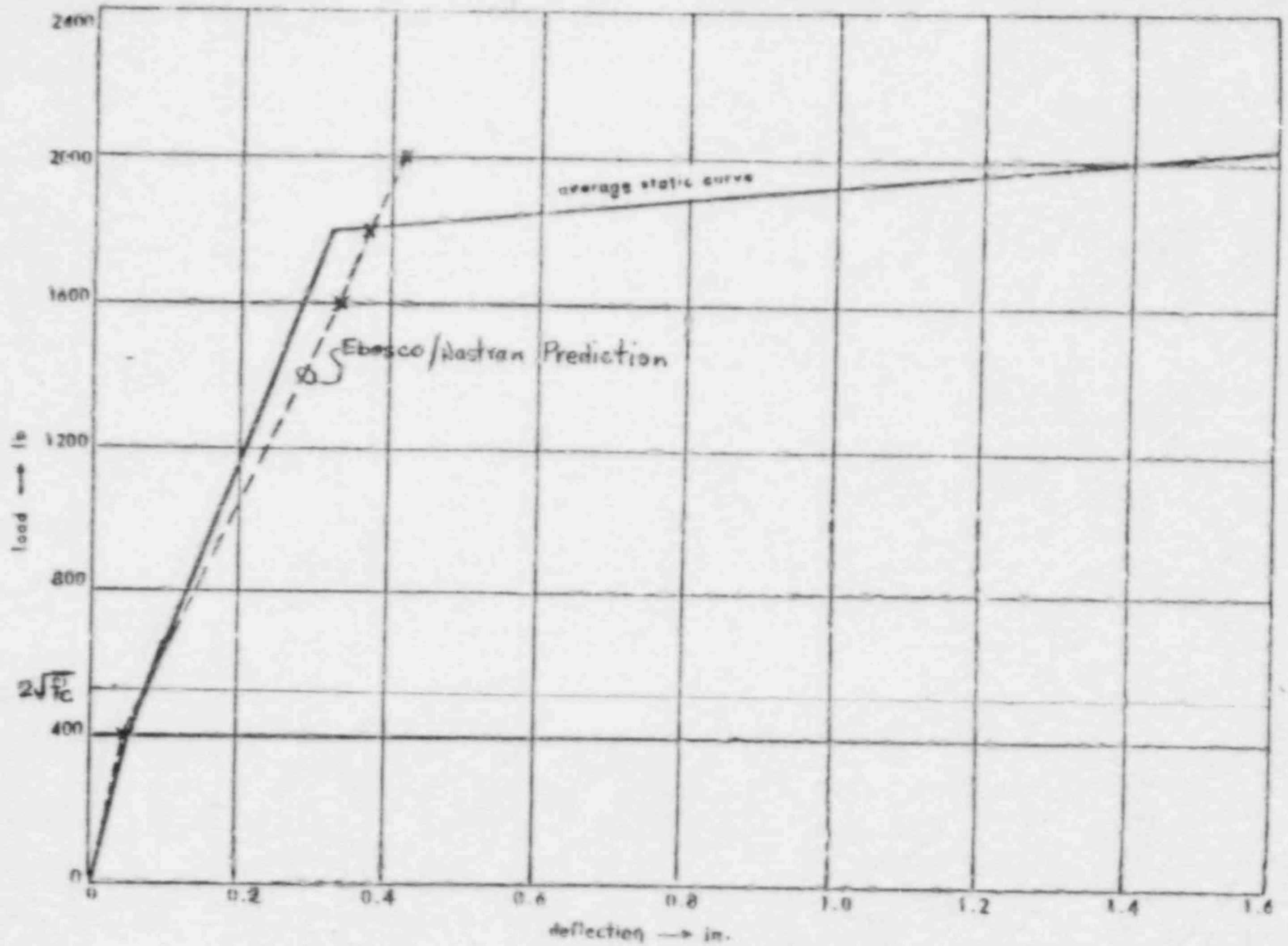

Figure 1. Static load deflection curves for series B beams.

