PROTA

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PROTA

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THE NEW EUROPEAN STANDARD EN 15129

ON ANTI-SEISMIC DEVICES

by

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1.- Scope

The scope of this lecture is to describe the European Standard EN 15129: *Anti-seismic devices* for use in structures erected in seismic areas and designed in accordance with Eurocode 8: *Design of Structures for Earthquake Resistance*.

2.- Introduction

An increasing number of Congresses and Symposia - as well as other professional meetings - give testimony to the significant strides made by earthquake engineering during the last forty years.

Progress has been the result of a better understanding of the seismic behaviour of structures as well as improved knowledge of the characteristics of seismic actions.

In relation to these two aspects, newly developed design strategies have been devised and implemented entailing the use of special mechanical devices to be included in the structural system in order to substantially:

- change its overall behaviour (e.g. through the use of seismic isolators) and/or
- dissipate most of any input energy (e.g. with energy dissipating braces, dampers) or
- provide a different behavior under service and seismic actions (e.g. shock transmission units).

Thousands of applications have been implemented all over the world to many types of structures of varying size.

However, such a large number could still be inadequate, when one considers the fact that structural safety can be easily improved by one order of magnitude using passive control systems.

Newly conceived design strategies could not have found useful application without a parallel development of the hardware needed to implement them.

Thus, many research laboratories and certain pioneering specialized industrial concerns decided to invest important resources in this field, inventing or improving a series of devices to seismically protect the 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.

According to 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 examining the inquiry results.

After due bureaucratic tribute was paid, the first meeting of the officially nominated Technical Committee finally convened in Vienna in October, 1993.

This occasion saw the creation of a Work Programme with fixed target dates, the election of a Chairman (this speaker) and the installation of four Working Groups, each with an appointed "Convener", namely:

- *Prof. Philippe Bisch - France*
- *Prof. Mauro Dolce - Italy*
- *Dr. Keith Fuller - UK*
- *Mr. Samuele Infanti - Italy*

3.- General Criteria Adopted

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 favoring 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 cannot be a totally positive one.

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).

An important observation about general criteria regards the fact that the European Standard on Anti-seismic Devices should be harmonized with the Eurocodes (hereinafter referred to as ECs), particularly in what relates to EC8 – Design of Structures for Earthquake Resistance dealing with buildings and bridges endowed with seismic isolation systems, whose logical implementation it represents.

4.- Structure of the Standard

The structure of the *European Standard on Anti-seismic Devices* has been modified several times.

Its definitive version includes the following:

1. Scope
2. Normative references
3. Terms and definitions, symbols and abbreviations
4. General Design Rules

5) Rigid Connection Devices
6) Displacement Dependent Devices
7) Velocity Dependent Devices
8) Isolators
9) Combination of Devices
10) Evaluation of Conformity
11) Installation
12) 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*".

5.- General Design Rules

General design rules are set forth in Clause 4 of the Standard and are consistent and strictly related to those stated in the EN 1998, Part 1: Buildings and Part 2: Bridges, particularly for devices used in seismic isolated structures, which are dealt with in specific sections.

According to the two limit states referred to in EC8, EN 15129 considers as fundamental the following types of requirements:

- *No failure requirement*
- *Damage limitation requirement*

Both are referred to the relevant seismic intensities defined in EN 1998-Part 1 for the
- Ultimate Limit State and for the
- Damage Limitation State respectively. .

The first one requires that devices retain their functional integrity and residual mechanical resistance, including, when applicable, residual load bearing capacity after the seismic event.

The second requires that devices withstand the corresponding seismic action without the occurrence of damage and associated limitations of use, whose costs would be disproportionately high in comparison to the cost of the structure itself.

Reliability differentiation is required for different types of buildings or civil engineering works and is implemented by classifying structures into different importance categories.

To each category, an importance factor γ_I is assigned and applied to the seismic action.

This γ_I factor is included in the seismic actions effects on the devices.

Increased reliability is required of the devices, in terms of the crucial role they play within the structural system.

This requirement is already stipulated in EN 1998-Part1 and EN 1998-Part2 for seismic isolation devices.

However, in EN 15129, it is extended to devices used in applications other than seismic isolation.

In order to comply with this requirement, according to EN 1998-1 (edifices) a magnification coefficient γ_x=1,2 shall be applied to the design seismic action effects on the devices and their connections to the structure.

In EN 1998-2 (bridges), the reliability factor is called γ_{IS} and its recommended value is 1,5.

The mechanical and physical properties of devices, of their components and of their connections to the structure shall be assessed by laboratory tests through appropriate procedures.

