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Proposed for Publication in _____ (Name of Journal)

Proposed for Presentation at AIAA Missile Systems - Missile Sciences Conference (Name of meeting, conference, or symposium)

Date of Meeting 11/28/88-12/1/88 Location Monterey, CA Sponsoring Org. AIAA

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Title
Target Nonhomogeneity and Effect on EPW Design

Type of Document ("x" one)

a. Scientific and technical report: ☐ monthly ☐ quarterly ☐ annual ☐ final ☐ topical ☐ other

b. Conference paper: Name of conference (no abbreviations)
AIAA Missile Systems - Missile Sciences Conference

Location (city/st/ctry) Monterey, CA

Date (mo/day/yr) 11/28-12/1/88 Sponsor AIAA

Contents: ☐ proceedings ☒ viewgraphs ☐ paper ☐ poster sessions

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(Organization) Sandia National Laboratories	Signature T. Aglesby for	Date 11/23/88

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TARGET NONHOMOGENEITY AND EFFECT ON EPW

C. W. YOUNG

W. J. PATTERSON

NOVEMBER 1988

SANDIA NATIONAL LABORATORIES
ALBUQUERQUE, NM

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EPW DESIGN CONSIDERATIONS

- PAYLOAD

  NUCLEAR VS. CONVENTIONAL, SIZE, ETC.

- DELIVERY SYSTEM CONSTRAINTS

  WEIGHT, DIAMETER, LENGTH, C.G.

- IMPACT CONDITIONS

  VELOCITY, ANGLE OF ATTACK (AOA),
  IMPACT ANGLE

- TARGET CONDITIONS

TYPICAL TARGET DESCRIPTION

- TARGET SET
  POINT OR AREA TARGETS? NUMBER?
  WELL CHARACTERIZED?

- SOIL - DETAILED DESCRIPTION NOT USUALLY NECESSARY
  LAYERING, TYPE, STRENGTH, WATER CONTENT, DENSITY, FROZEN, ETC.

- CONCRETE
  STRENGTH, REBAR, THICKNESS, BOUNDARY CONDITIONS

- ROCK
  - GIVEN
    TYPE, STRENGTH, DENSITY, WATER CONTENT
  - NEEDED
    WEATHERING, CRACKS, FISSURES, BEDDING PLANES, ETC.

EVALUATE EFFECT OF ASSUMING HOMOGENEITY
TYPICAL ANALYSIS

SOIL

- AXIAL - CAN BE HANDLED ANALYTICALLY
- LATERAL LOADING - NO SIGNIFICANT EFFECT

CONCRETE

- AS AN ENGINEERING MATERIAL
  - * EFFECTS OF REBAR, AGGREGATE, STRENGTH VS. THICKNESS VARIATIONS - RELATIVELY UNIMPORTANT
- AS A TARGET
  - * EDGE EFFECTS - MAJOR IMPORTANCE TO LATERAL AND AXIAL LOADS
  - * SOIL OVER OR UNDER - SECONDARY IMPORTANCE
  - * RUBBLE - IMPORTANT TO LATERAL LOADS

