Session 4: Testing Requirements and Performance Characteristics of Common Terminals and Crash Cushions
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Course Topics

- Session 3 – Testing Requirements and Performance Characteristics of Common Barrier Systems
- Session 4 – Testing Requirements and Performance Characteristics of Terminals and Crash Cushions

Session 4 Learning Outcomes

At the end of this session, you will be able to:

- Understand how terminals and crash cushions are tested for crashworthiness.
- Identify common terminals and crash cushions
- Explain how these systems function
- Choose the best system for a specific site
Guardrail Terminals

A barrier terminal must serve two functions:

- Be crashworthy when impacted end-on.
- Provide anchorage for downstream hits.

Guardrail Terminal MASH Test Matrix

Test 30
Test 31
Test 32
Test 33
Test 34
Test 35
Test 36
Test 37

Significant Change

* Small Car 1100C (2420 #)
* Pickup Truck 270P (5000 #)
Guardrail Terminals

Types of Terminals:
- Buried in Backslope
- W-beam *energy absorbing* terminals – terminal is parallel to the roadway or has a straight flare with a moderate offset
- W-beam *non-energy absorbing* terminals – terminal is generally flared away from the roadway with a specified offset
Guardrail Terminals: Buried in Backslope Guardrail

- Key design considerations:
  - Keep the height of the W-Beam rail constant relative to the roadway grade until the barrier crosses the ditch flow line,
  - Use a flare rate appropriate for the design speed,
  - Add a W-beam rubrail where needed, and
  - Use an anchor (concrete block or steel post) capable of developing the full tensile strength of the W-Beam rail.

NCHRP 350 Test 3-35
Buried in Backslope Guardrail

Video Clip
Guardrail Terminals: Energy and Non-Energy Absorbing Designs

Non-Energy Absorbing Terminal
Controlled Buckling Terminal
(vehicle may travel hundreds of feet before stopping)

Energy Absorbing Terminal
(vehicle is brought to a controlled stop in a short distance)
Guardrail Terminals: Energy Absorbing

- ET Plus (Guardrail Extruder Terminal)
  - Flattens and curves guardrail when hit
  - Breakaway wood or steel posts (several options available)
  - 25' long (TL-2)
  - 50' long (TL-3)
  - Recommended 1-2 ft. offset over 25 or 50 feet to reduce nuisance hits
  - Cable-anchored system

NCHRP 350 Test 3-31: ET Plus (Guardrail Extruder Terminal)

Video Clip
Guardrail Terminals: Energy Absorbing

- **SKT 350 (Sequential Kinking Terminal)**
  - Kinks and bends Guardrail when hit
  - Breakaway wood or steel posts – several options available
  - TL-2 is 25’ long; TL-3 is 50’ long
  - Recommended 1-2 ft. offset to reduce nuisance hits
  - Cable-anchored system

- **MSKT MASH Version of SKT (Sequential Kinking Terminal)**
  - Kinks Guardrail when hit
  - Steel post system
  - TL-3 at 50’ long for attachment to 31” MGS MASH Barrier
  - Cable-anchored system
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MASH 350 Test 3-31: MSKT 350

Guardrail Terminals: Energy Absorbing

- FLEAT 350 (FLared Energy Absorbing Terminal)
  - Straight flared (not parabolic),
  - Breakaway posts (wood or steel)
  - Energy Absorbing Variable offset 25'-0" long (TL-2) or 37'-6" long (TL-3)
  - Cable-anchored system

NCHRP 350 Test 3-30: FLEAT 350 (FLared Energy Absorbing Terminal)
Guardrail Terminals: Energy Absorbing

- X-Tension
  - Resistance is at the impact head – works in tension
  - Cables in the W-Beam are pulled thru friction plate
  - Median, Tangent, Flared from same hardware kit

NCHRP 350 Test 3-31: X-Tension Terminal

Video Clip
Guardrail Terminals: Energy Absorbing

- X-Lite
  - Uses a slider mechanism between post 1 and 2 that gathers and retains the rail when hit.
  - The anchor consists of posts #1 and #2 connected by tension struts and a soil plate below grade on post #2.
  - Both Tangent and Flared Layout.

NCHRP 350 Test 3-31: X-Lite Terminal

Video Clip
Guardrail Terminals: Energy Absorbing

- **Softstop**
  - Impact head flattens the w-beam guardrail vertically upon end-on impact.
  - Anchored upstream from impact head.
  - Breakaway steel posts at #1 and #2, standard posts and beyond.

