Vehicle Restraint Systems

Herbert Nyamakope (TII)
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TII Standards Training 2017

Athlone  09th May 2017
Carrick on Shannon  11th May 2017
Cork  16th May 2017
Dublin  18th May 2017
VRS – Overview of Changes
VRS – Need for Change

- 2012/2013 – substantial inventory gathering of VRS on the national road network
- Myriad of issues identified
VRS – Need for Change
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VRS – Need for Change

• Consultants were tasked with designing VRS for locations identified

• DN-REQ-03034 compliant VRS could only be designed for 30% of the locations

• Remaining 70% would require a risk based approach to design solutions for VRS in constrained locations
VRS – Need for Change

• Terminals and Transitions

• Issues with historical terminals
• Issues with transitions to bridge parapets
• Not CE Marked products as no harmonised European standards
  • Assessment for compliance?
VRS – Need for Change

Existing standards

DN-REQ-03034 - VRS Design

- When, where, what safety barriers are required
- Hazards definitions
- Mitigation of hazards
- Risk assessments
- Terminals and Transitions

Does not fully address:

- Designs in constrained locations – e.g. no working width
- Connections to historical bridge parapets
- Other constraints associated with retrofitting to legacy roads
VRS – Need for Change

Existing standards
CC-SPW-00400
• Installation specification
• Written mainly for new installations on new road schemes
• Recent revisions to comply with CPR

Does not fully cover:
• Maintenance/repair issues
• Ground condition testing
• Compliance with manufacturers installation manual
VRS - Need for Change

Main problems:

• Inadequate designs
• Poor installations
• Limitations in standards
• Evident a lack of understanding of proper design and installation of VRS within industry

How do we address these challenges?!
<table>
<thead>
<tr>
<th>Problem</th>
<th>Action</th>
<th>Status</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>VRS Design Course</td>
<td>Ongoing</td>
<td>2 Day VRS Design Course developed - 270 Candidates certified to date</td>
</tr>
<tr>
<td>Design</td>
<td>VRS in Constrained Locations</td>
<td>Complete</td>
<td>DN-REQ-03079 Retrofitting VRS on Single Carriageways issued as Interim Technical Advice for industry feedback</td>
</tr>
<tr>
<td>Design</td>
<td>Update to Standard</td>
<td>In progress</td>
<td>DN-REQ-03034 currently being updated for publication in Q3 (Safety barriers &amp; parapets)</td>
</tr>
<tr>
<td>Design</td>
<td>Terminal and Transitions</td>
<td>Complete</td>
<td>DN-REQ-03080 and 03081 outlining the assessment procedure for terminals and transitions issued, compliant lists being developed</td>
</tr>
<tr>
<td>Design</td>
<td>National VRS Consultant</td>
<td>In Progress</td>
<td>Assist LAs in designing, tendering and supervising annual repair /replacement programs</td>
</tr>
<tr>
<td>Construction</td>
<td>Update to Specification</td>
<td>In Progress</td>
<td>CC-SPW-00400 currently being updated for publication in September</td>
</tr>
<tr>
<td>Construction</td>
<td>Framework for Installers</td>
<td>In Progress</td>
<td>Tenders currently being reviewed – Strict conditions for qualification</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Guidance for Repair and Maintenance</td>
<td>In Progress</td>
<td>Currently being finalised for review, publication date to be confirmed</td>
</tr>
<tr>
<td>Other</td>
<td>Promote establishment of an industry led VRS association</td>
<td>Complete</td>
<td>IBA established, engaging with TII re standards update and training</td>
</tr>
</tbody>
</table>
VRS – Retrofitting VRS to the Single Carriageway National Road Network

Eoin Doyle (Arup)
VRS Retrofit – DN-REQ-03079

• DN-REQ-03079 issued as Interim Technical Advice in February 2017
• Applicable where site conditions and constraints are such that design compliance with DN-REQ-03034 Safety Barriers is not achievable
VRS Retrofit – Design Process

Does not provide specific design solutions for particular constraints

- Provides a risk based approach to designing at constrained locations
- Provides designers with a defined process to inform their design decisions
- Provides for a consultation and approval procedure with TII
- Includes examples of possible solutions with advantages, disadvantages and limitations of each to assist the designer in developing a solution
Categories of Constraints

• VRS at Constrained Locations;
  • Lack of set back/working width;
  • Installations within the clear zone;
  • Accesses preventing full length of need;
  • Third party considerations;
  • Road junctions i.e. VRS continuing down the side road.

• VRS at structures;

• VRS within urban settings.

