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Road restraint systems — Guidelines for computational mechanics of crash testing against vehicle restraint system

Part 3: Test Item Modelling and Verification

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National foreword

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A list of organizations represented on this committee can be obtained on request to its secretary.

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Road restraint systems - Guidelines for computational mechanics of crash testing against vehicle restraint system - Part 3: Test Item Modelling and Verification

Dispositifs de retenue routiers - Recommandations pour la simulation numérique d'essai de choc sur des dispositifs de retenue des véhicules - Partie 3: Composition et vérification des modèles numériques de dispositifs d'essai

Rückhaltesysteme an Straßen - Richtlinien für Computersimulationen von Anprallprüfungen an Fahrzeug-Rückhaltesysteme - Teil 3: Modellierung des Prüfgegenstands und Überprüfung

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Contents

Foreword

This document (CEN/TR 16303-3:2012) has been prepared by Technical Committee CEN/TC 226 “Road equipment”, the secretariat of which is held by AFNOR.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document consists of this document divided in five Parts under the general title: Guidelines for Computational Mechanics of Crash Testing against Vehicle Restraint System:

— *Part 1: Common reference information and reporting*

— *Part 2: Vehicle Modelling and Verification*

— *Part 3: Test Item Modelling and Verification*

— *Part 4:Validation Procedures*

— Part 5: *Analyst Qualification*[1]

1 In preparation

Introduction

This part of this Technical Report is meant to provide the user with all the information necessary for the development of a complete and efficient numerical model of a test item vehicle in order to properly simulate a crash event.

The vehicle restraint system (VRS) models represent the test item in a certification test according EN 1317. The model shall faithfully depict the performance of a VRS so that the performance criteria identified in EN 1317 can be extracted from the simulation of a vehicle impact with the VRS model. The VRS simulation can only be assessed in combination with a validated vehicle model described in CEN/TR 16303-2.

There are different types of VRS and they can incorporate concrete, metal, plastic, and composite materials in their construction. Each system has different modelling requirements and the following manual describes the guidelines applicable for all VRS. It is important to recognize that the requirements for modelling a deformable VRS are significantly different from a rigid systems and the latter are not covered in this version of the guidelines.

This document currently focuses on Finite Element simulation methodologies. Rigid body (or multi-body) dynamic codes are also used in the development of a VRS. The VRS model requirements are not the same as for the Finite Element approach and shall be consistent to the methodology. The CM/E group does not yet have guidelines for the use of rigid body codes and their application for certification requirement cannot be recommended until they are similarly defined.

1 Scope

The aim of this Technical Report is to provide a step-by-step description of the development process of a reliable VRS model for the simulations of full-scale crash tests.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1317-1, *Road restraint systems — Part 1: Terminology and general criteria for test methods*

EN 1317-2, *Road restraint systems — Part 2: Performance classes, impact test acceptance criteria and test methods for safety barriers including vehicle parapets*

EN 1317-3, *Road restraint systems — Part 3: Performance classes, impact test acceptance criteria and test methods for crash cushions*

ENV 1317-4, *Road restraint systems — Part 4: Performance classes, impact test acceptance criteria and test methods for terminals and transitions of safety barriers*

EN 1317-5, *Road restraint systems — Part 5: Product requirements and evaluation of conformity for vehicle restraint systems*

prCEN/TR 1317-6, *Road restraint systems — Part 6: Pedestrian restraint system, pedestrian Parapets* (under preparation)

prEN 1317-8, *Road restraint systems — Part 8: Motorcycle road restraint systems which reduce the impact severity of motorcyclist collisions with safety barriers*

CEN/TR 16303-2:2011, *Road restraint systems — Guidelines for computational mechanics of crash testing against vehicle restraint system — Part 2: Vehicle Modelling and Verification*

CEN/TR 16303-4:2011, *Road restraint systems — Guidelines for computational mechanics of crash testing against vehicle restraint system — Part 4: Validation Procedures*

3 General considerations on the modelling technique

3.1 General

Particular attention shall be paid on the geometrical description of the contact areas of the VRS model. Proper geometry and material properties shall be used. The fixation of the VRS to the roadbed shall correspond to the test conditions reflected by the standard and the application of the VRS. Modelling of any soil, asphalt, concrete, etc. element should be documented. Simplifications as well as rigid soil conditions shall be justified through empirical or engineering analyses independent of the computer model.

