Vehicle Restraint Systems

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TII Standards Training 2022
19th May 2022

Agenda

- Dynamic Testing
  - Importance of Ground Conditions
  - Current Testing Approach
  - Proposed Testing Approach
  - Overview of Research
- Ongoing Work Packages
  - Embankment Height Research
  - Radius Barriers
  - SCD Ramped Terminals
  - DN-REQ-03034 Updates

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Dynamic Testing

Importance of Ground Conditions

- Critical for safety barrier performance
- Initial Type Testing (ITT) Conditions v Site Ground Conditions

Ground Conditions during VRS Certification

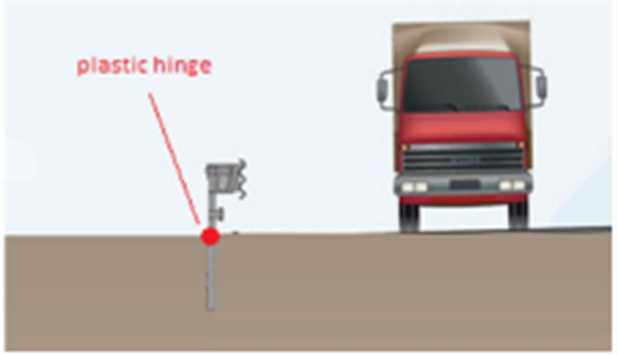
Importance of Ground Conditions

- Critical for safety barrier performance
- Initial Type Testing (ITT) Conditions v Site Ground Conditions

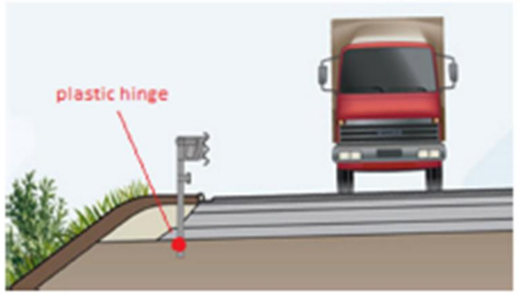
Importance of Ground Conditions

– Reasons for Differing ground conditions on site and during impact tests:

- Site ground conditions may have lower relative strength/stiffness
- Less passive resistance behind posts on embankments
- The degree of compaction at the verge of an embankment may be less than elsewhere
- The top layer of an embankment slope/ verge is a top soil layer that will have lesser strength properties than those of engineered fill



Plastic hinge develops at ground level or higher.



Plastic hinge may not develop at all or may occur at a lower level than required by the design.

Current Ground Testing Requirements for VRS Post Foundations

DN-REQ-03034

“All VRS rely on certain ground conditions in order to function satisfactorily. Testing, as described in the CC-SPW-00400, shall be undertaken to ensure that the system performs as intended”

CC-SPW-00400

- Test Procedure - Push tests in accordance with BS 7669 Part 3 Annex B
- Test Requirements – provided in the manufacturer’s I.S. EN 1317-5 compliant installation manual
- Independent Chartered Engineer attends site to witness and certify the pre-installation site testing

Limitations of Current Approach

Limitations of Current Approach

- Post does not experience dynamic loads which occur during vehicle impact tests
- Generally a plastic hinge does not develop
- Historical test originally developed for pre-EN 1317 type VRS (specific post type)
- Deflection time of the post is not considered

✓ Relatively cheap

✓ Equipment is readily available

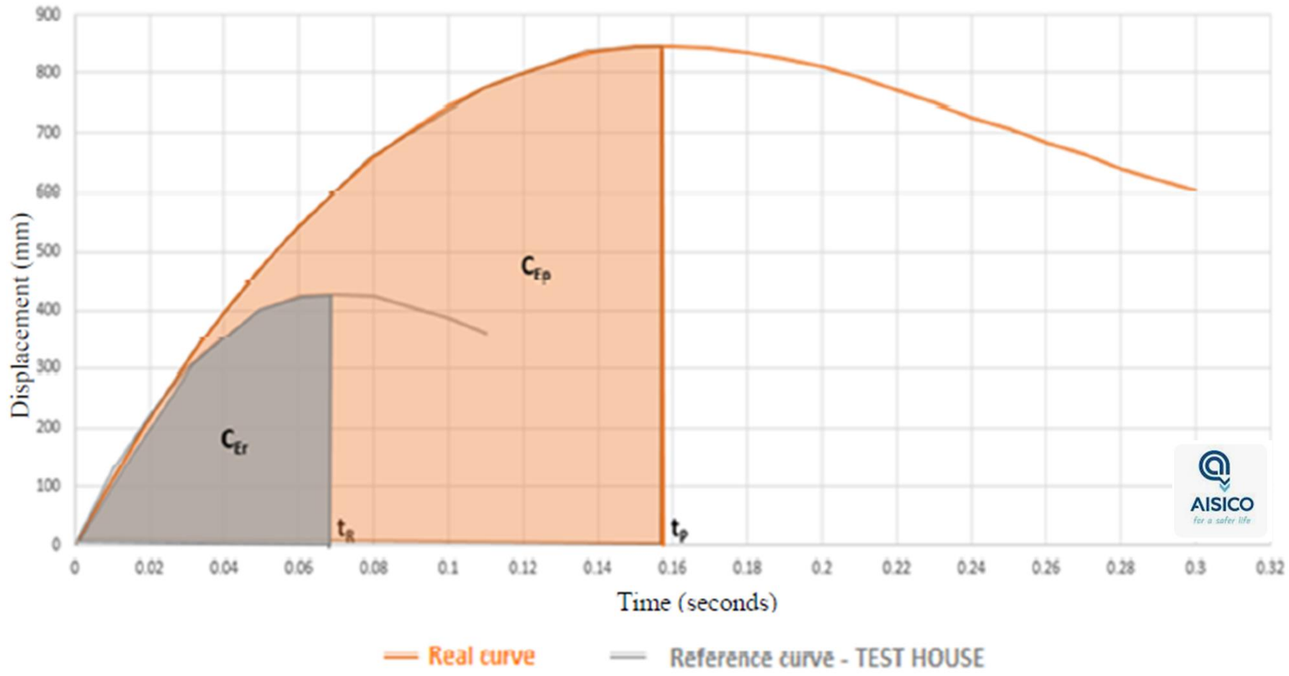
✓ Provides an indication of soil strength

