Development of $K_I(\varphi)$-Databases

Brief review of BARE work 2025/2026

Börje Andersson, BARE

AFGROW workshop Sept 2026

“The views expressed in this presentation are those of the author and do not necessarily reflect the official policy or position of the United States Air Force Academy, the Air Force, the Department of Defense, or the U.S. Government.

Approved for public release: distribution unlimited. PA Number: USAFA-DF-2025-868

The BARE work 2025/2026 split into the following elements,

1. Deriving *K*-databases for countersunk holes for *b/t*=0.15

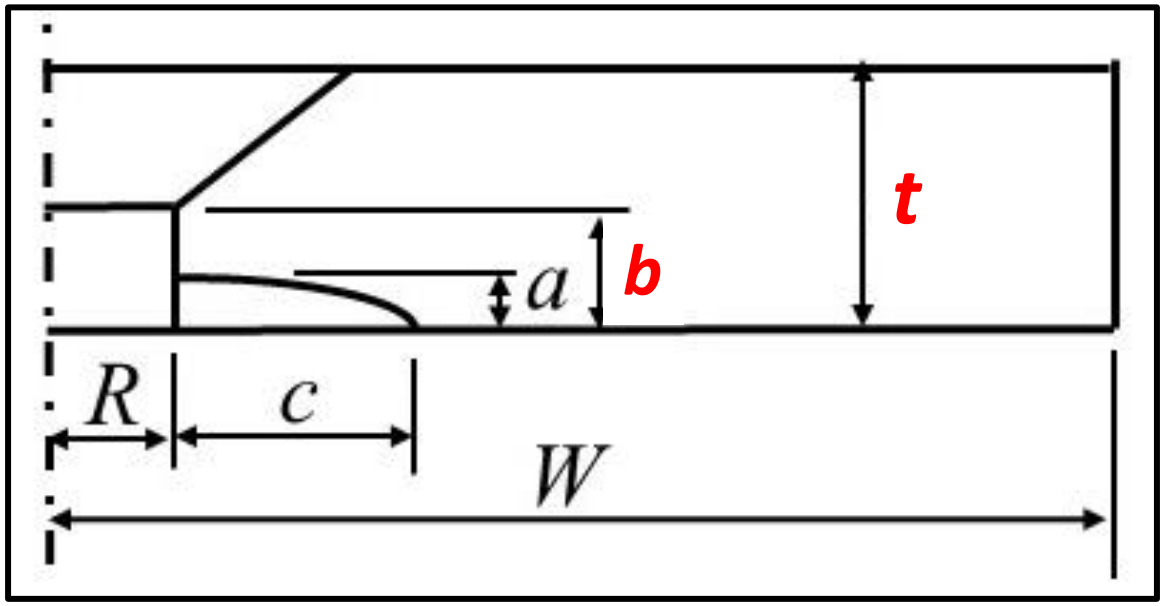
2. Calculating *K*-databases for the new tension load case

3. Providing support to AFGROW and NASGRO teams.

Note: Technical details for work element 1. is well described in the 2025 years AFGROW lecture by B. Andersson and is therefore not repeated here.

AFGROW lecture Sept 2025,

Objective: Derive $K_I(\varphi)$-databases for 3 b/t-values, single/double cracks.



c/a = 0.10,…,10.0 — 20 values

a/t = 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 0.95 — 10 values

R/t = 0.20, 0.333, 0.5, 1.0, 1.5, 2.0, 3.0, 5.0. — 8 values

b/t = 0.15, 0.25, 0.50 — **3 values**

W/R = 2.4, 2.6, 2.8, 3.2, …100.0 — 20 values

H/W = 3.0 — 1 value

Achievement 2025,

- $K_I(\varphi)$-databases for 2 b/t-values delivered.
- Work started on $K_I(\varphi)$-database for b/t=0.15