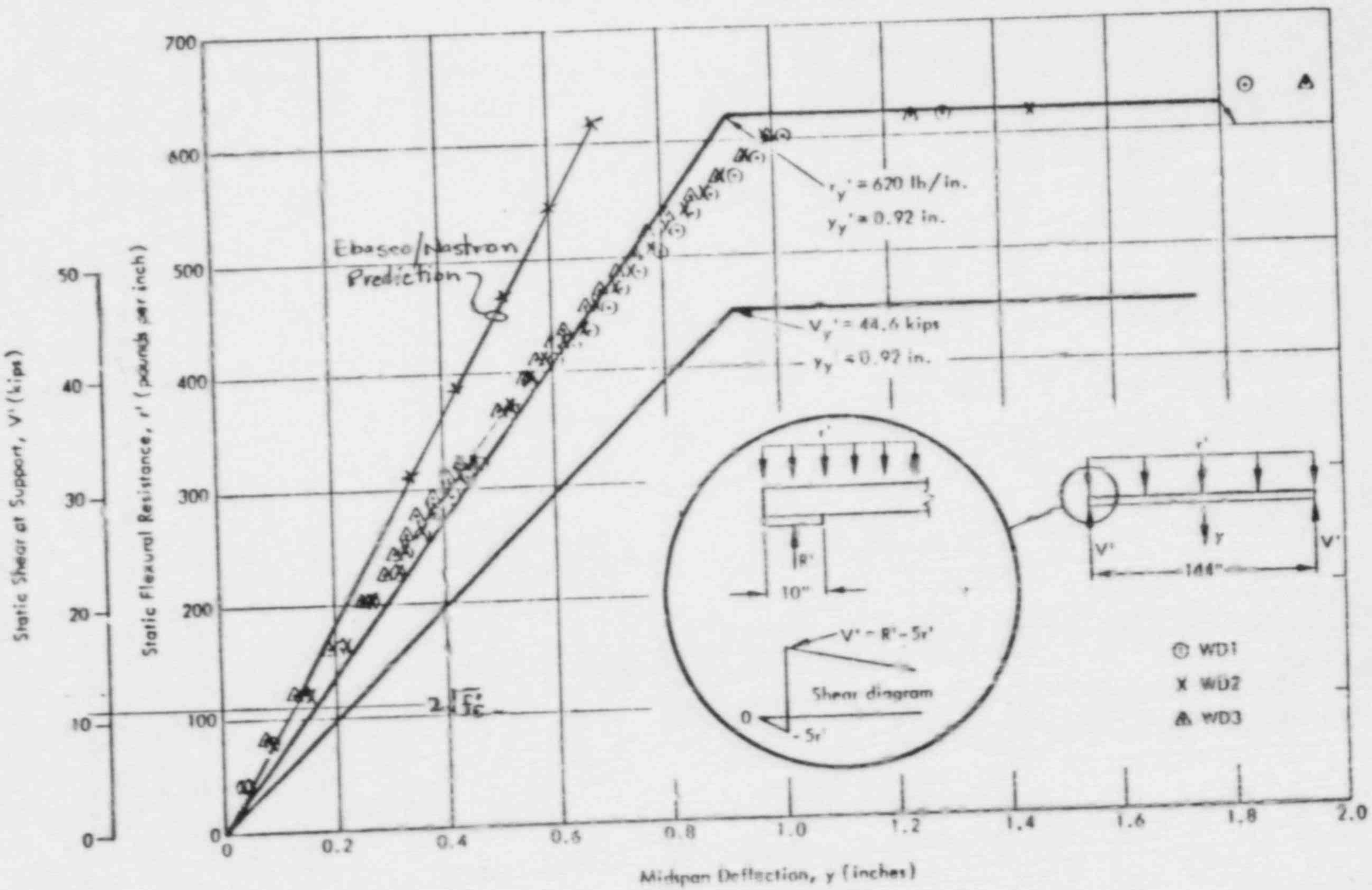

Figure 2. Measured and idealized static flexural resistance diagrams.