The model shall include all significant parts, the connections between the parts, and appropriate boundary conditions.

3.2 Finite Element and Multi-body approaches

3.2.1 General

Two main modelling approaches can be considered, using two different analysis tools: the Finite Element Method (FEM) and the Multi-Body (MB) approach. Both methods are widely known and broadly used in many fields of engineering, including the Automotive Industry.

The first method allows the user to build a very detailed vehicle model and to assess global results such as the barrier or vehicle performance in a crash test as well as the stress data in a local area of the vehicle. As a counterpart, a FEM analysis requires significant computational costs, thus proving less valid for parametric studies where a large number of simulations may be required.

Once the VRS model has been built, it shall be validated with simple tests, such as component tests and then full-scale dynamic tests. Validation procedures are listed in a separate document (CEN/TR 16303-4). These validation tests ensure the global response of the model is appropriate and any simplifications of the model still reproduce the functionality of the system. Numerical stability of the model can be assessed during the validation process. Subsequently, the model can be used to simulate full-scale crash tests within the application areas accepted in EN 1317.

Furthermore Computation mechanics when validated can provide support in real life situations that are not described within EN 1317.

3.2.2 Finite Element guidelines

Crash tests finite element (FE) simulations are usually run with a dynamic, non-linear and explicit finite element code. Computer runtime is usually significant, with the order of 30-40 hours on a 2,4 GHz personal computer for the simulation of a full-scale crash test with an effective simulated time of 0,25 second. In fact, the model shall include not only the vehicle model, but also several meters of roadside barriers (depending on the barrier type, up to 80 meters of barrier) to faithfully reproduce the interaction between the vehicle and the barrier and the boundary conditions. The integration time step is controlled by the minimum dimension of the smallest element of the FE mesh, therefore, the mesh size shall be a trade-off between the need for geometrical and numerical accuracy and computational cost: large elements guarantee a high time step but poor accuracy of the model and possible instabilities, while small elements give a better accuracy but a smaller time step. General criteria for Finite Element modelling techniques are identified in Annex A. The most significant parts of the VRS shall be modelled explicitly with a detailed mesh. Simplifications of certain structures (bolts, slots, etc.) are acceptable if the appropriate functionality is incorporated. For example, bolted connections can be replaced by beam elements if the appropriate failure characteristics of the beam elements are incorporated.

3.2.3 Multi-body guidelines

The MB approach consists in modelling the VRS with a number of rigid bodies connected by means of joints with specified stiffness characteristics. When reliable and validated data are available, the MB approach is very useful to perform parametric studies or big test scenario, since the computational cost of the analysis can be dramatically less than that of the corresponding FEM analysis.

4 VRS model

4.1 Component to be modelled

The majority of elements in a road restraint system lend themselves to direct geometric digitisation in a FE or MB model. These elements are (but not limited to):

1) posts;

2) horizontal elements;

   a. metal beams;

b. cables;

3) block-out beams / spacers;

4) bolted connections;

5) concrete elements;

6) soil.

General mesh specifications for FE method are listed in Annex A. These specifications are based on the date of publication (March 2006) level of simulation activities in research and product development. As general practice, the mesh size and arrangements shall permit the observed (or expected) deformed shape of the parts. Once a mesh specification has been determined, it becomes a practical issue to determine to which extent this mesh shall be applied to the entire test object. The level of detail required in the deformed parts may not need to be applied to all structures that are not subject to local buckling phenomena or other high stress gradients.

Recommendations for the development of Multi-Body VRS models, addressed to crash simulations method, are listed in Annex B.