MASH Test 3-31: Softstop Terminal

- Video Clip

Impacted Softstop Terminal
Guardrail Terminals: Non-energy Absorbing

- SRT 350 (Slotted Rail Terminal)
  - W-Beam rails with a parabolic curve and horizontal slots in rail
  - Variable parabolic offset
    - 3’-4’
  - 37’-6” long with 8 posts
  - Cable-anchored system

- SRT M10 (Slotted Rail Terminal)
  - Modified W-beam panels containing horizontal slots installed in a straight line flare.
  - CRP at post 1.
  - SYTPs at posts 2 to 10.
  - System is 37’-6” long and connects to 31” high guardrail.
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MASH Test 3-31: SRT M10

Guardrail Terminals: Non-Compliant
- Turned-down Terminal
- Breakaway Cable Terminal (BCT)
- Modified Eccentric Loader Terminal – (MELT)

Turned-down Terminal
Guardrail Terminals: Non-Energy Absorbing

- MELT – Modified Eccentric Loader Terminal (TL-2)
  - W-Beam rail with a parabolic curve and 4-ft offset
  - Strut between the steel tube foundation between two end posts.
  - 37’-6” long with 8 breakaway posts.
  - No rail-to-post bolts except at posts 1 and 8 and beyond,
Selection of W-Beam End Terminals

Is Barrier Needed?
- No, Discuss Elimination Of Hazard with Engineer
- Yes, Proceed with other steps

Is Length of Barrier Optimal?
- No, Adjust Length of Barrier
- Yes, Proceed with other steps

Is there a Steep Backslope near by?
- No, Proceed with other steps
- Yes, Can Barrier be Terminated in Backslope?
  - Yes, Proceed with other steps
  - No, Proceed with other steps

Can Barrier be Terminated in Backslope?
- Yes, Proceed with other steps
- No, Proceed with other steps

Is Runout Area beyond Terminal Adequate?
- No, Proceed with other steps
- Yes, Use any Crashworthy Terminal

Can barrier be extended to obtain adequate runout area?
- No, Proceed with other steps
- Yes, Use Energy Absorbing Terminal
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Crash Cushions
Crash test with blunt end:

Video Clip

Crash Cushions
Crash test with ramped end:

Video Clip
Crash Cushions

- CAT (Crash Cushion Attenuating Terminal) (NCHRP 350)
  - Slotted rail tears tabs between slots
  - Best suited to terminate a double-faced strong-post median W-Beam barrier
  - Can be attached directly to a W-Beam median barrier, or to a Thrie-Beam median barrier using the standard W-Beam to Thrie-Beam transition section
  - Cable-anchored system

- Quest (NCHRP 350)
  - Approved for TL-2 & TL-3 systems.
  - Designed to attach to a concrete median barrier.
  - Consists of a series of W-beam fender panels supported by diaphragms with a trigger mechanism at the nose that releases the front assembly for end on hits.
Crash Cushions

- TRACC (TRinity Attenuating Crash Cushion) (NCHRP 350)
  - Permanent or Construction Zone
  - TL-3 TRACC / TL-2 Short TRACC / FASTRACC / WIDETRACC
  - Designed to attach to a concrete median barrier.
  - Consists of an impact “sled,” energy absorbing tracks, intermediate steel frames, and double tiered 10 gauge W-Beam side panels; shipped to the field assembled.

- QuadGuard (MASH)
  - Can be attached directly to a W-beam or Thrie-beam median barrier as well as to a concrete safety shape.
  - Slides back on a single track when struck head-on and uses specially fabricated side panels having four corrugations.
  - Energy-absorbing cartridges in each bay need to be replaced after a crash.
  - Available in widths from 2 to 3 feet.
  - Adjustable in length from 1 to 12 bays for various speeds including 70 mph.
QuadGuard Variations:
- **QuadGuard LMC** (Low Maintenance) – narrow parallel sided version that uses elastomeric cylinders; essentially self-restoring after most impacts and best suited for use in locations where a high number of hits are anticipated.
- **QuadGuard 69/90 LMC** – wide tapered version of the QuadGuard LMC (widths from 5’-9” to 7’-6”).
- **QuadGuard Elite** – uses High Density Polyethylene cylinders; essentially self-restoring after most impacts.

**TAU II and TAU IIR Systems (NCHRP 350)**
- Approved for TL-2 & TL-3 systems.
- Designed to attach to a concrete median barrier.
- Common set of parts for 36” to 102” widths in 6” increments.
- Consists of Thrie-beam panels, expendable energy absorbing cartridges, steel diaphragms and two cables at the bottom to provide redirection. Anchored at front and rear only.
Crash Cushions

- SCI Smart Cushion (MASH)
  - Variable Reaction Force
  - Re-usable without Component Replacement

Crash Cushions: Non-Redirective and Gating

- Sand Barrels (NCHRP 350)
  - Four types of sand barrels:
    - CrashGard / Energite / Fitch / Big Sandy.
    - Individual barrel designs vary in shape by manufacturer, but they all function the same. For the same barrel weights, they are interchangeable within a given array.
    - Arrays of sand barrels may be designed to shield any shape hazard.
    - Susceptible to damage from nuisance hits; best used in areas where hits are infrequent.
    - No appreciable re-directive capability, so the corner of the hazard must be reasonably shielded. The rear corner barrel should overlap the shielded object by at least 30".
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Crash Cushions:
- Sand Barrels: Energite, Fitch, TrafFix Big Sandy, CrashGard

Review Learning Outcomes
- Understand how terminals and crash cushions are tested for crashworthiness.
- Identify common terminals and crash cushions
- Explain how these systems function
- Choose the best system for a specific site