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Air Transport Testing -Impact

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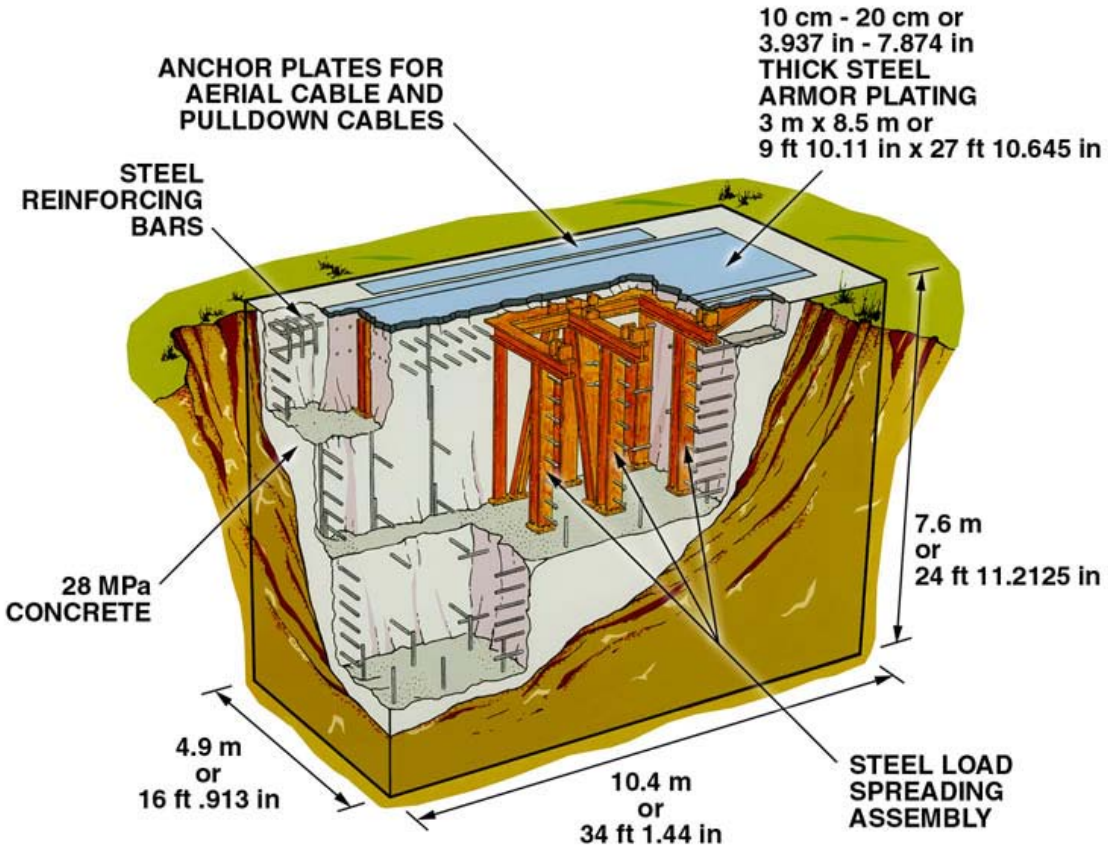
Requirements

- 10CFR71.74(a)(1) requires a 129 m/sec (422 ft/sec) right angle impact onto a flat, essentially unyielding, horizontal surface.
- The U.S. regulations do not define an essentially unyielding target.
- TS-G-1.1 (ST-2) paragraph 717.2, suggests for air transport packages a target mass 100 times the package mass resting on bedrock or firm soil is an example of an unyielding target.
- A good way to define an essentially unyielding target is one that an increase in the target stiffness will not substantially increase the damage to the package.

