

The European Standard on Anti-Seismic Devices

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2017 NZSEE
Conference

ABSTRACT: The European Committee for Standardization (CEN) officially created the Technical Committee CEN-TC 340: *Anti-seismic Devices* in 1993. The scope of this TC was to proceed with the standardization of devices for use in structures erected in seismic areas and designed in accordance with EUROCODE 8: *Design of Structures for Earthquake Resistance*, with the aim of modifying their response to the seismic action. This European Standard, named EN 15129, specifies functional requirements and general design rules thereof, material characteristics, manufacturing and testing requirements, as well as acceptance, installation and maintenance criteria of all the types of seismic devices. The final version of the European Standard on Anti-seismic Devices was completed in November 2007, when the comments received during the Public Enquiry were examined by the TC 340 for possible implementation. This Standard represents the most complete and up-to-date document in this field presently available to Seismic Design Engineers and Seismic Hardware Manufacturers. In effect, the Standard aims to cover all types of Seismic Hardware in existence in Europe and leaves a door open to future progress. This principally derives from the fact that the Standard is highly performance-oriented and this feature also constitutes *per se* a guarantee of equity between the various systems that may be used as alternatives. The scope of the paper is that of illustrating the structure of EN 15129, the criteria adopted in its drafting, the procedures followed for its approval, and some of the aspects which render this document unique and innovative.

1. INTRODUCTION

An increasing number of congresses and symposia as well as other professional meetings give testimony to the significant strides made by seismic engineering during the last quarter century. Progress, has mainly been the result of newly developed design strategies taking hold (*e.g.*, base isolation) and the awareness that energy dissipation can be a useful tool in the hands of the design engineer to control the response of structures struck by an earthquake.

In other words, earthquakes are being increasingly perceived as phenomena involving the transmission of mechanical energy instead of being interpreted only in terms of resulting forces.

Notwithstanding, the newly conceived design strategies could not have found useful application without a parallel development of the hardware needed for their implementation. Thus, many research laboratories and certain pioneering industries have decided to invest important resources in this field, inventing and improving a series of devices that exploit well known physical phenomena for the seismic protection of structures.

As it is often the case when technological growth in a given field reaches important levels of development as well as a reasonable degree of maturity, a need spontaneously arises to establish ground rules that define principles of general validity. Said rules ultimately come to nest in documents of increasing importance like *recommendations*, *guidelines* and *standards*.

Within the spirit of the above, in March, 1992, the Italian Standardization Institute (UNI) forwarded to the European Committee on Standardization (CEN) a formal request calling for the creation of a Technical Committee charged with drafting a norm to cover anti-seismic hardware.

Within the framework of existing procedures, CEN launched an inquiry amongst the member nations with a July, 1992 deadline. Fourteen of them responded to the inquiry with 11 votes in favour and 3 against. In September 1992. The Bureau Technique Secteur 1 (BTS1) as the competent body in construction within CEN, responded favourably to the UNI request upon examination of the inquiry results.

After having paid due bureaucratic tribute, the first meeting of the officially nominated Technical Committee finally convened in Vienna in October, 1993. This occasion saw the creation of a work program with fixed target dates, the election of a Chairman (this author) and the installation of four Working Groups, each with an appointed "Convener".

2. GENERAL CRITERIA

A Standard, given its nature, is in principle a document that limits user's freedom (*i.e.*, manufacturers, design engineers, etc.). However, in order to be a *good* Standard, it cannot impair technological progress within its area of applicability by favouring what is in existence over what might be developed in the future.

So as to avoid such an eventuality, CEN established few rules. The three most important of these rules are:

- a) Requirements should be expressed in terms of *performance* as much as possible;
- b) Only those characteristics which can be verified by a given method shall be included in the Standard; and
- c) The Standard must represent an objective state-of-the-art and thus must not exclude any systems whose validity has been proven through successful applications.

Point (a) above regards a long held controversy as to whether it might be possible to draft a Standard that can be purely performance oriented. Unfortunately, the answer has to be negative. Nonetheless, it is always possible to find an equitable compromise between "*product oriented*" and "*performance oriented*" requirements that can result in full observance of criteria (b) and (c).

The application of the above cited criteria favours progress inasmuch as it promotes loyal competition through clear and fair rules that protect the interest of the community.

A final observation about general criteria regards the fact that the *European Standard on Anti-seismic Devices* should be harmonized with the *Eurocodes*; particularly in what respects *EC8 – Design of Structures for Earthquake Resistance*, whose logical implementation it represents.