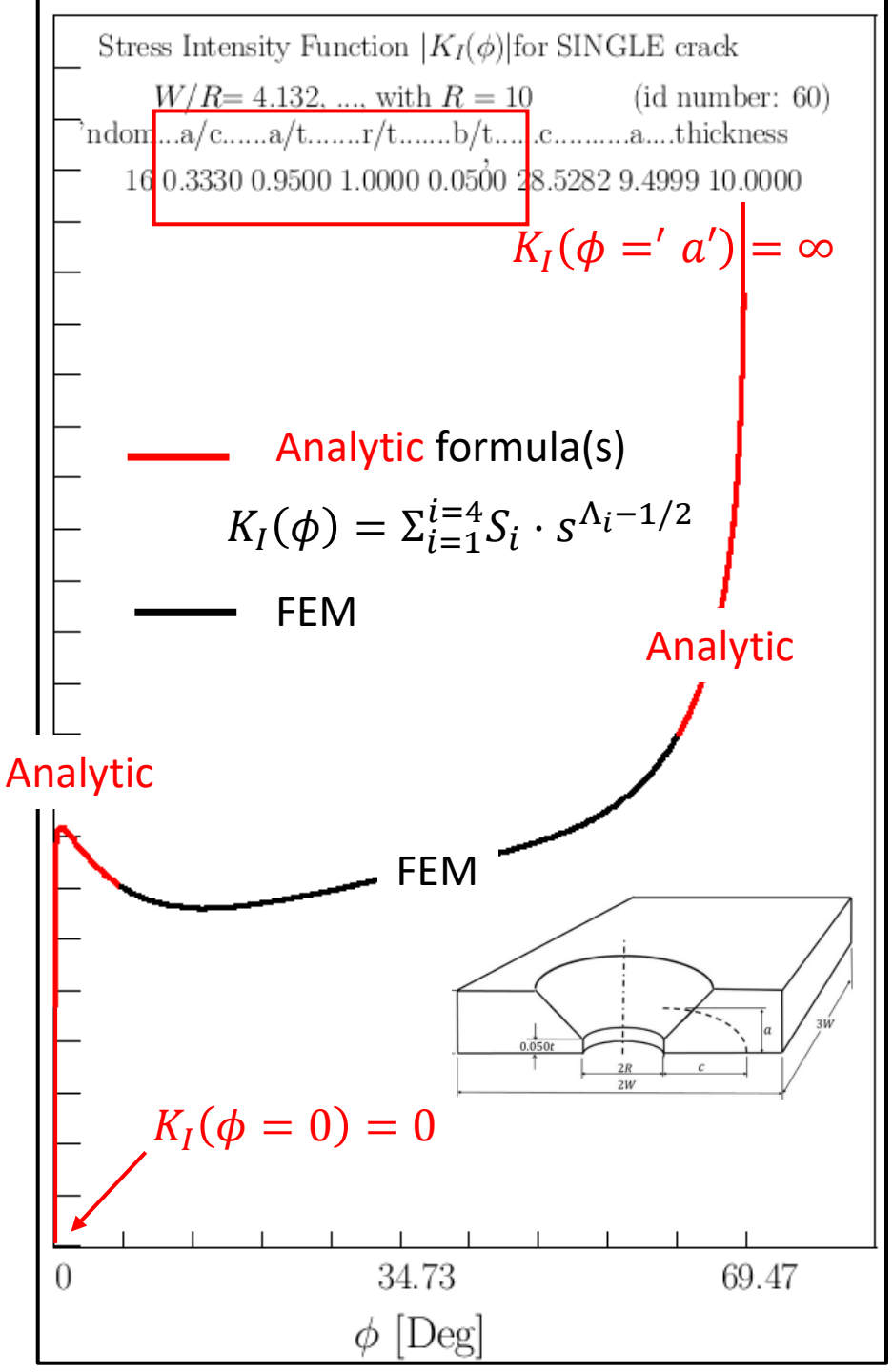
Achievement until 1 Sept 2026,

- 75% of $K_I(\varphi)$-database are available