ROCK - PROPERTIES TAKEN FROM INTACT SAMPLES

- * AXIAL LOADS - CONSERVATIVE APPROACH
- * LATERAL LOADS - VERY NON-CONSERVATIVE

DATA BASE

D-BASE III: OVER 800 SELECTED DATA POINTS

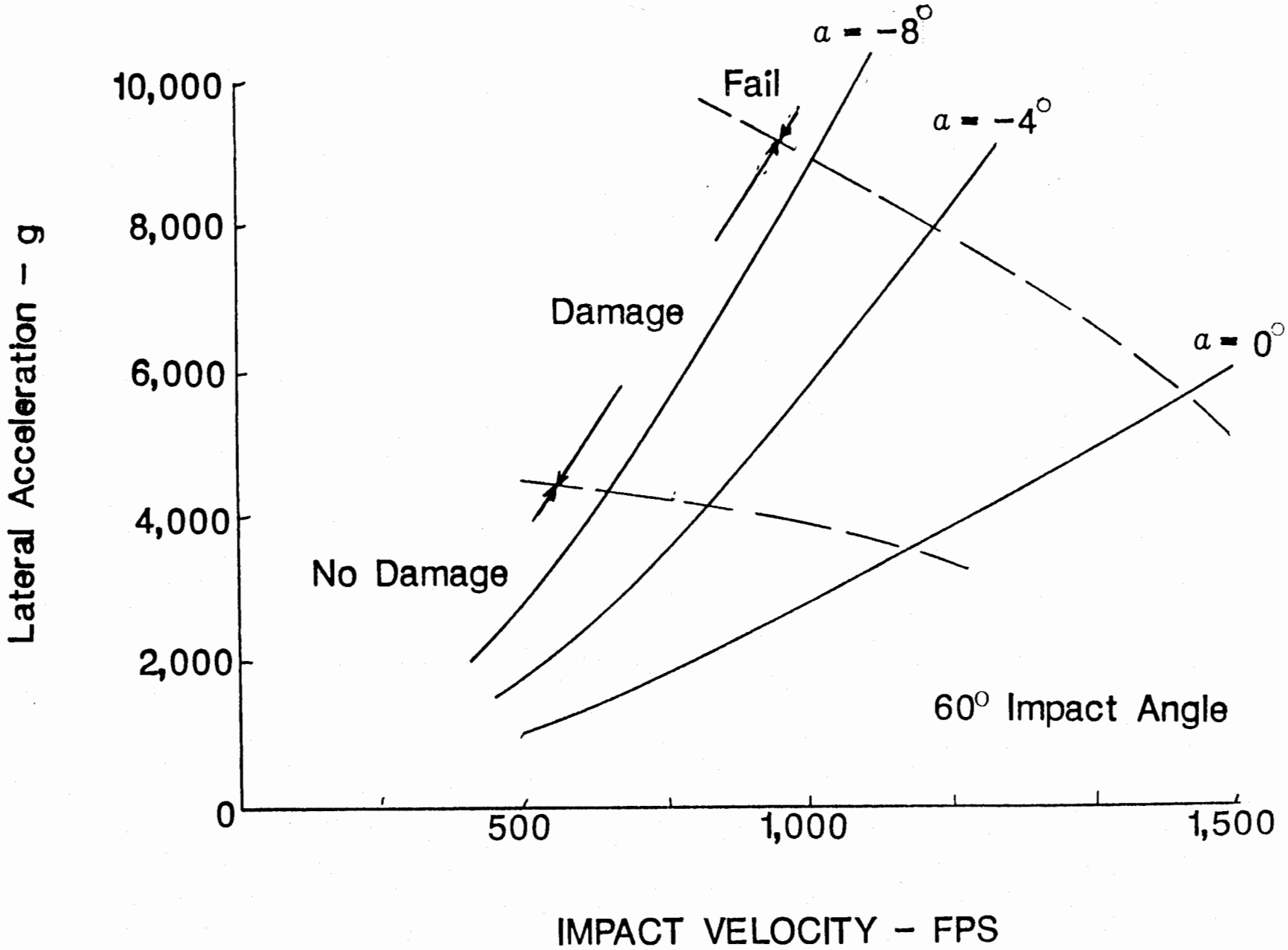
- SEARCHED FOR
  - * ROCK
  - * NO ANGLE OF ATTACK
  - * NORMAL IMPACT
- LOCATED 51 TESTS
  - * THESE <u>SHOULD</u> HAVE HAD NO LATERAL LOADING
  - * 21 OF THESE WERE BENT DUE TO LATERAL LOADING
- CONCLUSION
  - * 40% OF OUR EPW'S ARE DAMAGED DUE TO TARGET NONHOMOGENEITY
  - * METHOD OF ANALYSIS IS NEEDED

APPROACHES TO SOLVING ROCK NONHOMOGENEITY PROBLEM

- MODELING
  - * ELASTIC-PLASTIC MODELS OF ROCK REQUIRE MORE WORK
  - * RANDOMNESS OF CRACKS, FISSURES, ETC., MAKES THIS APPROACH IMPRACTICAL

- QUASI EMPIRICAL (BASED ON DATA BASE)
  - * SINCE WE CAN CALCULATE LOADING DUE TO ANGLE OF ATTACK, DETERMINE AN EQUIVALENT ANGLE OF ATTACK TO QUANTITATIVELY MATCH THE EFFECTS OF NONHOMOGENEITY