Unfortunately, coordination between the activities of the Technical Committees did not meet with the success that was expected inasmuch as up to now there exists some "overstepping of borders" amongst the respective areas of responsibility and competence – which one hopes

3. STRUCTURE OF THE STANDARD

Before defining the structure of the Standard, in the same manner as other scientific fields (*e.g.*, Biology) there was an attempt to create a "*systematics*" of present seismic hardware, that is to say, to group existing devices on the basis of the functions they perform or the common principles governing their functioning. Thus, the starting point was the creation of divisions of a general character and then moving toward increasingly detailed subdivisions.

After several reconsiderations and changes of mind, the existing seismic hardware has been subdivided into the following four groups according to the functions they perform:

- Rigid Connection Devices
- Displacement Dependent Devices
- Velocity Dependent Devices
- Isolators

Each group has been further sub-divided. For instance, Rigid Connection Devices have been sub-divided into:

- Permanent Connection Devices
- Fuse (Sacrificial) Restraints
- Temporary (Dynamic) Connection Devices

Similarly, Displacement Dependent Devices have been sub-divided into:

- Linear devices
- Non-linear devices

The Seismic Isolators have been subdivided as shown in Figure 1 here below

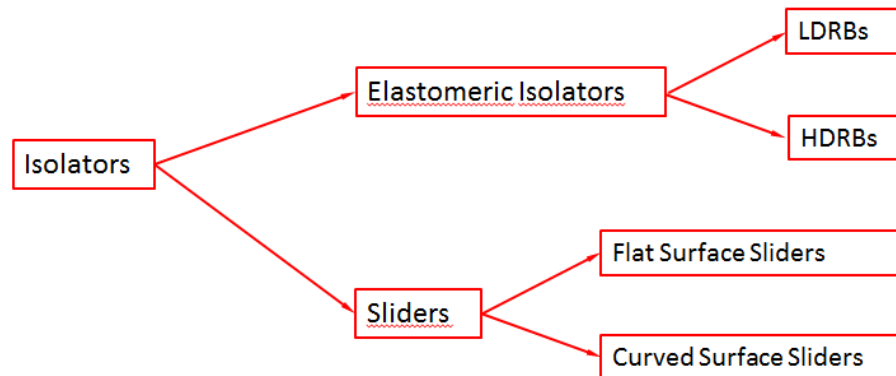


Figure 1: Subdivision of Seismic Isolators

The subdivisions within the other groups have followed the same fashion.

The structure of the *European Standard on Anti-seismic Devices* has been modified several times. Besides the sections dedicated to the four groups of devices, in its definitive version it includes also the following:

- Scope
- Normative references
- Terms and definitions, symbols and abbreviations
- General Design Rules
- Combination of Devices
- Evaluation of conformity
- Installation
- In-service inspection

Informative Annexes accompany the various Sections of the Standard, in order to give useful comments and explanations to the reader.

Much attention has been focused on the definition of the various types of devices. In effect, the CEN rules require that "*the definitions shall be unambiguous and as concise as possible*". As an example, let's examine the case of "Scope".

This is a required clause at the beginning of every CEN Standard to define its subject as well as the aspects in unambiguously and thereby indicate the limits of its applicability. In our case, this clause is as follows:

"This European standard covers the design of devices that are provided in structures with the aim of modifying their response to the seismic action.

It specifies functional requirements and general design rules in the seismic situation, material characteristics, manufacturing and testing requirements, as well as acceptance, installation and maintenance criteria" ..

Some comments on the more important clauses.

3.1 General Design Rules

This Clause specifies the fundamental requirements, such as “*No failure requirement*”, “*Damage limitation requirement*”, as well as gives important prescriptions on other important matters, such as “*Reliability differentiation*”, “*Increased reliability*” etc.

It is of interest to also cite an innovative criterion adopted to evaluate the re-centering (restoring) capability of an isolation system and the same is based on energy concepts. In the case of an equivalent linear analysis, to ensure adequate re-centering capability of a seismically isolated structure, it shall be verified that, for a deformation from 0 to d_{\max} :

$$E_s \geq 0,25 E_h$$

where:

- E_s is the reversibly stored energy (elastic strain energy and potential energy) of the isolation system, including those elements of the structure influencing its response;
- E_h is the energy dissipated by the isolation devices.

The above is a general validity criterion (i.e.: one applicable to any type of device) that also incorporates praiseworthy simplicity (it just involves the comparison of two calculable and measurable physical magnitudes). The suggested verification requirement can be easily translated in formulae or design rules for each type of isolator or isolation system.

Finally, section “General Design Rules” gives requirements for Type-testing and Production control testing. It should be noted that, in addition to the above, individual sections also contain clauses governing the testing of various types of devices (i.e., test methods, equipment and procedures) as well as evaluation criteria geared to the specific type of device

3.2 The Anti-seismic Devices

It's not worth the trouble to dwell upon the sections dedicated to individual types of devices. Notwithstanding, it is important to keep in mind the fact that the Norm takes into consideration all the types presently in existence within the European market – even those developed outside Europe (e.g. Lead rubber bearing and Friction pendulum).