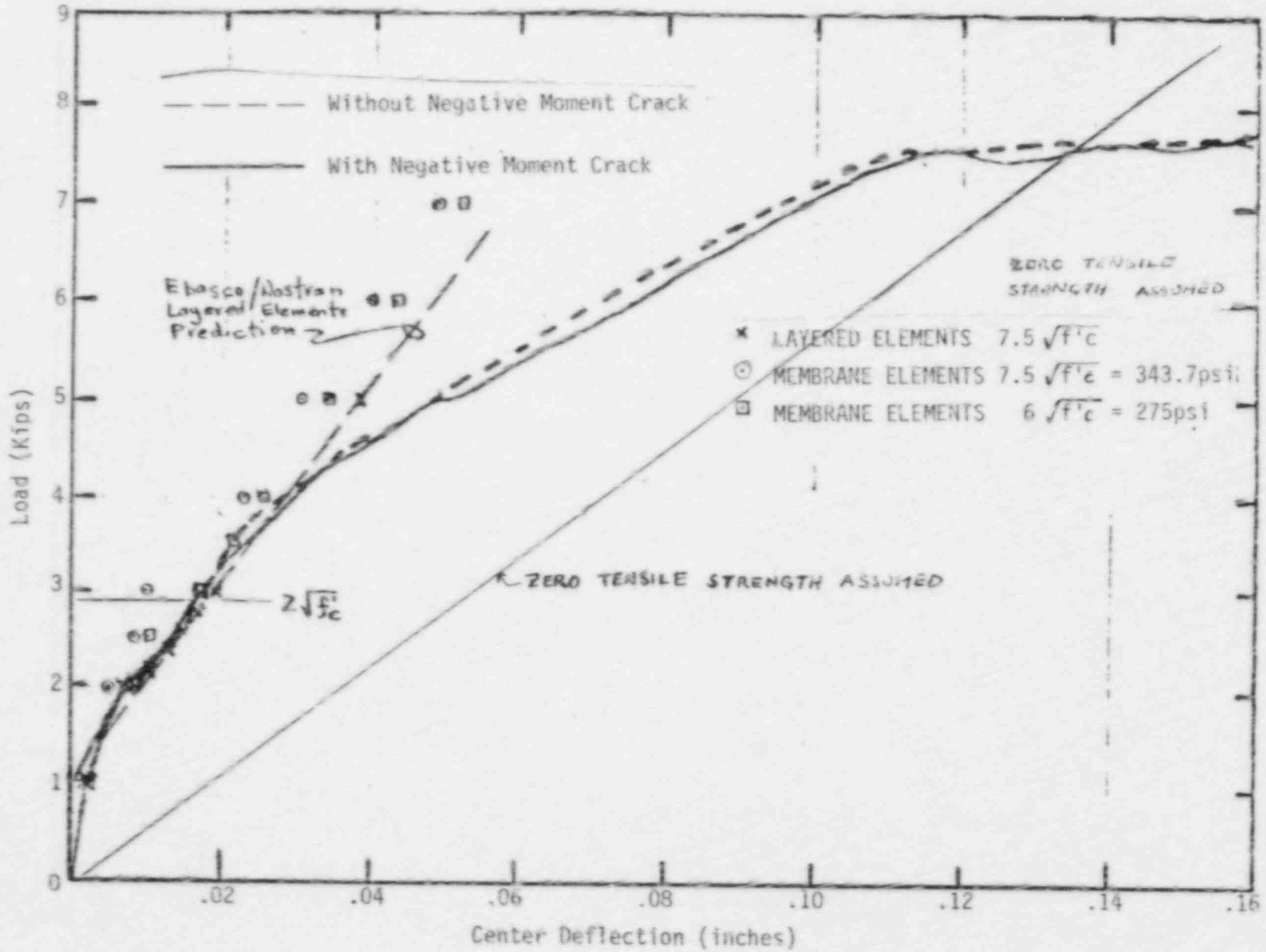

Fig. 3. Load Deflection Curve For Beams Subjected to Positive Bending Moment.