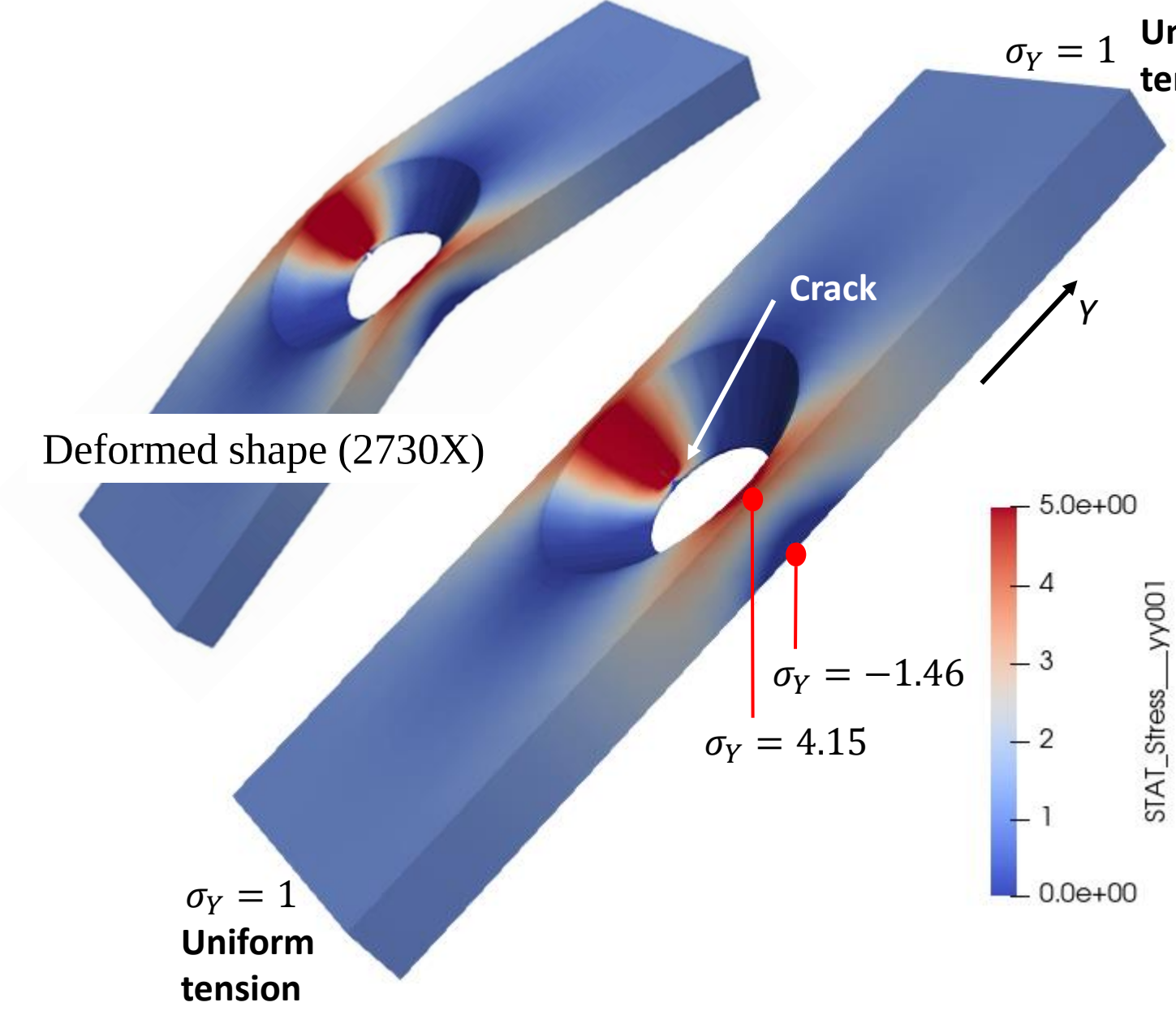
Remaining work after 1 Sept 2026 on databases for *b/t*=0.15