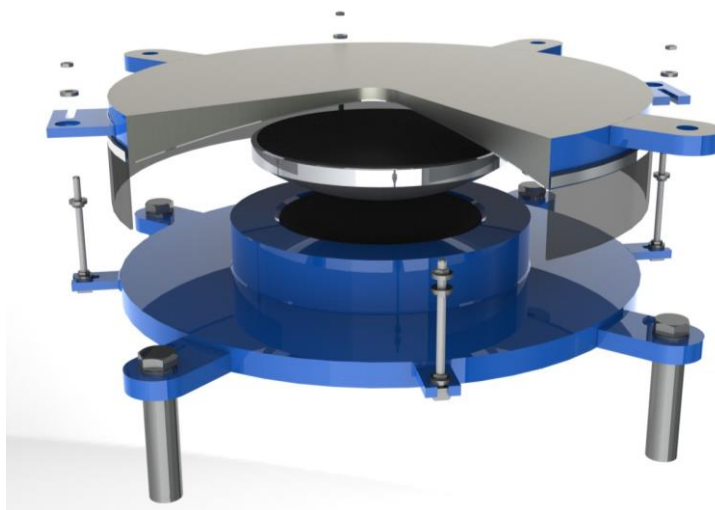


Figure 2: Sliding Isolation Pendulum, an example of Seismic Isolator
Courtesy of Maurer SE – Munich – Germany

Nonetheless, it should be noted that whenever it has been the case to formulate requirements for isolators on a “performance-oriented” criterion, the experts were put to the test and found themselves forced to make more than one concession to the “product-oriented” approach which, as stated before, is not well tolerated by CEN rules.

3.3 Combination of Anti-seismic Devices

Combining pre-existing devices generates "hybrids" that, may show interesting new characteristics.

However, something quite to the contrary could also occur. Thus, general rules are furnished to avoid any such eventuality.

3.4 Evaluation of Conformity

This section is not to be confused with "attestation of conformity".

- "evaluation" is the answer to the question: "How can conformity be ensured? " whereas,
- "attestation" is the answer to the question: "Who is going to certify conformity, and under what prerequisites and conditions?"

In other words, evaluation of conformity is seen as a purely technical matter closely linked with a specific product and the way it is produced which can be standardized for the benefit of comparability.

The evaluation of conformity specifies which tests and inspections shall be carried out to demonstrate conformity of the anti-seismic device with the European Standard EN 15129.

Conversely, the attestation is an administrative process that is carried out by the so called Certification Body.

In conclusion, there are three organisms involved in the CE marking procedure, namely the following:

- Notified body (testing laboratory)
- Inspection body
- Certification body

The norm clearly distinguishes between

- Type testing, which shall be performed prior to commencing manufacture and repeated if changes in the construction product or manufacturing processes occur.
- Factory Production Control (FPC), where extent and frequency of factory production control procedures are given.

Whenever a change occurs in the design of the anti-seismic device, the raw material, or the production process, which would change the tolerances or requirements for one or more of the characteristics of a device, the Type Tests shall be repeated for the appropriate characteristic(s).

In conclusion, Type Tests shall be required for:

- The validation of new devices;
- The validation of existing devices in ranges of use outside those previously validated;

The FPC system shall consist of procedures, regular inspections and tests and/or assessments and the use of the results for example to control raw and other incoming materials or components, equipment, the production process and the product.

Tasks and responsibilities in the production control organisation shall be documented and this documentation shall be kept up to-date.

The manufacturer shall have available the installations, equipment and personnel which enable him to carry out the necessary verifications and tests.

He may, as may his agent, meet this requirement by concluding a sub-contracting agreement with one or more organizations or persons having the necessary skills and equipment.

4. APPROVAL PROCEDURES

Fifteen years have transpired since work on the drafting of the European Standard on Anti-seismic Devices was began. The preliminary document (prEN 15129) was completed in June, 2004 and, after having been translated into the three official EU languages - French, German and English - was submitted to CEN Inquiry (January – June 2005).

CEN Inquiry represents an important stage in the drafting process of a European Standard and entails

the right of any one person to submit observations, comments and suggestions in writing for a 6-month period subsequent to the prEN's official publication.

All such information must be examined by the Technical Committee (actually, it is the Working Groups tasked with the relevant sections who do it) and there are two possible outcomes:

- a) observations may be accepted as valid and thus lead to prEN modifications, or
- b) comments may be rejected, in which case the reason for rejection is forwarded in writing to the proponent, on a case by case basis.