4.2 Coordinate system

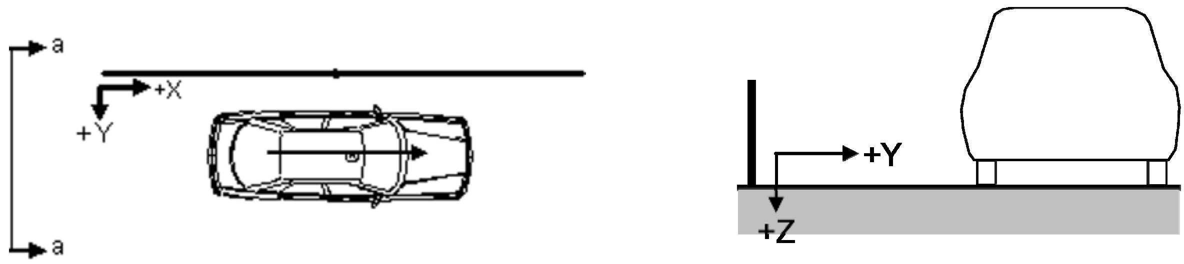
The model of the test article should be defined with a consistent coordinate system. The origin of the coordinate system may differ for the analyst's or system modelling requirements, but the orientation of the axis should follow the following principles:

X axis oriented along the traffic face of the system for redirective features. Symmetrical structures (crash cushions) may use the axis of symmetry. The positive direction is in the direction of traffic flow.

Y axis oriented normal to the X axis, parallel to the plane of the road with the positive direction oriented towards the traffic face of the structure.

Z axis oriented normal to the X-Y plane with the positive direction such that the X-Y-Z triad follows the right hand rule.

An example of the coordinate system for a safety barrier is shown in Figure 1. Note that that the origin of the coordinate system is moved away from the VRS for clarity.



a) Plan View **b) View a-a**

Figure 1 — Vehicle Restraint System Coordinate Systems

The preferred units for the models are millimetres, newton, tons and seconds. These units guarantee consistency of results and are consistent with the vehicle modelling guidelines in CEN/TR 16303-2.

Nodal coordinates should be defined in the test article's reference frame.

In case of FE models the fibre direction for all the shell elements should be coherent (same orientation, except in case of contact definition regions).

4.3 Material models

4.3.1 General

The types of materials used in the test article will define the type of material model definitions used in the simulation models. The material properties should reflect the properties of the actual part after manufacture. Thus representative specimen tests should be used as much as possible to represent the current state of the material properties.

4.3.2 Material modelling for dynamic finite elements simulations

The most common materials for test articles are steel and these materials lend themselves to commonly used material models. For example in LS-DYNA:

— **MAT_ELASTIC,*

— **MAT_PIECEWISE_LINEAR_PLASTICITY*,

— **MAT_PLASTIC_KINEMATIC*

Each material model has its own input requirements that should be obtained from laboratory tests of coupons or similar specimens from representative sections of the test article.

Non-metallic materials that may be required to model a test item include concrete, plastic, wood, and soils. Material models are usually available in commercial programs. For example in LS-Dyna many non-metallic material models are provided with default parameters. It is strongly recommended that relevant laboratory tests of these materials are used to define input values.

Documentation for soil models is available [Lewis]. Selection of soil modelling parameters should represent actual crash test conditions used for model validation. There may be occasions where the soil parameters should be selected in order to represent a critical design condition.

4.3.3 Material modelling for dynamic Multi-Body simulations

In MB technique elastic-plastic material properties are assigned to spring and damper elements at the hinges between rigid body elements instead of material models. Spring and damper elements shall consider nonlinearities such as plasticity, viscosity and load history as appropriate

5 Verification of the model

5.1 General

It is crucial that any simulation models used as part of a standardisation process are reproducible and repeatable. This requires that the model is numerically stable, i.e. it is not susceptible to divergent solutions and can complete the simulation run to the specified termination time. These conditions are a necessity for any analysis and are not special requirements for the CEN standards.