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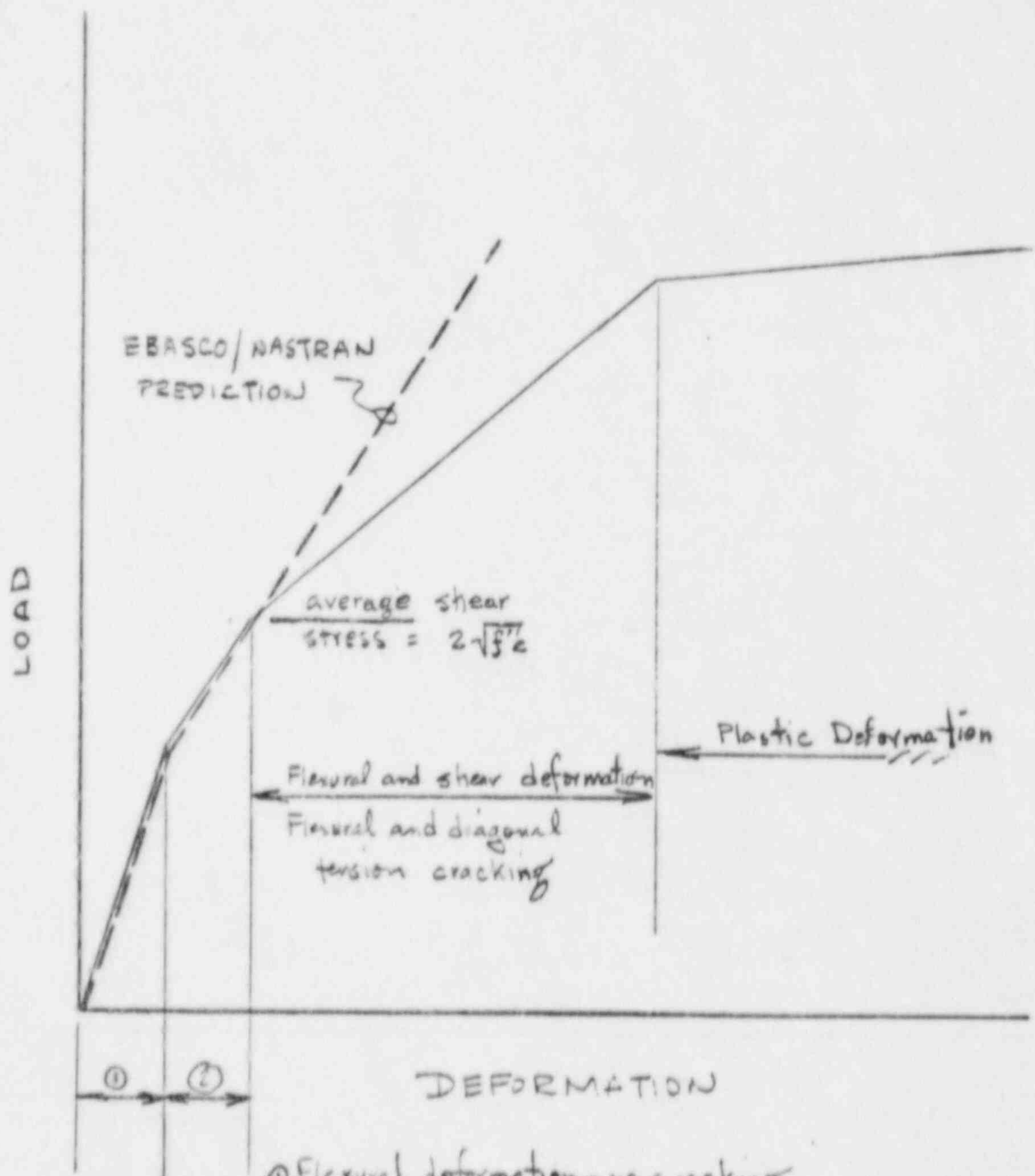

① Flexural deformation - no cracking

② Flexural deformation - flexural cracking

FIGURE 4