Separate design process flowchart for each category
Overview of the Design Process

- Consult with TII to check if any improvement or refurbishment works are planned at the location
- Initial risk assessment to check if a VRS is actually required
- Assess if mitigation measures can be implemented to remove the need for a VRS
- Analyse the site specific constraints that may prohibit a compliant VRS design
- Develop suitable design options identifying the advantages and disadvantages of each.
- Identify the preferred option with appropriate reasoning, including consideration of whole life cycle costs, and
- Submit VRS PDR to TII for approval.
Category A – Constrained Locations

1. Consult with TII Network Management
2. Identify the hazard
   - Steep side slopes;
   - Water with a depth > 0.6m;
   - Fixed objects within clear zone;
   - Linear Hazards.
3. DN-REQ-0304 Chapter 8 Risk Assessment
   - Are there any minor improvement, road safety or maintenance schemes planned for the location?
   - Regrade the side slopes;
   - Remove the hazard from the clear zone;
   - Install passively safe road furniture;
   - Clearance of vegetation/trees;
   - Use of delineation markings;
   - Obtain additional lands.
4. Is a VRS still required post risk assessment?
   - Yes
     - Can mitigation measures be implemented? (If Yes, calculate life cycle costs of mitigation measures)
   - No
     - Consult with TII Network Management
       - Are there any minor improvement, road safety or maintenance schemes planned for the location?
       - Regrade the side slopes;
       - Remove the hazard from the clear zone;
       - Install passively safe road furniture;
       - Clearance of vegetation/trees;
       - Use of delineation markings;
       - Obtain additional lands.
5. Can the VRS be designed in accordance with DN-REQ-03034?
   - Yes
     - Consult DN-REQ-03034 for VRS design and specification
   - No
     - Identify the constraints preventing a compliant design
6. Prepare a preliminary design report
7. Submit the report through the TII departures website
8. Consider VRS removal (If a VRS is to be removed, submit a completed DN-REQ-03034 Risk Assessment Sheet to TII)

- Analysis:
  - Analyse the problem;
  - List all possible design options;
  - Include life cycle costing analysis;
  - Identify the preferred option with reasoning.
Constrained Location - Worked Example

- Steep drop to the adjacent land.
- Stone wall within the clear zone.

Consult with TII Network Management

Identify the hazard
Constrained Location - Worked Example

- Lack of set back and working width requirements.

**DN-REQ-03034 Chapter 8 Risk Assessment**

**Is a VRS still required post risk assessment?**
- Yes
- **Can mitigation measures be implemented? (If Yes, calculate life cycle costs of mitigation measures)**
  - No
  - **Can the VRS be designed in accordance with DN-REQ-03034?**
    - No
    - **Identify the constraints preventing a compliant design**

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8. Risk Assessment Procedure

8.1 To assess the need for a safety barrier on a scheme involving colour grading, a risk assessment procedure shall be undertaken in accordance with paragraphs 6.2 to 6.7. Before this, the designer's professional judgment is required to check alignment and variable obstacles.

Risk Assessment Procedure:

- Identify the constraints preventing a compliant design.
- Calculate life cycle costs of mitigation measures (if applicable).
- Design the VRS in accordance with DN-REQ-03034.
Constrained Location - Worked Example

- Analyse the problem;
- List all possible design options;
  - Install a high containment VRS;
  - Install concrete baseplates;
  - Install delineation;
  - Bespoke option.

Prepare a preliminary design report
Constrained Location - Worked Example

• Identify the preferred option:
  – Construct a dedicated pull in area;
  – Construct a reinforced masonry clad concrete wall;
  – Construct a high containment kerb;
  – Install edge delineation markers;
  – Renew road markings and install new signs.

• Reasoning:
  – Mitigation is not practical
  – It is an area of natural beauty which an aluminium VRS would detract from.

Submit the report through the TII departures website
Category B - Structures

- Exposed parapet ends are a hazard
- Parapets have no/unknown containment;
- No transition between the safety barrier and the parapet
Rail Bridge Crossing - Constraints

• No transition included;
• An unapproved connection detail.
Culvert Crossings - Constraints

• No end terminal, no working width, length of need not catered for, height above the carriageway too low.
Category B – Structures

Consult with the TII Regional Bridge Manager

Identify the hazard
- Is the structure included in a capital refurbishment programme?

• Exposed parapet ends
  • No transition between the safety barrier and the parapet

Can mitigation measures be implemented (If Yes, calculate life cycle costs of mitigation measures)

Can the VRS be designed in accordance with DN-STR-03011/ DN-REQ-03034?