5.2 Basic Requirements

The computer files comprising the test article shall be arranged in such a manner that a 3rd party review is possible. This means than no encryption of data elements will be permitted in simulation models submitted for standardisation purposes.

The files and any computer scripts required to start the simulation shall be available for review by the Notified Body when required. If necessary, the simulation shall be run and witnessed by a Notified Body.

Simulations shall not require restarts or parameter adjustments during the simulation process. Any input files to be qualified as reference information for the standardisation process shall result in stable simulation runs (no divergent solutions, termination errors, etc.). Any warning errors issued during the simulation shall be submitted with the simulation results for review.

For FE simulations limits for changes in the system mass (due to mass-scaling), hourglass energy, and total system energy are defined in CEN/TR 16303-4.

5.3 Model Verification and Proof of Performance

5.3.1 General

The numerical representations of the test articles shall demonstrate their capability to reproduce the crash performance in the EN 1317 test procedures. This shall be demonstrated through the reproduction of a documented crash test as well as other conditions listed in the following sections.

5.3.2 Finite Element Model

The function of critical components in the test item shall be demonstrated. All failed and strongly deformed components shall be reproduced using simulation and validated by component full-scale test. For example:

— Embedded posts: A quasi-static simulation of a single post shall be conducted for comparison with representative tests from the test facility. Post deflection and deformation behaviour shall correspond to the test results.

— Bolted connections: A quasi-static simulation of a single bolted post connection shall be conducted for comparison with a representative test. Bolt and bracket deformation and fracture modes should correspond between the simulation and test results.

The function of non-critical components: Suitable engineering analysis can be used to demonstrate model performance, particularly where the component is not a weak point in the structure.

5.3.3 Multi-Body Model

Depending on the used MB code, for the interconnection structure with several closed chains additional kinematical equations have to be provided to solve the general coordinates for the holonomic and nonholonomic constraints. There exist some different numerical techniques which support the build-up of the loop closure equations, see i.e. Hiller or Kecskeméthy.

The multi body model has to be validated with equal requirements and limits as the finite element model.

5.4 Full-scale dynamic testing and Simulated Crash Testing

The simulation model should be able to duplicate the crash performance required in EN 1317. These test protocols identify vehicle and test article performance parameters that shall be exported from the simulation model. The validation procedures for these test conditions are specified in CEN/TR 16303-4.

The test object models shall demonstrate the proper representation of the mechanical structures of interest. This shall be demonstrated by a report of the stress/strain behaviour in case of FE technique or of the load/deformation behaviour in case of MB technique for all deformable components. This information shall be compared to the material properties to verify that unrealistic loads are not transferred within or between parts. Examples of unacceptable model behaviour are bolts without failure criteria, metal structures experiencing stress beyond the ultimate limit, etc.

The test article components will be monitored during the validation procedure and final Type Test Simulations and any material stress / strain or load/deformation values that exceed accepted failure conditions shall be reported. Only stress / strain or load/deformation data for the test item need be reported. Components with excessive stress / strain or load/deformation data that can be justified (not part of critical components, deformations after period of interest, etc.) shall be documented so that 3rd party reviewers can determine if this behaviour is acceptable for the model behaviour.

5.5 Failure mode reproduction capability

We define failure mode the sequence of the failure of single components of the VRS, as specified in the document PIRT (phenomena importance ranking table; Annex C), which leads to its final deformed configuration. In this context, the term “failure” is applied to an event that alters the cinematic of the component (e.g. rail yielding) without necessarily leading to the physical rupture of the component itself.

The test object (VRS) should reproduce all the failure modes that are possible in the device according to sound engineering judgement. Modifications should be made on the device model in order to take into account new failure modes observed in testing or otherwise encountered during the study.

6 Collection Data

The test article is primarily assessed by the deflection of the system during the impact test. Computer simulation allows for the collection of deformation data to be directly recorded during the simulation. Dynamic deflection output shall be given in a coordinate system consistent with the EN 1317 report. A series of reference points should be capable of capturing the maximum system deflection.