EXAMPLE OF COMBINED EFFECTS OF AOA AND IMPACT ANGLE



DETERMINATION OF EQUIVALENT AOA

- USING SAMPLL CODE, DETERMINE AOA NECESSARY TO DAMAGE ROCK PENETRATORS AS NOTED IN OUR DATA BASE

- THE TYPICAL EQUIVALENT AOA WAS DETERMINED TO BE 4°

- BASED ON TRAJECTORY DATA IN ROCK, IT WAS ALSO NOTED THAT

  - THE EQUIVALENT AOA CONCEPT APPEARS REASONABLE
  - THE AFFECTS OF NONHOMOGENEITY ARE INDEED VERY RANDOM

ASSUMPTIONS FOR A "WORST CASE" ANALYSIS

- USE WORST CASE IMPACT ANGLE
- ASSUME AOA IS ADDITIVE EFFECT TO IMPACT ANGLE
- ASSUME EQUIVALENT AOA (NONHOMOGENEITY) TO ALSO BE ADDITIVE

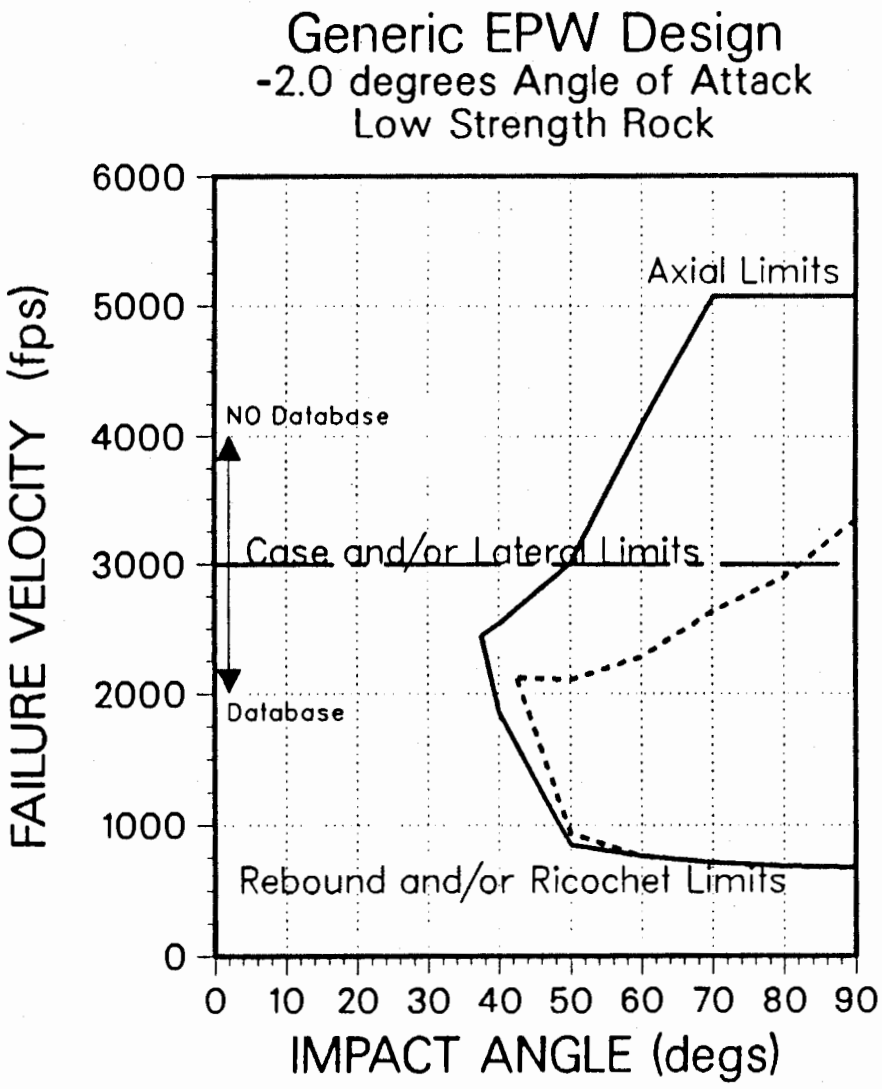
POSSIBLE CONCLUSIONS

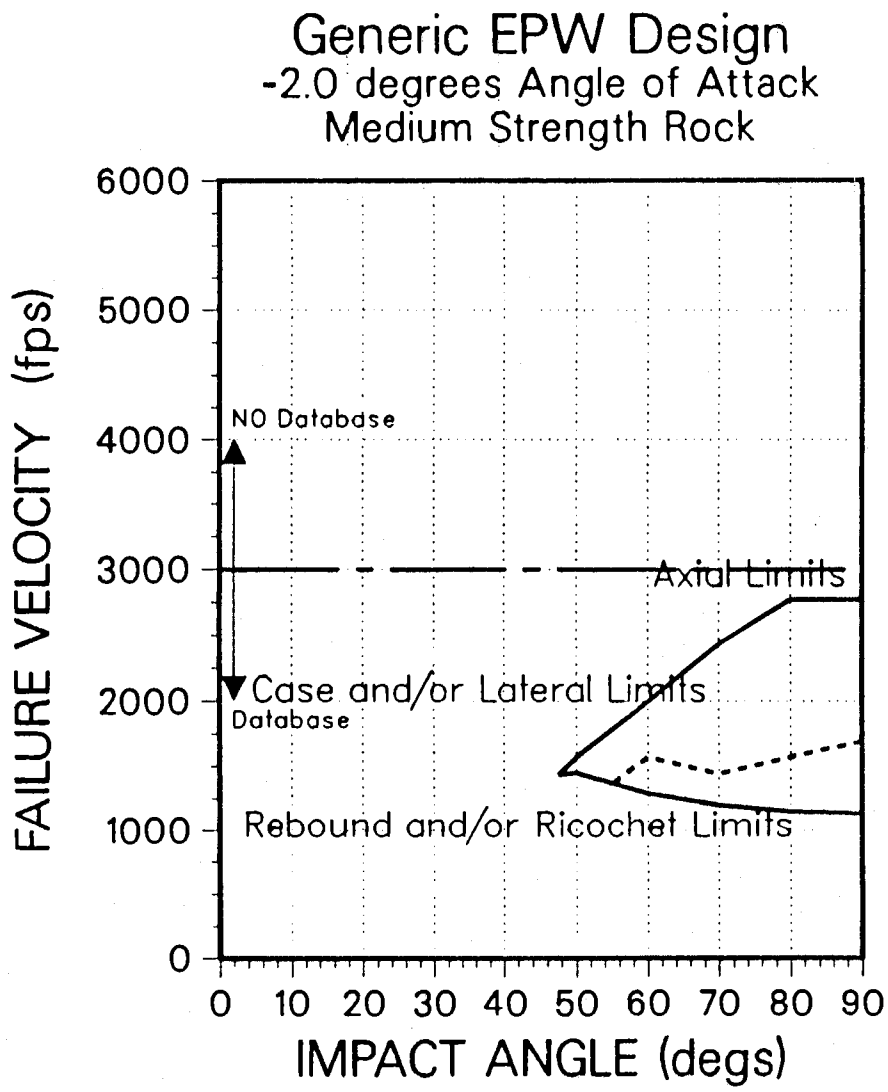
1. IF YOU CAN SURVIVE ABOVE ASSUMPTIONS, THE DESIGN IS ADEQUATE FOR MOST CONDITIONS
2. IF THE DESIGN IS NOT ADEQUATE FOR THE ABOVE ASSUMPTIONS, A STATISTICAL ANALYSIS WILL BE NECESSARY

STATISTICALLY BASED DESIGN

- USE REALISTIC VALUES FOR VARIATION OF EACH INPUT PARAMETER
- CALCULATE P_K FOR EACH TARGET
- SELECT NUMBER OF WEAPONS REQUIRED TO GIVE DESIRED P_K

NOTE: THIS TYPE ANALYSIS IS OF MORE USE TO THE WEAPONEER, EVEN THOUGH IT CAN BE USEFUL AS A DESIGN TOOL


Generic EPW Design
-2.0 degrees Angle of Attack
Low Strength Rock
FAILURE VELOCITY (fps)
6000
5000
4000
3000
2000
1000
0
NO Database
Database
Axial Limits
Case and/or Lateral Limits
Rebound and/or Ricochet Limits
0 10 20 30 40 50 60 70 80 90
IMPACT ANGLE (degs)


Generic EPW Design
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IMPACT ANGLE (degs)