No

Identify the constraints preventing a compliant design

Propose options in consultation with the TII Regional Bridge Manager

Prepare a preliminary design report

Submit the report through the TII departures website

Yes

Consult DN-STR-03011/ DN-REQ-03034 for VRS design and specification

Possible options
- Install barriers in front of parapet (check working width and setback);
- Full parapet reconstruction to include transition to safety barrier
  • Modify parapets to enable VRS connection (all proposed transitions need approval);
  • Crash Cushions;
  • Other innovative alternatives.

- Taper bridge parapets away from the carriageway;
- Increase the length of a culvert so that the parapets are outside the clear zone.

• Masonry parapet with unknown containment;
  • Pre IS EN 1317 parapet which may need to be replaced;
  • Cultural heritage issues which may prohibit modification or demolition of an existing parapet;
  • Access or junction adjacent to the structure.
  • Insufficient lands available to provide the required approach and departure lengths;

• Analyse the problem;
  • List all possible design options;
  • Include life cycle costing analysis for each option;
  • Identify the preferred option with reasoning.

• Exposed parapet ends
  • No transition between the safety barrier and the parapet
Category B – Structures

Consult with the TII Regional Bridge Manager

Identify the hazard

Can mitigation measures be implemented (If Yes, calculate life cycle costs of mitigation measures)

No

Identify the constraints preventing a compliant design

No

Can the VRS be designed in accordance with DN-STR-03011/ DN-REQ-03034?

Yes

Consult DN-STR-03011/ DN-REQ-03034 for VRS design and specification

No

Propose options in consultation with the TII Regional Bridge Manager

Prepare a preliminary design report

Submit the report through the TII departures website

Possible options

• Install barriers in front of parapet (check working width and setback);
• Full parapet reconstruction to include transition to safety barrier
• Modify parapets to enable VRS connection (all proposed transitions need approval);
• Crash Cushions;
• Other innovative alternatives.
Category C - VRS within urban settings

**VRS should not be provided in urban settings unless exceptional circumstances**

- Category C flowchart provides a risk based decision making process primarily for use when considering the removal of legacy VRS:
  - in urban settings or speed limit zones;
  - locations where the speed limit may have been reduced subsequent to the installation of the VRS;
  - locations where traffic calming may have been reduced subsequent to the installation of the VRS.
VRS within urban settings
Category C – Urban Settings

Identify the hazard

Consult with TII Network Management

Are traffic calming measures in place?

Have vehicle speeds been adequately reduced potentially allowing for VRS removal?

Are there any minor improvement, road safety or maintenance schemes planned for the location?

Can the VRS be designed in accordance with DN-REQ-03034?

Risk Assessment

Can mitigation measures be implemented (If Yes, calculate life cycle costs of mitigation measures)

Can the VRS be designed in accordance with DN-REQ-03034?

Are there third party considerations?

Can the VRS be designed in accordance with DN-REQ-03034?

Identify the constraints preventing a compliant design

Prepare a VRS preliminary design report

Submit the report through the TII departures website

Consider VRS removal (If a VRS is to be removed, submit a Risk Assessment to TII)

Consult DN-REQ-03034 for VRS design and specification

* Non-exhaustive list.

- Domestic/commercial/agricultural accesses;
- Street furniture;
- Cultural heritage;
- Headstones;
- Town/village name installations;
- Pedestrian/cyclist facilities.

- Playgrounds;
- Playing pitches;
- Schools;
- Monuments;
- ESB sub-stations;
- Bridge with pedestrians.

- Speed limit reduced to 50 or 60 km/h;
- Segregated turning lanes;
- Reduced carriageway width;
- Gateway set up;
- Hatched central reserve;
- Reduced Clear Zone width.

- Steep side slopes;
- Water with a depth > 0.6m;
- Fixed objects within the reduced clear zone;
- Linear Hazards.

- Headstones;
- Town/village name installations;
- Pedestrian/cyclist facilities.