Simulations provide the capability to record data not reported in physical testing. Additional information for the test article should be provided so that the test item and the computer model performance can be evaluated. For simulations supporting the certification of modified products, the additional information that should be reported is listed in Table 1.

Table 1 – Additional information

Test Item	**Additional documentation**
Safety Barriers (length of need)	Tension in rail elements, anchorage forces
Transitions	Forces in transition elements, connections between transition and safety barrier elements.

Annex A

Recommendations for the mesh of Finite Element VRS models addressed to crash simulations

A.1 Material recommendations for Finite Element VRS models addressed to crash simulations

See CEN/TR 16303-2, A.3.

A.2 General recommendations for the mesh of Finite Element VRS models addressed to crash simulations

NOTE This Annex contains recommendation that can be used to develop a FE model to be used during impact analysis against.

A.2.1 2D-Mesh Specifications

A.2.1.1 General recommendations

See CEN/TR 16303-2, A.4.1.1.

A.2.1.2 Criteria for the definition of geometric details

See CEN/TR 16303-2, A.4.1.2.

A.2.1.3 Mesh features

Metal sheets shall be meshed with four-node shell (plate) elements (capable of reproducing membranal and flexural stiffness) with linear formulation.

Three-node elements can be used for mesh consistency. Three-sided elements should not be more than 5 % of the total number of elements in the model and more than 10 % in a single metal sheet.

The following mesh information is based on the current practice in research and industry development activities.

Mesh size	Refined structures are typically meshed with elements with side lengths between 5 mm and 30 mm. Parts requiring less detailed mesh geometry (objects distant from the contact zone) may be modelled with elements with side lengths 30-100 mm.
Mesh Uniformity	Mesh should be as uniform and homogeneous as possible. The ratio between the dimensions of two adjacent elements should be less than 1,5 for boxes and 2 for panels.
Minimum number of elements	For spotwelded components, element dimensions should not be greater than the welding pitch For boxes and boxed beams: define at least 5 elements along each dimension. Flanges with lateral dimensions greater than the minimum element dimension should be modelled with at least 3 elements
Aspect Ratio	Preferred ratio < 2 ; Maximum allowed < 4
Warping	Preferred limit < 10 deg, maximum allowed < 20 deg.

A.2.1.4 Welding and connections

A.2.1.4.1 Spot-welding

Spot-weld should be modelled with rigid links. The nodes to be connected should be facing each others as much as possible. The projection of the midpoint of two connected nodes should not draw more than 7 mm away from the measured theoretical position. The maximum distance between two nodes connecting two adjacent sheets should not be greater than 10 mm; in particular it should not be greater than 7 mm in the 80 % of occurrences.

A.2.1.4.2 Seam welding

The seam welding should be modelled by rigidly connecting the nodes in the weld. Appropriate failure criteria should be identified.

A.2.1.4.3 Bonded joints

In case of structural adhesive materials or glues, the junction should be modelled with solid elements. It is admissible the use of 1-dof spring elements between coincident nodes. Adequate documentation should be provided for the computation of spring characteristics.

If the bonding has no structural function, it can be neglected.

A.2.1.4.4 Bolted joints

Bolted joints are extremely complex. Characteristics that should be considered include friction, joint slippage, bolt tension, bolt bending, bolt shear, contact definitions, material failure criteria, pre-clamping tension of bolts, and bolt pull through are some of the many factors need to taken in consideration. These are not all necessarily required for all joints, but each connection needs to be reviewed and modelled appropriately.

A.2.2 3D-Mesh specifications – Mesh features

In general solid elements are more computationally costly and are not appropriate for sheet metal structures. When cast, machined, or forged metal parts are included in the test article, solid elements are the most appropriate element type. Specialized materials like honeycomb and plastic foams may also require solid elements to represent their geometry.

The mesh size and quality currently employed for 2-D elements are also generally used for solid elements. Note that there were fewer applications of solid elements reported by the organisations reviewed.