Dynamic Testing of Post Foundations

- Tests the safety barrier post in a manner comparable to the impact test
- Impact mass and speed are controlled
- Height of the impact is controlled
- Considers energy dissipation, displacement, torsion, and plastic hinge – more representative of ‘real’ post-ground behaviour
  - ➢ Capacity of post/ soil system to absorb energy (C_E) is calculated

Dynamic Testing of Post Foundations

- Energy dissipating capacity (C_E)



Displacement vs. time curve derived from the dynamic test

C_E Reference – Test House

C_E Real – Site

Dynamic Testing of Post Foundations

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Dynamic Testing of Post Foundations

- The test considers the dynamic behaviour of the soil
- Test load and impact load are more comparable
- Plastic hinge is more likely to develop
- Test can be applied to any post type and related back to the initial type test

  - ➢ Recognised standard?
  - ➢ Irish Soils?
  - ➢ Acceptable limits?

Dynamic Testing Research Stages

Phase	Title	Status
Phase 1	Literature Review	Complete
Phase 2	Test House Testing	Complete
Phase 3	FEM Analysis for Acceptability Limits	Complete
Phase 4	Site Testing in Irish Ground Conditions	Complete
Phase 5	Final Verification and Interim Technical Advice	Ongoing

Stage 1 - Literature Review

- Literature review of available test methods and their applicability to Irish road projects
  - Static push pull tests
  - Driving time test
  - Dynamic Testing
- Manufacturer Consultation and Feedback
- Recommended Testing Schedule for Stage 2

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Dynamic Testing of Vehicle Restraint Systems

Module 180.1 - Literary Review

236135-180-TPS-0002001-D02

Issue | 5 June 2018

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Job number 236135-00

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Stage 2 – Test House

- Completion of a series of dynamic and static push pull tests at the Aisico test house facility
  - Post section
  - Earthworks materials
  - Slope profile
  - Relative compaction of earthworks material
  - Post embedment length
  - Set-back distance from crest of embankment to post
  - Concrete foundations
- Compare results and determine acceptability limits for push-pull tests in various scenarios

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Dynamic Testing of Vehicle Restraint Systems

WP3.4A - Specification for VRS Testing

262866

Issue 1 | 5 October 2018

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Dynamic Testing of Vehicle Restraint Systems

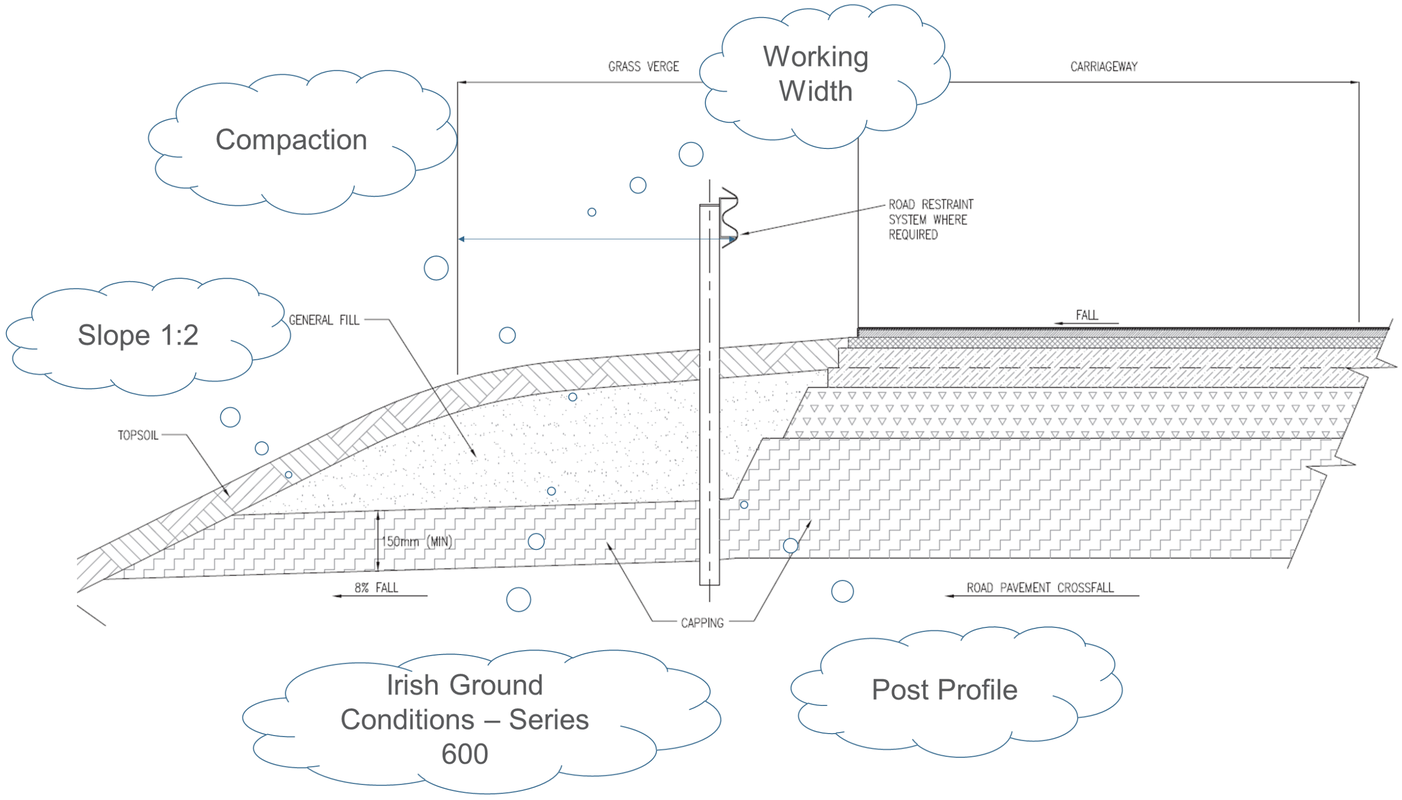
VRS Barrier Testing: Preliminary Interpretation