- Playgrounds;
- Playing pitches;
- Schools;
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- Playgrounds;
- Playing pitches;
- Schools;
- Monuments;
- ESB sub-stations;
- Bridge with pedestrians.
VRS Preliminary Design Report

- Templates for VRS PDR for each category of constraint are provided as appendices including worked examples;
- Simple format with standard information in line with design process required;
- Life cycle cost analysis required (SAVERS);
- MS Word templates available [http://tiipublications.ie/downloads/](http://tiipublications.ie/downloads/)

**Worked Example 1 – Category A, VRS at a constrained location**

<table>
<thead>
<tr>
<th>VRS ID / Location: N56DL-01 (N56DL_100066_S1_B4)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong> A short section of existing untensioned corrugated VRS on timber posts with a ramped terminal upstream and full height fish tail terminal downstream.</td>
</tr>
<tr>
<td><strong>Length:</strong> 15m</td>
</tr>
</tbody>
</table>

**VRS Preliminary Design Report Summary**

**VRS at Constrained Location**

<table>
<thead>
<tr>
<th>Consultation</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Til Network Management</td>
<td>Following consultation with AN Other on 11/08/2016 it has been established that there are no minor improvement, road safety or maintenance schemes planned for this location.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Identify the Hazard(s)</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steep embankment slope and water of likely depth &gt;0.6m</td>
<td>Steep slope into deep water to the west.</td>
</tr>
<tr>
<td>Substantial fixed object extending above the VRS</td>
<td>A low stone wall approximately 600m in length but with no piers.</td>
</tr>
</tbody>
</table>
VRS – Terminal and Transition Assessment Procedures

Eoin Doyle (Arup)
New Standard established to allow an assessment to be undertaken of the suitability of end terminals proposed for use with safety barriers on Irish national roads so as to develop a “Compliant Terminals List”

Need for the Standard

- Safety barrier end terminals not currently CE marked products – no Harmonised European Standard.
- DRAFT prEN 1317-7 is being developed for the testing and approval of terminal systems.
- TII have implemented the testing requirements of prEN 1317-7 in DN-REQ-03034 Safety Barriers.
- Standard will allow equivalent procedure to CE Marking based on Draft EN Standard.
- Some key items not clearly defined within prEN 1317-7 and are open to interpretation – clarified within standard.
Assessment Procedure

- **Independent professional review** of the test documentation provided by the supplier.
- **Terminal Assessment Checklist** of documentation to be provided included as appendix.
- **Individual Terminal Test Assessment** form used as a standard template of review and as a checklist for the minimum requirements of each individual impact test.
- **Terminal Assessment Summary** form will be used to summarise findings of the independent review for each impact test.
- Systems assessed as having undergone appropriate testing shall be added to the **Compliant Terminal Systems list** on the TII Publications website.
Items Clarified within Standard

**Critical Impact Point**

**Test Approach 6 - prEN 1317:7 2014**

- The aim of this test is to evaluate the danger of pocketing where there is a sudden change in stiffness between the connecting barrier and the terminal.
- PrEN 1317-7 does not provide specific parameters in relation to choosing the CIP.
- 2m to 5m is provided as guidance within standard based on experience and prEN 1317:7 2012.
- If outside range requires computational simulations to verify point chosen is most critical point to assess potential pocketing.
Items Clarified within Standard

Connecting to safety barriers systems other than that which the terminal was originally tested with

- Required to notify TII - may or may not require further submission depending on characteristics of connecting barrier

Where connected directly to different barrier:

- the cross section and material of the proposed barrier compared to the barrier used for the ITT
- the difference in dynamic deflection between the barrier system used for the ITT and the proposed system; and
- an assessment of a simulated crash test using the proposed barrier if deemed necessary.

Where terminal is provided with the transition piece it was tested with:

- connection to adjacent barrier is subject to transition requirements of ENV 1317:4.
New Standard established to allow an assessment to be undertaken of the suitability of transitions between VRS of different performance or cross section proposed for use on Irish national roads so as to develop a “Compliant Transitions List”

Need for the Standard

• Transitions not currently CE marked products – no Harmonised European Standard.

• Standard will allow equivalent procedure to CE Marking based on Draft EN Standard through an independent assessment of test results.

• Some key items in relation to the testing of transitions are clarified within standard.
Assessments

- Full Scale Physical Impact Tests
- Simulated Crash Tests
Assessment Procedure

• Individual Transition Physical Test Assessment Form used to assess each individual physical impact test.

• The virtual tests will be assessed and a Virtual Test Assessment Report will be prepared to summarise the findings of the assessment.

• Transitions deemed suitable following assessment under this Standard will be added to a Compliant Transitions list on the TII Publications website.
Items Clarified within Standard

- The point shall be taken as the point of intersection of a straight line parallel to the vehicle centreline, at the maximum width of the vehicle.

- Light Vehicle Test (TB11) to evaluate the impact severity of the transition.

- Containment Test (TB32 or higher) to evaluate the containment level of the transition and to identify any potential for pocketing.
Questions & Answers

Thank you