Mesh size	Refined structures are typically meshed with elements with side lengths between 5 mm and 30 mm. Parts requiring less detailed mesh geometry (objects distant from the contact zone) may be modelled with elements with side lengths up to 100 mm.
Mesh Uniformity	Mesh should be as uniform and homogeneous as possible. The ratio between the dimensions of two adjacent elements should be less than 1,5 for boxes and 2 for panels.

Annex B

Recommendations for development of Multi-Body VRS models addressed to crash simulations

B.1 Test item requirements

The MB model for the posts and the beams can be defined as rigid bodies or, if the program code allows for flexible multi-body modelling, as finite element bodies, but this kind of structure modelling will need time consuming computer runtime. For flexible multi-body modelling refer to Appendix A for Details of mesh definitions.

In case of rigid body models, a deformable beam can be defined by a jointed-beam-element [Rauh]. This element is defined by four rigid bodies, two cardan joints and a torsional-shear joint. To represent the stiffness, the bodies are connected by additional springs. The spring constants can be derived by means of a comparison with the known elastostatic properties of the beam for the elementary strain cases. To cover also the plasticity and viscoelasticity, the theory of elastic plastic hinges can be applied to the jointed connections by means of spring and damper elements, where the springs are defined by nonlinear spring constants.

B.2 Welding and connections

Any type of connection/fastener, i.e. single bolt, bolt group or decisive weld (if any), is represented by a group of combined spring and viscous damper elements (Kelvin-Voigt parallel arrangement recommended) in total either of:

— 6 (3 x 2 in pair) translational springs and viscous damper elements, or

— 3 rotational springs and viscous damper elements.

With this approach, resistances for all kinematical degrees of freedom are fully described. If possible, of course a reduced set of spring and damper elements can be used.

Each spring element is provided with a characteristic line including multi-linear plastic and hysteretic properties and taking account of the relevant resistance (shear or axial load). Damper coefficients for linear viscous damping should been calibrated according to representative full-scale tests with respect to appropriate strain rates.

Concrete or other material parts or elements can be modelled similar as for steel elements.

B.3 Model validations

Depending on the used MB code, for the interconnection structure with several closed chains additional kinematical equations have to be provided to solve the general coordinates for the holonomic and nonholonomic constraints. There exist some different numerical techniques which support the build-up of the loop closure equations, see i.e. Hiller or Kecskeméthy.

The multi body model has to be validated with equal requirements and limits as the finite element model.

Annex C

Phenomena importance ranking table for test Items

It is assumed that a test item (barrier, parapet, end terminal etc.) will consist of several discrete items (posts, rails etc.) assembled with fixing systems. To comply with the standard, a system model of the test item shall necessarily include discrete and qualified representations of each discrete item.

— All components of the test article shall be modeled.

— Failure modes shall be include and demonstrated in the model.

— If failure modes are not explicitly described “sensors” shall be used to verify that these elements are far from failure.

— According to the energy to be transferred and to the design philosophy critical components shall be identified.

— Failure description can be reported using already existing experience.

— The function of non-critical components: Suitable engineering analysis can be used to demonstrate model performance, particularly where the component is not a weak point in the structure

— Influence of loading speed shall be considered.

— All failed and strongly deformed components shall be reproduced.

Component tests validation is suggested and is critical for the components influenced by the modification of the ITT. Examples of component tests and measure comparison are reported in the annex.