262866-GE-RP01

Issue 1 | 07 November 2019

ARUP

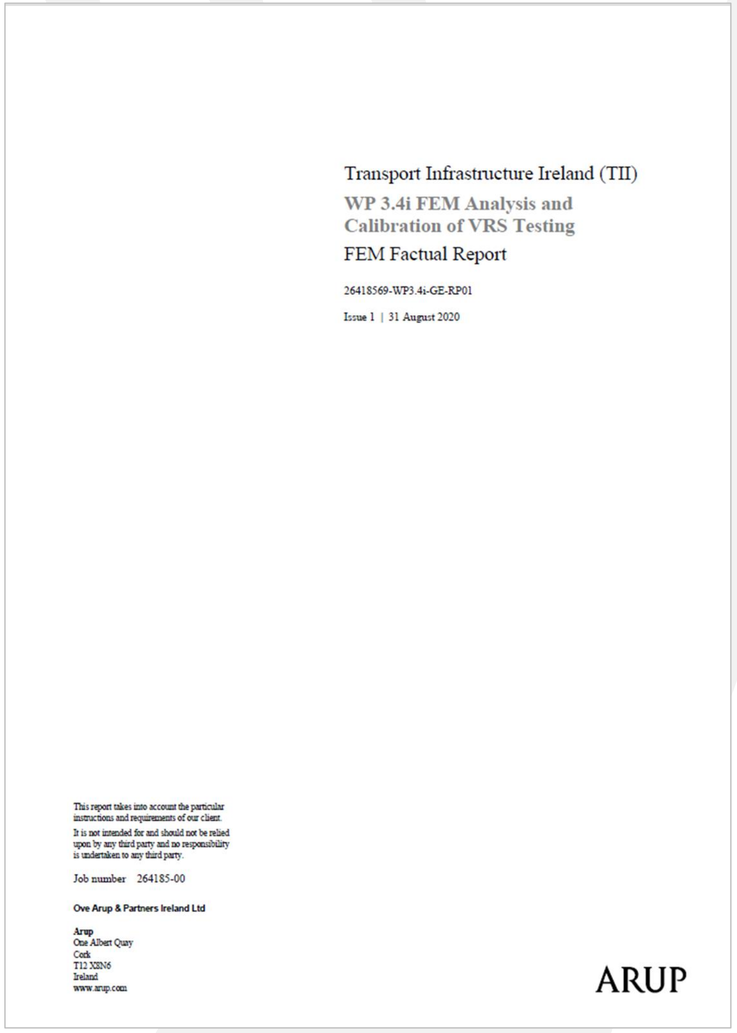
Stage 2 – Test House



- No consistent relationship between static and dynamic tests
- Base data set for further simulation work

Stage 3 – FEM Analysis for Acceptability Limits

- Development of fully calibrated numerical models (FEM) of the dynamic tests undertaken in Phase 2
- Undertake 2no. full-scale TB32 crash tests in scenarios considered in Phase 2
- Development of fully calibrated numerical models of the TB32 crash tests using soil conditions modelled in dynamic tests
- Undertake additional TB32 FEM with varying soil stiffness to determine the ‘ok/fail’ limits
- Develop a draft Dynamic Testing Standard including the initial ‘acceptable CE’ values



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WP 3.4i FEM Analysis and Calibration of VRS Testing

