UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

August 05, 1998

Dr. H. Larry McKague, Manager
Geology/Geophysics Program Element
Center for Nuclear Waste Regulatory Analyses
6220 Culebra Road, Building 189
San Antonio, Texas 78238-5166

SUBJECT: ACCEPTANCE OF "CONSTANT-THICKNESS DEFORMATION ABOVE CURVED NORMAL FAULTS," INTERMEDIATE MILESTONE 20-1402-471-733

Dear Dr. McKague:

The subject report, in the form of a journal article, "Constant-Thickness Deformation Above Curved Normal Faults," by Alan P. Morris and David A. Ferrill, was submitted by letter dated July 8, 1998, from H. L. McKague to P. S. Justus. This milestone (originally 20-5708-71-733) had been approved on July 9, 1997 (letter from P. S. Justus to H. L. McKague), with a request that it be resubmitted for review prior to publication. The staff anticipated that some of its suggestions for improving the paper by streamlining certain algebraic-geometric equations and their derivations would entail substantial changes to equations and re-labeling key linear elements. This submittal is the Center for Nuclear Waste Regulatory Analyses' response to that request.

This letter is an FY98 administrative item (AI) that we are handling rather formally (in same format as an intermediate milestone), in the tradition of the original. We have completed a programmatic and technical review and find that the report fulfills the intent of staff suggestions made in the July 9, 1997, letter cited above. Please note that there are two typographical errors in two equations shown in two boxed areas in the enclosure.

The subject report continues to be a significant contribution to the practice of structural geology because it enables workers to describe the constant-thickness geometry of hangingwalls developed above normal faults of any shape. Alternatively, the model can be used to predict the amount and location of departures from constant-thickness (and constant bed length) deformation in a fault hangingwall. Further, the paper enables workers to forward-model listric-fault-generated folds. This version of the paper may be placed in the Public Document Room.

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The deliverable (AI) was reviewed by L. Abramson and me. Mr. Abramson can be reached on (301) 415-6180, and I can be reached on (301) 415-6745.

Sincerely,

Original Signed By

Philip S. Justus
GLGP Program Element Manager
Engineering and Geosciences Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure: As stated

cc: J. Linehan
B. Meehan
B. Caudle

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Using the relationships:

$$\frac{d[\tan(u)]}{du} = \frac{\pi}{90}\left[\frac{1}{\cos^2(u)}\right]$$

and

$$\frac{d[\cot(u)]}{du} = -\frac{\pi}{90}\left[\frac{1}{\sin^2(u)}\right]$$

(for u in degrees).

Therefore:

$$\cos^2\left(\frac{\alpha}{2}\right) = \sin^2(\alpha + \theta_2) \qquad \text{(i)}$$

In equation (i) and for $0 \le \alpha \le (\alpha + \theta_2) \le 180$, both $\cos(\alpha/2)$ and $\sin(\alpha + \theta_2)$ are positive. Therefore we can take the square root of both sides:

$$\cos\left(\frac{\alpha}{2}\right) = \sin(\alpha + \theta_2) \qquad \text{(ii)}$$

Equation (ii) has two solutions depending on whether $(\alpha + \theta_2) \le 90$ or $(\alpha + \theta_2) > 90$.

If $(\alpha + \theta_2) \le 90$ then for all α:

$$\cos\left(\frac{\alpha}{2}\right) = \sin\left(90 - \frac{\alpha}{2}\right)$$

Enclosure

$$A'G = t\cdot\left(\frac{1}{\tan(\theta_1)} + \tan\left(\frac{\alpha}{2}\right) - \tan(\psi)\right)\cdot\cos(\theta_2 - \alpha)$$

$$\boxed{A'H = \sin(\theta_2 - \alpha) \quad HG = A'\overset{H}{\cancel{B'}}\sin(\theta_2 - \alpha) = t\cdot\sin(\theta_2 - \alpha)\cdot\left[\frac{1}{\tan(\theta_1)} + \tan\left(\frac{\alpha}{2}\right) - \tan(\psi)\right]}$$

$$A'E' = \frac{\sin\left(90 + \frac{\alpha}{2}\right)\cdot t\cdot\left(\frac{1}{\tan(\theta_1)} + \tan\left(\frac{\alpha}{2}\right) - \tan(\psi)\right)}{\sin\left(90 - \theta_2 + \frac{\alpha}{2}\right)}$$

$$HI = l_0 - \frac{t}{\tan(\theta_1)} - t\cdot\tan\left(\frac{\alpha}{2}\right)$$

Undeformed area:

$$Area = t\left(l_0 - \frac{t}{\tan(\theta_1)}\right) + \frac{t^2}{2\cdot\tan(\theta_1)}$$

Deformed area:

$$AreaA'HG = \frac{\left[t\cdot\left(\frac{1}{\tan(\theta_1)} + \tan\left(\frac{\alpha}{2}\right) - \tan(\psi)\right)\right]^2\cdot\cos(\theta_2 - \alpha)\cdot\sin(\theta_2 - \alpha)}{2}$$

$$AreaGHE' = \frac{\left[t\cdot\left(\frac{1}{\tan(\theta_1)} + \tan\left(\frac{\alpha}{2}\right) - \tan(\psi)\right)\right]\cdot\sin(\theta_2 - \alpha)\cdot(AD - AC)}{2}$$