Deformable Components					
	Characteristic to be described	*notes*	*Relevant Test*	*type of result expected*	*Import. (0-10)*
Steel structures					
Post Guardrail Bracket …	Geometry / Mass Precision	Need to be as accurate as possible. To guarantee the correct dynamic behaviour	---	---	9
	Mesh	Dimension: in accordance with the vehicle used, limited to the impact area	---	---	8
		Define mesh around bolt holes	Bearing	Correct Behaviour Evaluate force limit	7
		overlapping	If a thicker part is defined a previous test has be done with the two surface defined (tension test)	General behaviour force / deflection	6
	Multibody elements	Deformable elements shall describe the real behaviour of the components	Bending, Torsion, Axial loading	General behaviour force / deflection (component tests)	9
	Friction	Between components	??	Identify the correct value	7
	Elasto-plastic behaviour	Correct dynamic behaviour on all axis in bending and twisting	Bending and torsion tests (POST BEAM GUARDRAIL) Load / deflection test to evaluate the correct material behaviour (BRACKET or other)	force / deflection Stress / strain Curves (component tests)	9
	Failure	Identify the component in which define it.	Subgroup test Impact test until failure	Identify the range (values: stress or stain limit) within be safe	6-9
		Where not included: post impact control	After simulation	Value for these components has to be within the range	6-9
	Post	Strong and weak axis bending. Twisting.	Post bending and torsion testing	Yielding of post – force deflection curves	9
	Beam	Strong and weak axis bending. Twisting.	Beam bending and torsion testing	Yielding of beam – force deflection curves	6 – fence 9 – parapet
	Connections	Tension, bending and shear	Tension, bending and shear	Force deflection curves	5
Boundary cond. constrains	End elements Anchoring	Reproduce the real anchoring (or the same behaviour) If the real anchoring is not reproduced a system that permit the same deformation has to be modelled	Pull out test Full scale test	Evaluate strain /stain curve	6-10 avoid fix ends
	Constrains	If rigid	Full scale test	In accordance with full scale test has to be rigid	6
	connections	Tension bending shear Pre tension (overlapping areas)	Tension Bending and torsion tests	force / deflection Stress / strain Curves Failure for shear stress	7

Concrete						
Concrete element …	Geometry / Mass Precision		Need to be as accurate as possible. To guarantee the correct dynamic behaviour	-	-	7
	Mesh dimension		Dimension: in accordance with the vehicle used, limited to the impact area			
	Friction		Between components	??	Identify the correct value	7
	Mat.	concrete	Material behaviour	3 axial test	force / deflection Stress / strain Compression / deflect.	9
		reinforcement	Define it?	??	Identify the importance in respect of the crash test	2-7
	Failure		Different materials can be used: identify the correct in respect of the crash test	3 axial test (with different material models)	force / deflection Stress / strain Compression / deflect.	8
Boundary cond. constrains	End elements Anchoring		Reproduce the real anchoring (or the same behaviour) If the real anchoring is not reproduced a system that permit the same deformation has to be modelled	Full scale test	Final decision can be taken on the base of the full scale test	6
	links between elements		Subgroup test	Tension Bending and torsion tests	Reproduce the right behaviour	8

Underlying structures					
Soil	Spring model Fluid model Discrete model	Characteristic and behaviour	Experimental test	Stress distribution inside the soil	7
Structural frame	Concrete	(see other table)	---	---	---
	other	All anchoring point has to be defined			

Rigid Components					
	Characteristic to be described	*notes*	*Relevant Test*	*type of result expected*	*Import. (0-10)*
Element					
Not deformable structure	Geometry / Mass Precision	Need to be as accurate as possible. To guarantee the correct dynamic behaviour	-	-	6
	Mesh dimension	In accordance with the location			7
	Friction	In accordance with the location			
	Dynamic properties	Well described	Evaluation of the proprieties		10

Tweak		
	Type of change	*notes*
Element		
Shape Bolt …	Little modification	At least same standards can be applied but higher are suggested
	Change ends	

Tweak examples, change:

— bolt conserving the same bolthole: the bolt has to be completely meshed,

— material: describe the new material with a correct description of the constitutive law including the failure.

Bibliography

[1] CEN/TR 16303-1, *Road restraint systems — Guidelines for computational mechanics of crash testing against vehicle restraint system – Part 1: Common reference information and reporting*

[2] prEN 1317-4, *Road restraint systems — Part 4: Performance classes, impact test acceptance criteria and test methods for transitions of safety barriers* (under preparation)

[3] prEN 1317-7, *Road restraint systems — Part 7: Performance classes, impact test acceptance criteria and test methods for terminals of safety barriers* (under preparation)

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389 Chiswick High Road London W4 4AL UK

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