FEM Factual Report

26418569-WP3.4i-GE-RP01

Issue 1 | 31 August 2020

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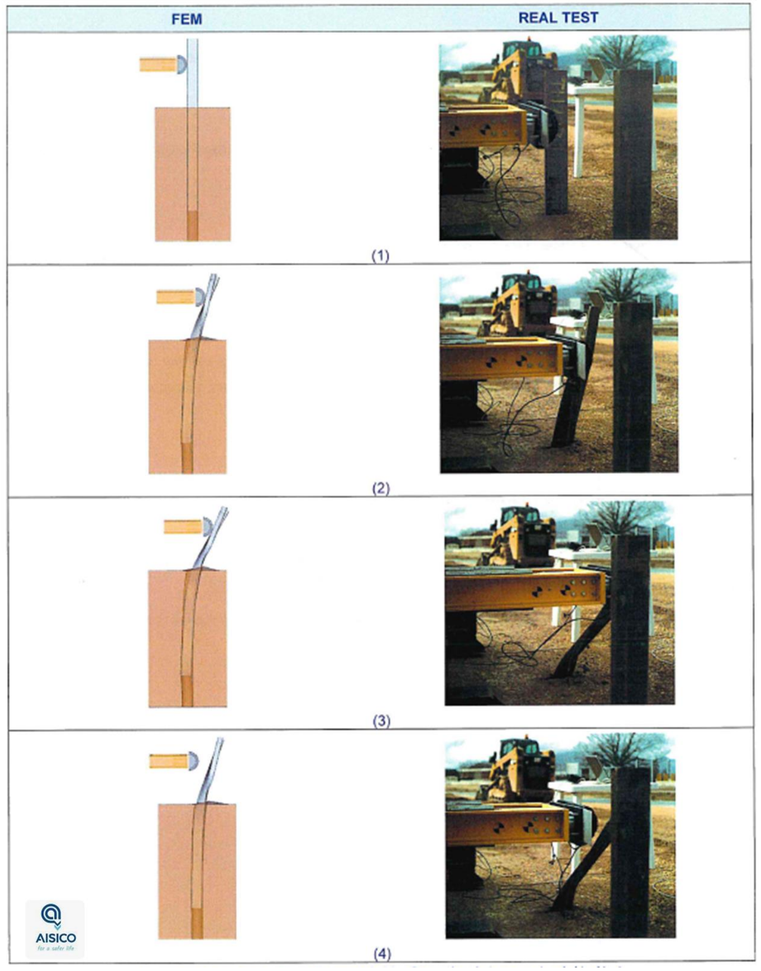
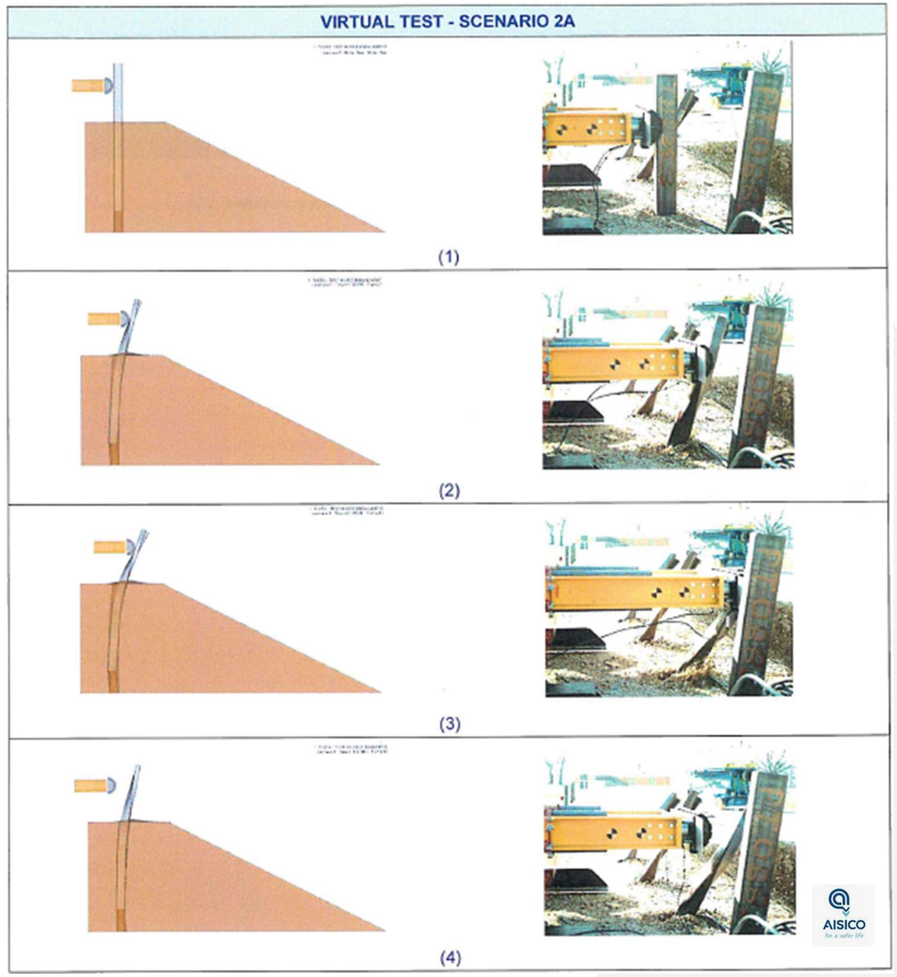
Stage 3 – FEM Analysis for Acceptability Limits