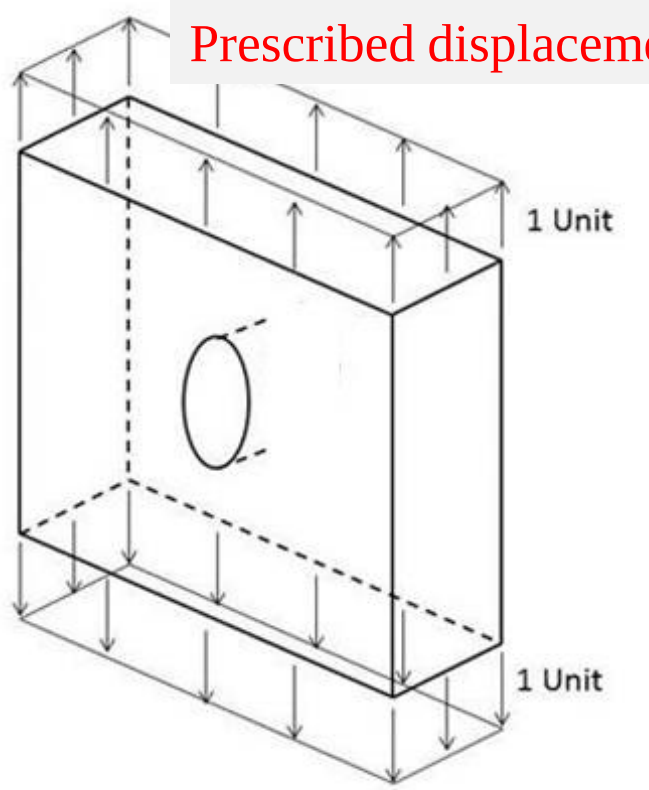
Stored in databases are $K_I(\phi)$ -functions which are a mix of FEM-data and two analytic formulas for $K_I(\phi)$ near vertices 'a' and 'c'.
(See previous years AFGROW lectures)

What remains to do is to derive the analytic formulas near the two vertices.