When the results of a CEN Inquiry demonstrate insufficient agreement on the prEN (i.e., an excessive number of comments, their relative importance, etc.) a second CEN Inquiry on the revised prEN, normally lasting 2-months but up to a maximum of 4 months, may be decided by the Technical Committee. Further inquiries are not allowed.

A second CEN Inquiry also becomes necessary when a Technical Committee decides to introduce relevant modifications such as adding new sections. This is precisely the case with that occurred with this Norm - because the TC 340 deliberated to include new types of isolators at year's end in 2005 (specifically, the Lead Rubber Bearing and the Sliding Pendulum) which were subject to a patent pending situation in the past.

However, it should be emphasized that the lack of inclusion of a type of device within a Norm's stipulations does not necessarily imply its being excluded from the European market – it only means that a need arises for European Assessment Document (EAD).

Approval of the final version of a Norm is carried out through a formal vote by CEN member nations. Each of them is entitled to a number of votes which is proportional to its population (i.e., a weighed voting procedure). All votes are unconditional but editorial comments may nonetheless be made. All negative votes must be accompanied by a justification.

If the outcome of the voting is positive, the CEN Technical Board notes the approval of the EN and establishes a target availability date. If the outcome is negative, the Technical Board decides what further action is to be taken.

As it may be appreciated from the above, in addition to bureaucratic "red-tape", "technological democracy" also exacts its "pound-of-flesh" but, in exchange, it affords fair treatment and equal opportunity to all.

In December 2015 started the process of revision of the Norm EN15129 that will extend over few years.

5. APPLICATION OF EN 15129

The application of a Norm can be carried out at various levels, as we will see below.

At this point it is appropriate to mention that in the European Union (EU), the matter of construction products is regulated by the Council Directives 93/68/EEC and 93/68/EEC.

For the purposes of said Directives, "construction product" means any product which is manufactured for incorporation in a permanent manner in construction works, including both buildings and civil engineering works.

All construction products shall bear the CE marking, which signifies their compliance with a relevant:

- European product standard or, where there isn't one, with
- National standard (provided it has been published in the Official journal of the European Communities), or
- European Assessment Document (EAD)

The EN 15129 is, effectively, a "product standard" that covers the design, manufacturing, testing and validation of the seismic hardware, i.e. the whole of the mechanical devices used in seismic engineering.

As already stated, this norm became effective in all member states of the European Union on August 1st, 2011, and therefore from that date all anti-seismic devices installed must bear the CE marking, which certifies their conformity with EN 15129.

Nonetheless this Norm was also adopted in countries outside the EU, even if only the requirements related to design, manufacturing and testing, that is, without necessarily affixing the CE marking.

Its adoption in individual projects is spreading in the Ex-Soviet countries, Mediterranean countries, as well as in Central and South America, with important demanding applications.

Amongst these we mention the Bilkent University in Erzurum (Turkey), the Russkij Bridge in Vladivostok (largest cable-stayed bridge in the world, see Fig. 3) the Izmit Bay Suspension Bridge (Turkey), the Isparta Hospital (Turkey) and the monumental Grand Mosque in Algiers (the third largest in the world - see Fig. 4), still under construction.

In the latter case the Designer specified that all devices (Sliding Pendula and Hydraulic Dampers) must bear the CE marking, despite being Algeria outside the European Union.



Figure 3: Cable-stayed Russkij Bridge – Vladivostok – Russian Federation



Figure 4: The monumental Grand Mosque in Algiers - Algeria

6. CONCLUSIONS

- The *European Standard on Anti-seismic Devices* represents the most complete and up-to-date document presently available to Seismic design Engineers and Seismic Hardware Manufacturers. In effect, the Standard aims to cover *all* types of Seismic Hardware in existence and leave a door open to future progress.
- This principally derives from the fact that the Standard is highly performance-oriented and this feature also constitutes *per se* a guarantee of equity between the various systems that may be used as alternatives
- The wealth represented by alternative systems available ensures a freedom of choice to the design engineer insofar as the design strategy deemed most appropriate.
- The long period of time allocated by the Work Program for the completion of the *European Standard on Anti-seismic Devices* is justified not only by the observance of procedures and regulations established by CEN, but also by the vast entity of the material treated as well as the fact that important processes of development are presently in progress.
- This presentation of the *European Standard on Anti-seismic Devices* has also given this speaker an opportunity to illustrate the procedures adopted in Europe to draft and approve norms.
- CEN has established very stringent rules regarding the structure and contents of a Standard as well how it is presented. However, this set of rules is far from being a handicap. In fact, it actually constitutes a most useful tool that facilitates the work of those who endeavor to draft a Standard.

Acknowledgments

This author wishes to express his appreciation to all the Conveners of the Working Groups, namely Prof. Philippe Bisch, Prof. Mauro Dolce, Dr. Keith Fuller and Dr. Samuele Infanti

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