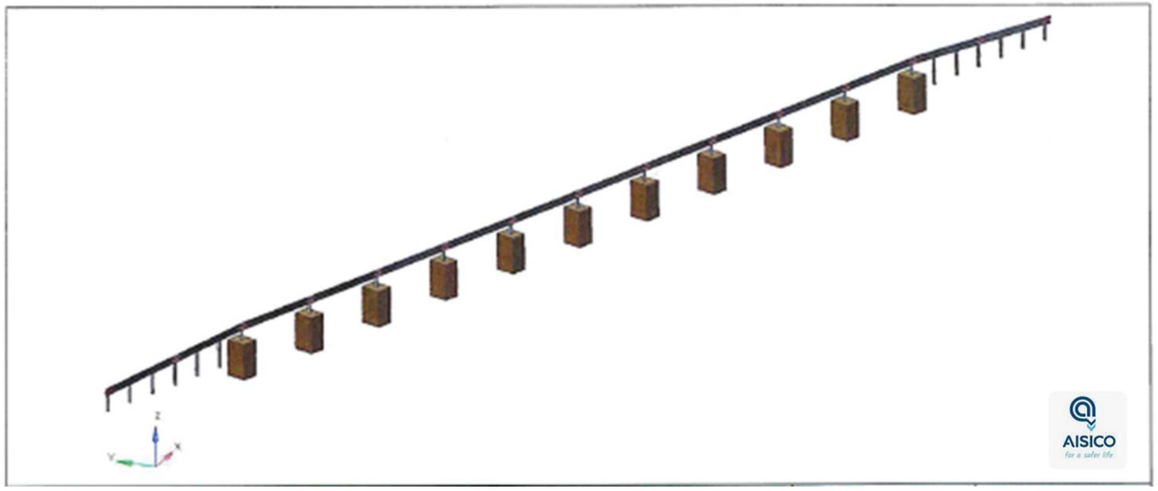


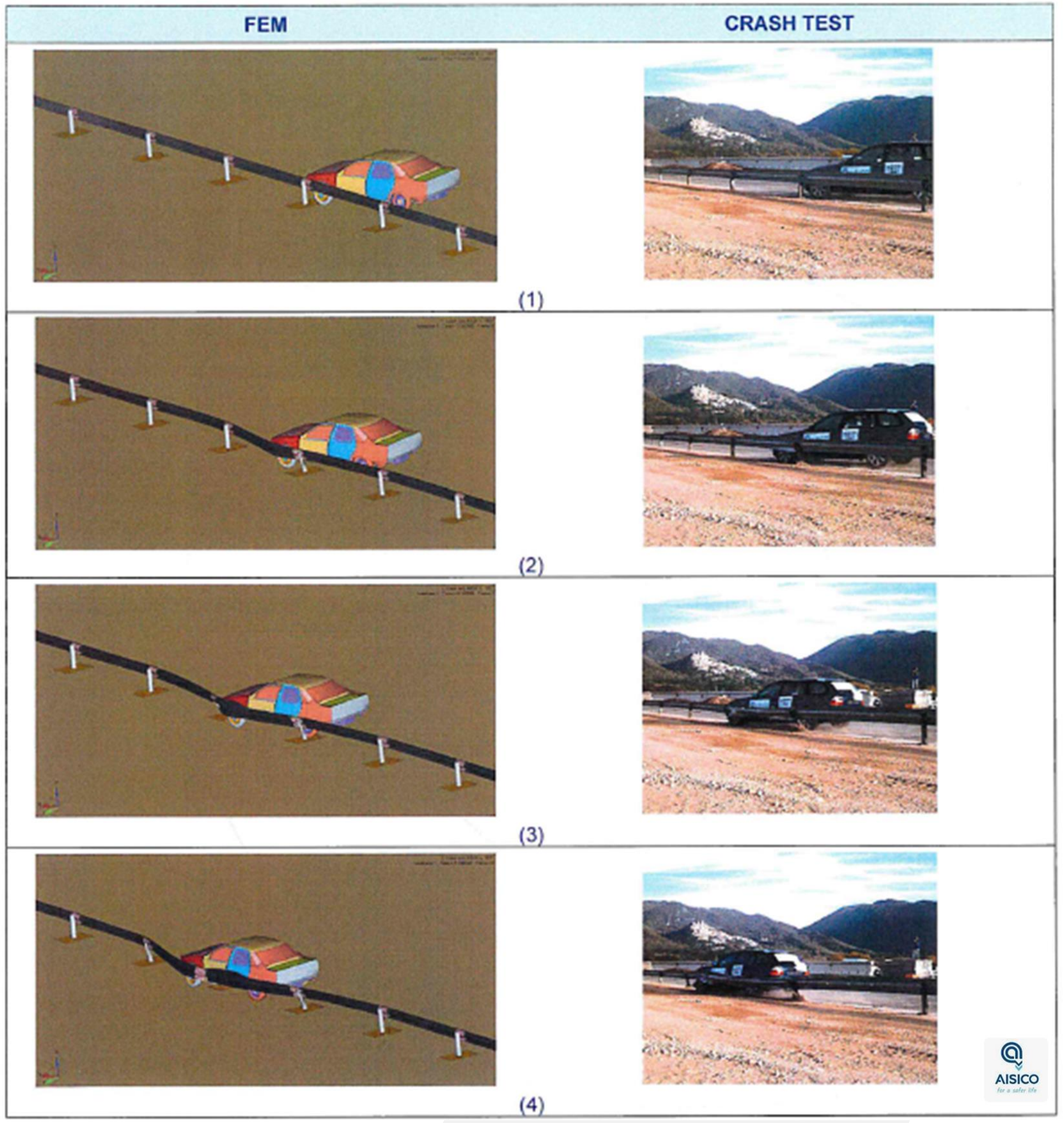
Plastic hinge [cm]
Final height of the post head [cm]
Displacement of the post base [cm]
Maximum Dynamic Deflection at the impact height [cm]
Peak force [kN]