Unyielding Target at the Sandia Cable Site

910-Tonne (1000 U.S. tons) Armored Target at Sandia National Laboratories

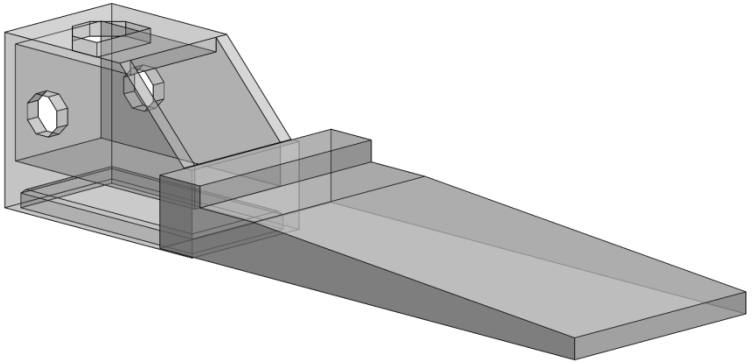


Target for a Sled Track Impact

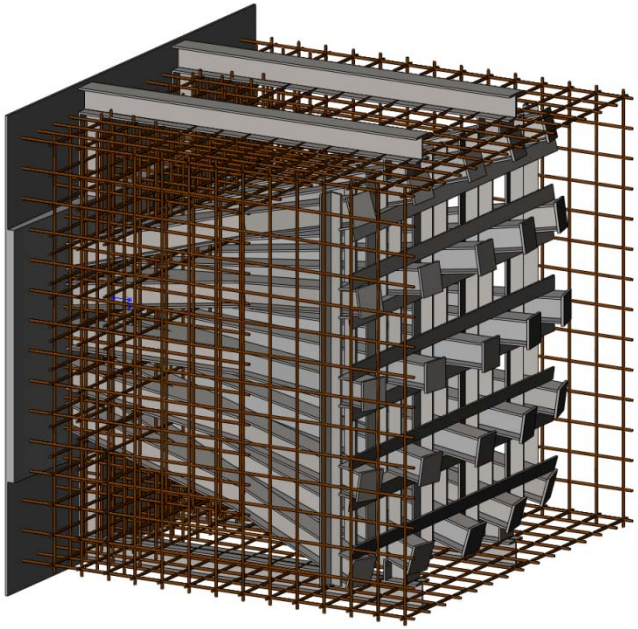
- Programmatic, technical, and practical issues make sled track testing preferable for large air transport packages.

- Since this type of testing does not meet the “letter of the law”, it must be demonstrated that the impact is equally severe.

Proposed Target at the Sled Track



Existing ~3 million pound concrete support structure

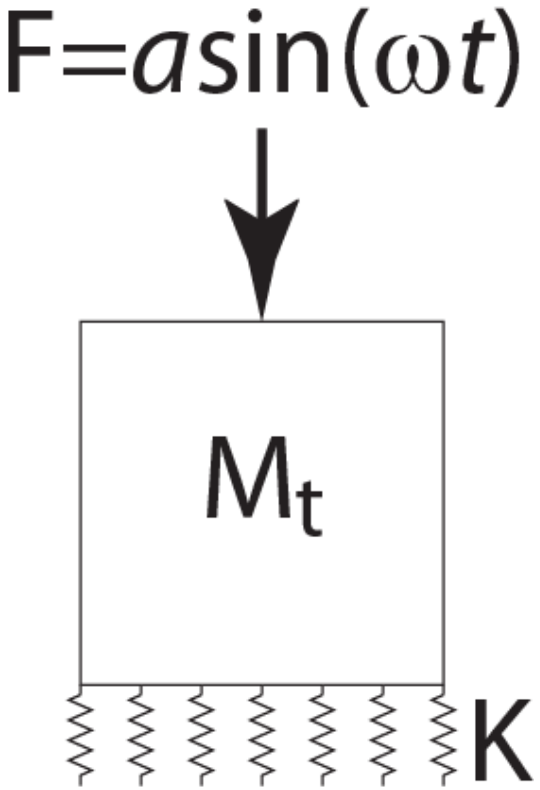


Additional steel face and reinforcement to be added to make the target “essentially unyielding”, will also add ~1 million pounds of concrete

IAEA "Essentially Unyielding" Target Response

- For a large air transport package (12,000 lbs), the target should weigh 1,200,000 pounds.
- A 20-foot cube of concrete weighs this much.
- Very stiff soil has a bearing pressure of 400,000 pounds/square foot.
- This leads to a soil spring stiffness of 16×10^6 pounds/foot.

IAEA Target as SDOF System



F is the impulse force applied by the impact

a is the peak contact force (100,000,000 pounds)

ω is the natural frequency

t is the pulse duration

Solution for IAEA Target

- Total impulse (M_pV_i) is =155,000 lb-sec
- Pulse duration (t) is 0.00244 sec.
- Target deflection at the end of the impact is 0.061 in.
- Target velocity at the end of the impact is 4.16 ft/sec.
- Target kinetic energy is 323,000 foot-pounds
- KE is ~1% of initial package KE

Sled Track Target Response

- Case A: Perfectly plastic collision
  - Initial kinetic energy is $\frac{1}{2}M_pV_i^2$ = 33,000,000 ft-lbs
  - Initial momentum is: M_pV_i=155,000 lb-sec
  - Conservation of momentum gives $(M_p + M_t)V_f=M_pV_i$
  - Solving gives V_f = 1.264 ft/sec
  - Final kinetic energy is $\frac{1}{2}(M_p+M_t)V_f^2$ = 98,000 ft-lbs
  - **The package absorbs 99.7% of the initial kinetic energy**

Sled Track Target Response (continued)

- Case B: Elastic collision
  - Initial kinetic energy and momentum as in Case A
  - Final kinetic energy is: $\frac{1}{2}\left(M_p V_{pf}^{\ 2} + M_t V_{tf}^{\ 2}\right)$
  - Final momentum is: $M_p V_{pf} + M_t V_{tf}$
  - Use conservation of energy and conservation of momentum
  - Final target velocity is 2.528 ft/sec
  - Final target kinetic energy is 391,000 ft-lbs
  - Target kinetic energy is 1.2% of initial kinetic energy

  - **Package response covers 98.8% of the initial kinetic energy**

Conclusions

- Case A is far more realistic than Case B.
- Even neglecting friction on the base of the target and the mass of soil on top of and behind the target, very little of the initial kinetic energy of the impact is transferred to the target.
- During testing the motion of the target will be monitored to validate these calculations.
- It is possible to slightly increase the initial velocity to make it so the package effect is identical to a regulatory speed impact onto a rigid target.