New Tension Load Case

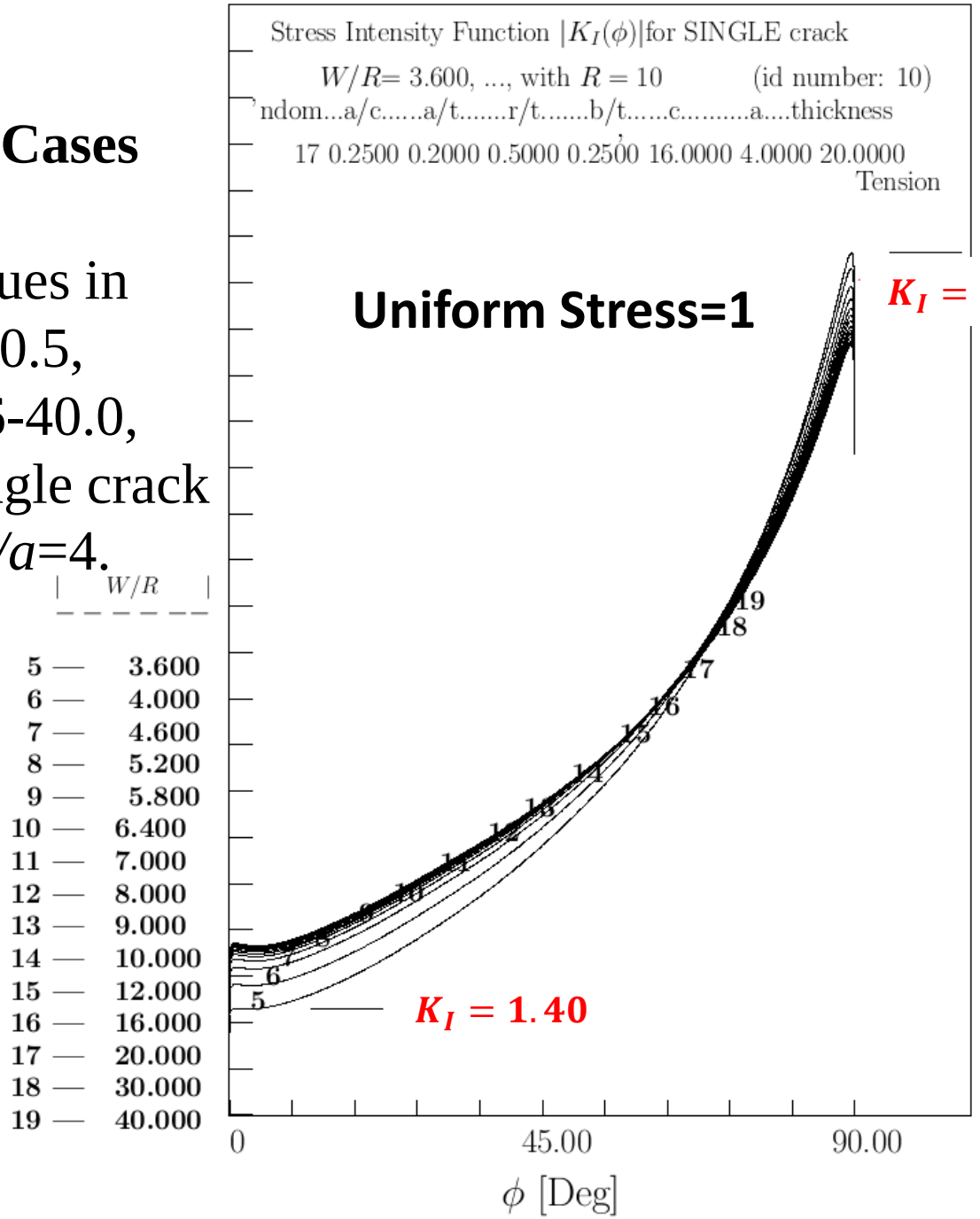


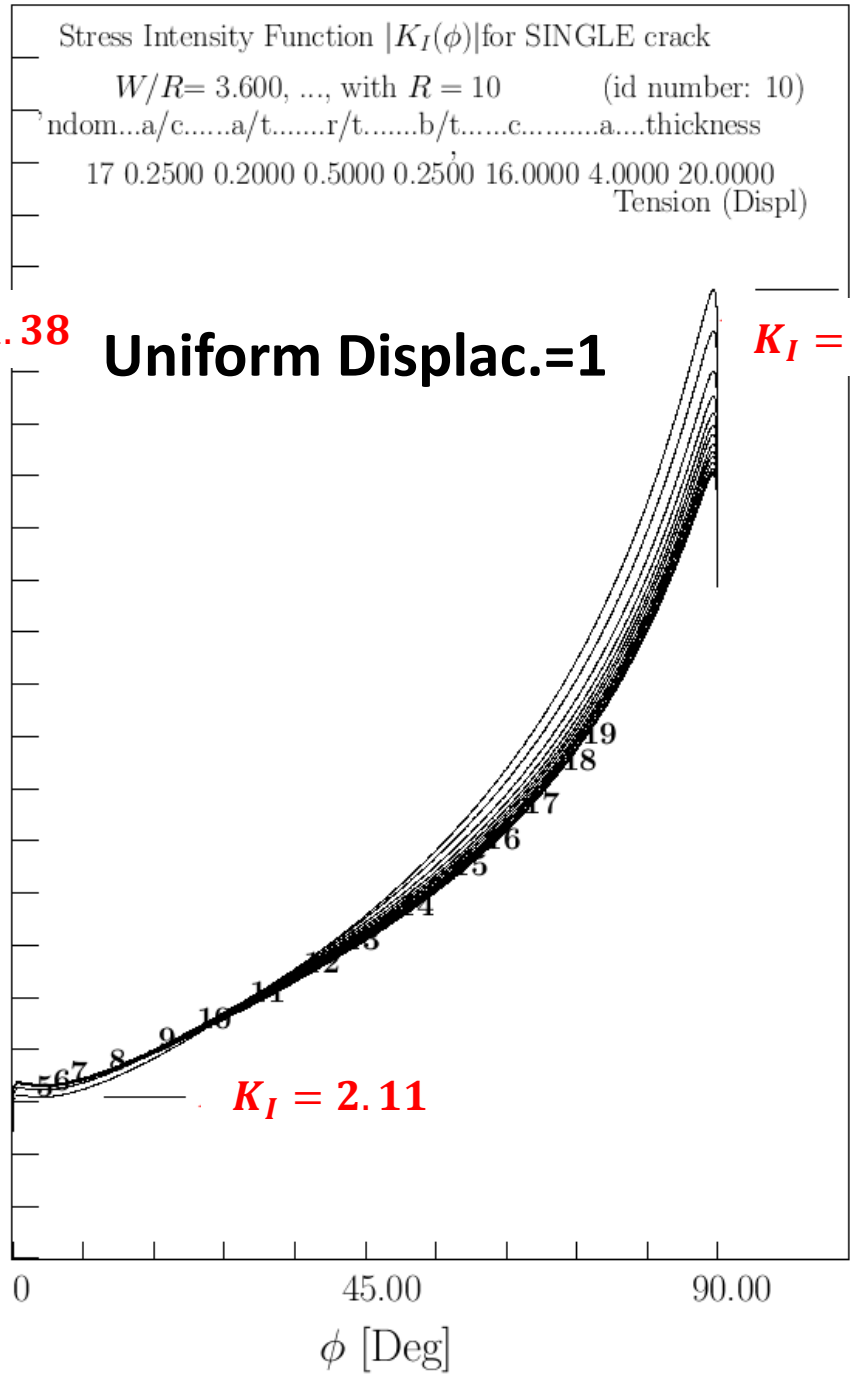


Calculated stress σ_Y in narrow plate of size *R/t*=1, *H/W*=3, *W/R*=2.4, *b/t*=0.050 for a single crack of size *a/t*=0.1, *c/a*=10. Loading is tensile stress $\sigma_Y = 1$ at end surfaces of the plate.

Example: Load Cases

Calculated *K*-values in plate of size *R/t*=0.5, *H/W*=3, *W/R*=3.6-40.0, *b/t*=0.25 for a single crack of size *a/t*=0.2, *c/a*=4.





A reduced parameter space was analysed in the fall 2025 for the modified tension load case.

$c/a =$ 0.10, ~~0.1667~~, 0.333, ~~0.5000~~, 0.667, ~~0.75~~, 0.800, ~~0.900~~, 1.000, ~~1.111~~, 1.25, ~~1.333~~, 1.500, 2.00, ~~3.000~~, 4.00, ~~5.00~~, 6.00, ~~8.00~~, 10.00.

$a/t =$ 0.10, 0.20, 0.30, 0.40, 0.50, ~~0.60~~, 0.70, ~~0.80~~, 0.90, 0.95.

$\boldsymbol{b/t = 0.15}$ and $\boldsymbol{b/t = 0.25}$

R/t = 0.2, 0.333, 0.5, 1.0, 1.5, 2.0, 3.0 and 5.0

$W/R =$ 2.4, ~~2.6~~, 2.8, ~~3.2,~~ 3.6, ~~4.0~~, 4.6, ~~5.2~~, 5.8, ~~7.0~~, 8.0, ~~9.0~~, 10.0, ~~12.0~~, 16.0, ~~20.0~~, 40.0

$\boldsymbol{H/W =}$ **3.0.**

About 40 thousand accurate *K*-functions were derived for the two *b/t* cases for single cracks. Missing data can be obtained by additional computations (2027) or perhaps by interpolation.

Support to AGROW and NASGRO teams

- AFGROW team: Jimmy Lambert reported in mid July 2026 that the K_I-values for some *R/t*-values and pin loading from 2023 must be wrong.Jimmy was correct. BARE traced the error back to a HPC-system (of three used 2023) that provided wrong FEM-loads for the $\cos^2(\phi)$-load on the hole surface. BARE has in August started to recompute the flawed solutions from 2023. These jobs runs in ’background’ queue now due to lack of CPU-hours 2025/2026.

- NASGRO team: BARE has provided BARE-developed software, and instructions for calculation of vertex *K*-data to the NASGRO team in August 2026

Acknowledgements

The author wish to express his gratitude to Mrs Cindy Buckley USAFA and project manager Dr Jack Lloyd-Reilley at South West Research Institute.

This work could not have been accomplished without the support of the DoD High Performance Computing Modernization Program HPCMP.