- Calibration, Verification and Validation

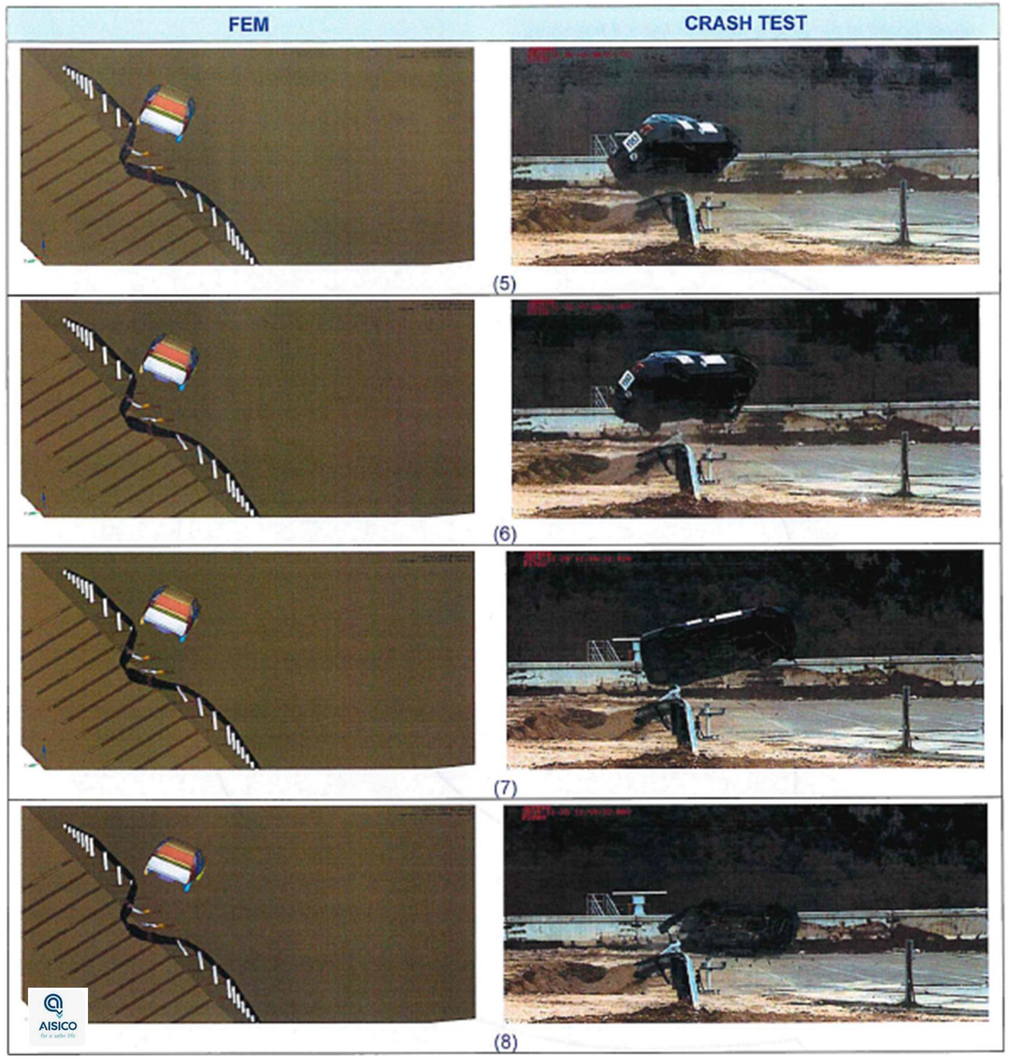
Stage 3 – FEM Analysis for Acceptability Limits





- Identification of the acceptable CE tolerance limit

Stage 3 – FEM Analysis for Acceptability Limits



- Soil stiffness gradually reduced in FEM for full scale TB32 crash test
- ‘Ok/ fail’ limit established
- Soil stiffness at failure applied to FEM of dynamic tests to establish the corresponding C_E value
- C_E acceptable tolerance limit established

➢ Identification of the acceptable CE tolerance limit

Stage 4 – Site Testing

- Site testing on Irish VRS installation projects with a view to assessing and verifying the appropriateness of the CE tolerance limit

  - N4 Collooney to Castlebaldwin (new construction)
  - N4, N15, N60/61 and N25 (legacy network)

- 4 No. reference tests undertaken in test facility
- 89 No. tests undertaken in various configurations

Stage 5 – Final Validation and ITA

- Analysis of site testing results
- Recommend approach for final validation of acceptable tolerance limits
- Update the Draft Dynamic Testing Standard as required for issue as an Interim Technical Advice Note
- Pilot on selected Call-off Contracts under the TII VRS Installation framework
- Consider publication of final Standard and implementation via CC-SPW-00400

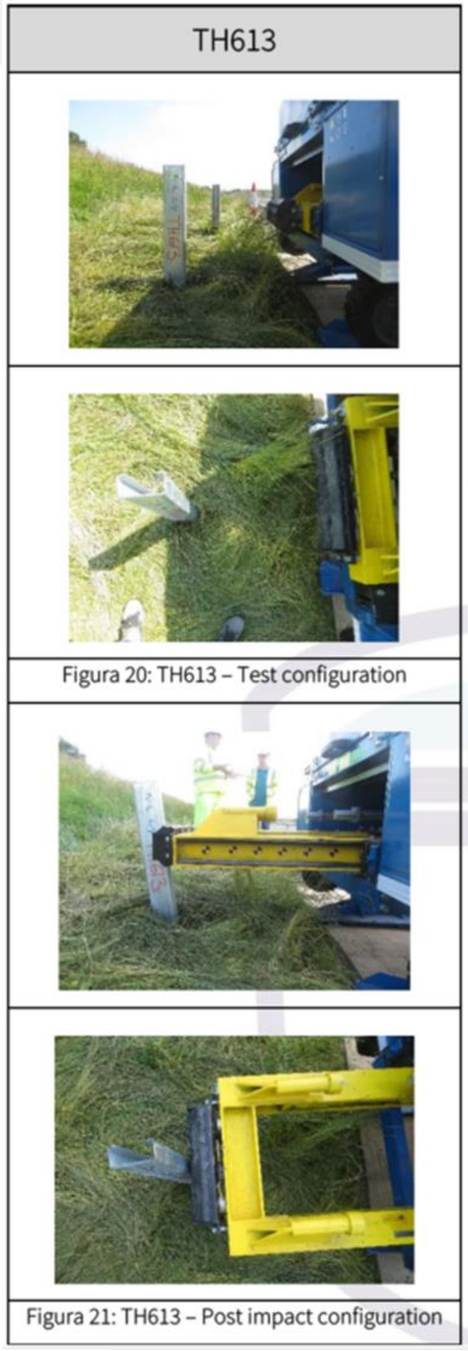


Figura 20: TH613 – Test configuration

Figura 21: TH613 – Post impact configuration

Dynamic Testing - Other Research Applications

Verge Construction

Concrete Foundation
Standard Detail

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Ongoing Work Packages

Embankment Height Research

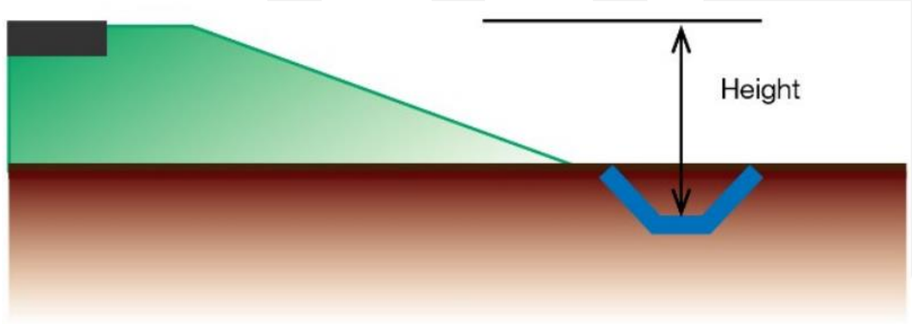
Radius Barriers

SCD Ramped Terminals

DN-REQ-03034 Updates

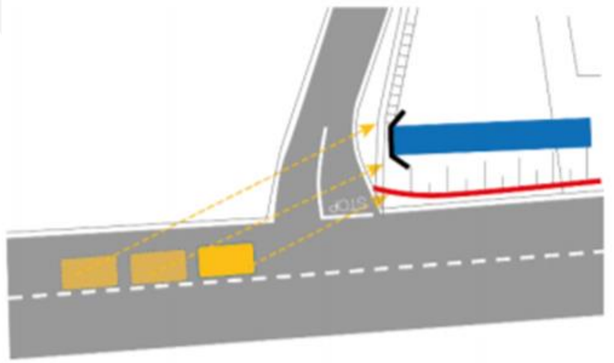
Embankment Height Research

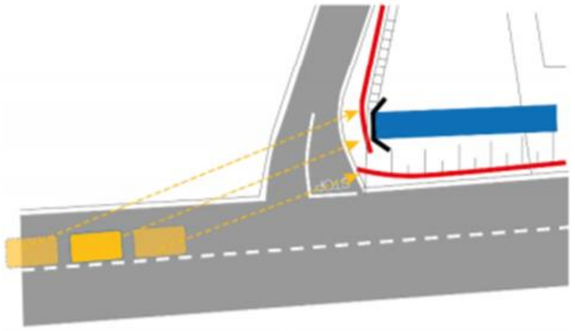
- Pre 2014 embankment slopes between 1:2 and 1:3 and less than 2m high were not considered a hazard
- Research to understand the level of risk associated with embankments with 1 in 3 slope that is 0.5m, 1m, 1.5m or 2m high
- Virtual testing of vehicles running off the embankments at different heights and slopes
- Selection of full scale tests to calibrate/ validate the models
- Comparison of whole life cost of protecting these slopes versus the risk presented

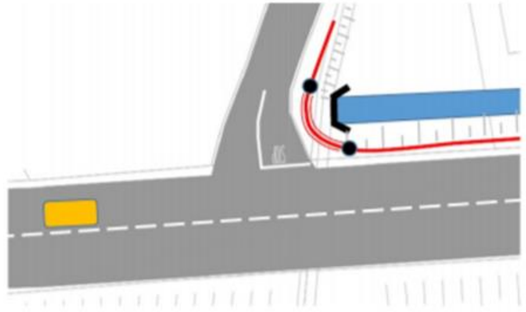


Radius Barriers

- Review of the use of higher containment barriers on curves
- International review of the testing, design and installation of curved barriers
- Develop and undertake matrix of appropriate numerical simulations of radius barriers of varying configurations
- Make recommendation for standard construction detail

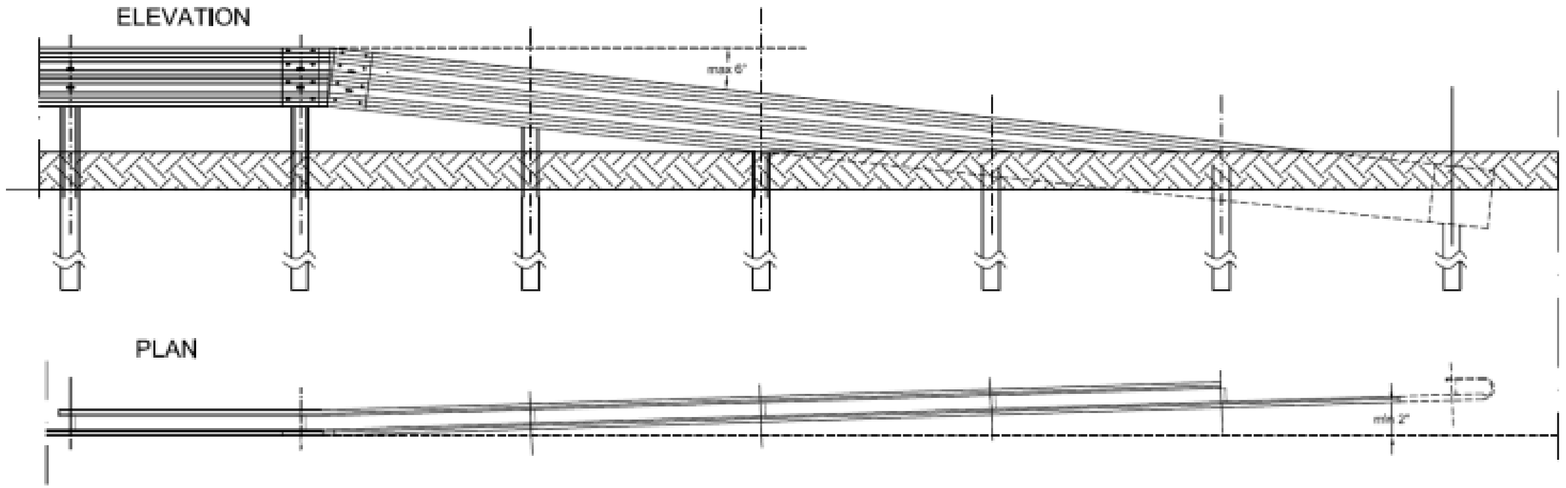






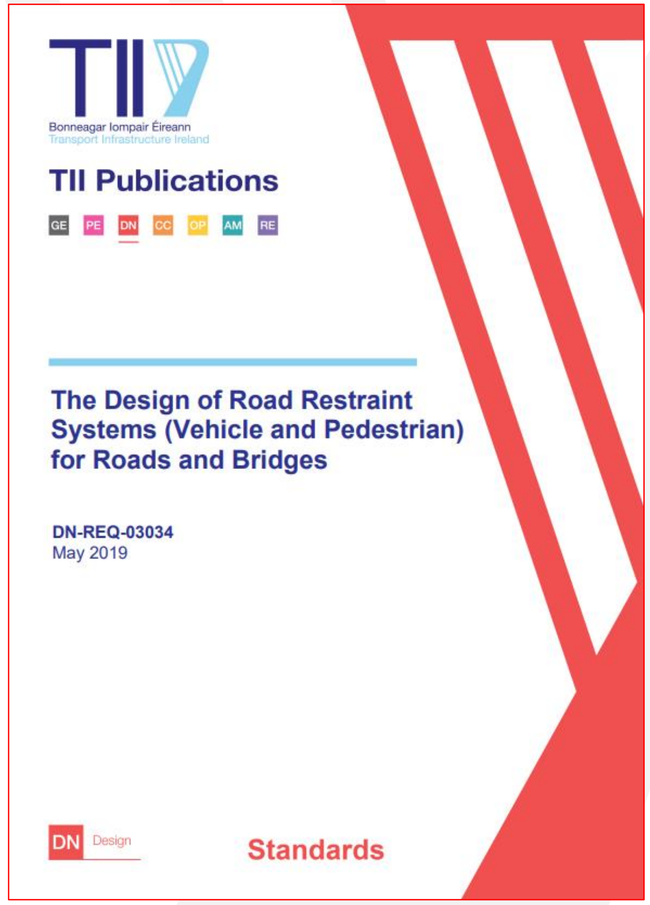
SCD Ramped Terminals

- Ramped down terminals only permitted downstream
- *“Ramping the barrier down to ground level and anchoring the safety barrier as it was anchored during the Initial Type Test (System Anchorage)”*
- International review of the use of ramped down terminals
- Develop a Standard Construction Detail for ramped down terminals (downstream only)
    - ➢ Ramp rate
    - ➢ Anchorage



DN-REQ-03034 Updates

- Review of Departures received
- Review of queries received
- VRS Design in wide medians
- Impending issue of TRs and TS in relation to Terminals, Transitions and Removable Barrier Sections
- Outcome of ongoing research



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Questions and Answers