Amongst functional requirements, specific emphasis is placed upon the need that devices and their connections to structures shall be designed, manufactured and installed in such a way that their routine inspection and replacement are possible during the service lifetime of the construction

In order to account for the inevitable variability in device characteristics due to the dependence of the mechanical behaviour of their materials on several factors, such as temperature and other environmental conditions (age, strain rate, etc.,) the upper and lower limits of the mechanical parameters of the core materials and of the devices shall be checked through experimental tests.

It is of interest to also remind the innovative criterion developed by this speaker and adopted in the Norm to evaluate the re-centering capability of an isolation system, which 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_{Ed} :

Elastically (or reversibly) stored energy

$$E_S \geq \frac{1}{4} \cdot E_H$$

Hysteretically dissipated energy

Finally, in the Clause "General Design Rules" specific concern is given to Validation of Anti-seismic Devices.

Any type of device shall be subjected to a technical validation procedure, which shall include elements proving that the device conforms to its functional requirements.

It shall include at least the following:

1. a description of the ranges of parameters relevant to the type of device under consideration covered by the validation procedure;
2. a method to estimate its expected lifetime;
3. proof of the device's ability to function in a reliable and stable manner during its lifetime;
4. values of the mechanical properties of the device;
5. range of acceptable environmental conditions;

6. description of the behavior beyond design seismic action to determine the γ_m values;
7. a constitutive model describing the behavior of the device under different conditions of use, including all combinations of actions as defined in EN 1990, representative of the physical phenomena which are expected during the lifetime, notably during the seismic movement;
8. type tests covering the anticipated ranges of use of relevant parameters.

Type tests shall be required for the validation of new systems, or of existing systems when materials are changed, as well as of existing systems in ranges of use outside those previously validated.

The mechanical properties of the devices needed in the design for the anticipated service lifetime of the system, together with their ranges of variation, shall be determined by the type tests.

Full-scale devices shall be required for these tests, unless otherwise specified in the relevant clauses of the Norm.

A given percentage of the devices to be installed in a structure shall be subjected to acceptance tests, before putting them into place, in order to confirm that their properties conform to the design values.

6.- The Anti-seismic Devices

Before defining the structure of the Standard, and similar to what happened in 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

It is worth summarizing the essential features of these fundamental groups of devices-

- Rigid Connection Devices: devices which link two structural elements without transmitting bending moments and vertical loads;

Shock Transmission Unit (STU), an example of Rigid Connection Device

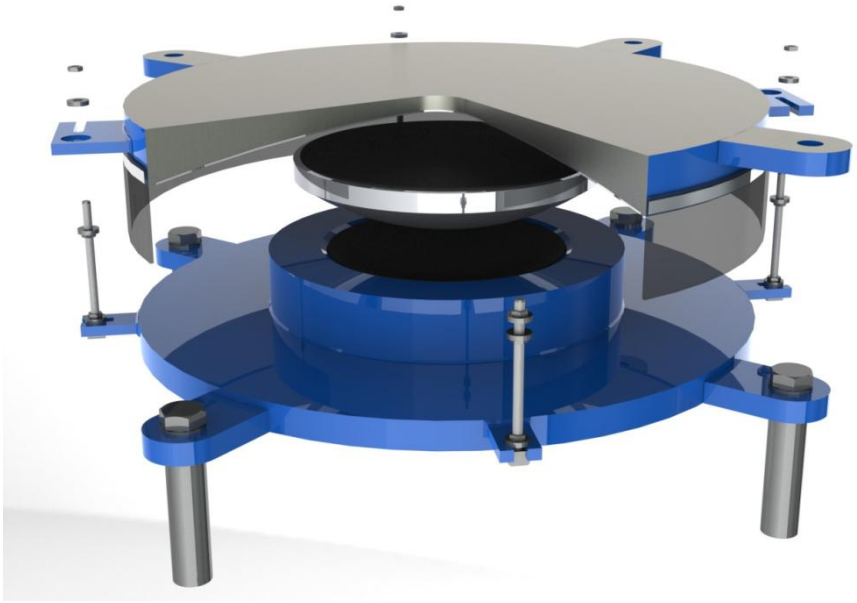
- Displacement Dependent Devices: devices which do not carry vertical loads, whose behaviour is mainly displacement-dependent rather than velocity-dependent;

Arrangement of Steel Hysteretic Elements, an example of Displacement Dependent Device

- Velocity Dependent Devices: devices which do not carry vertical loads and whose behaviour is mainly velocity-dependent rather than displacement-dependent;

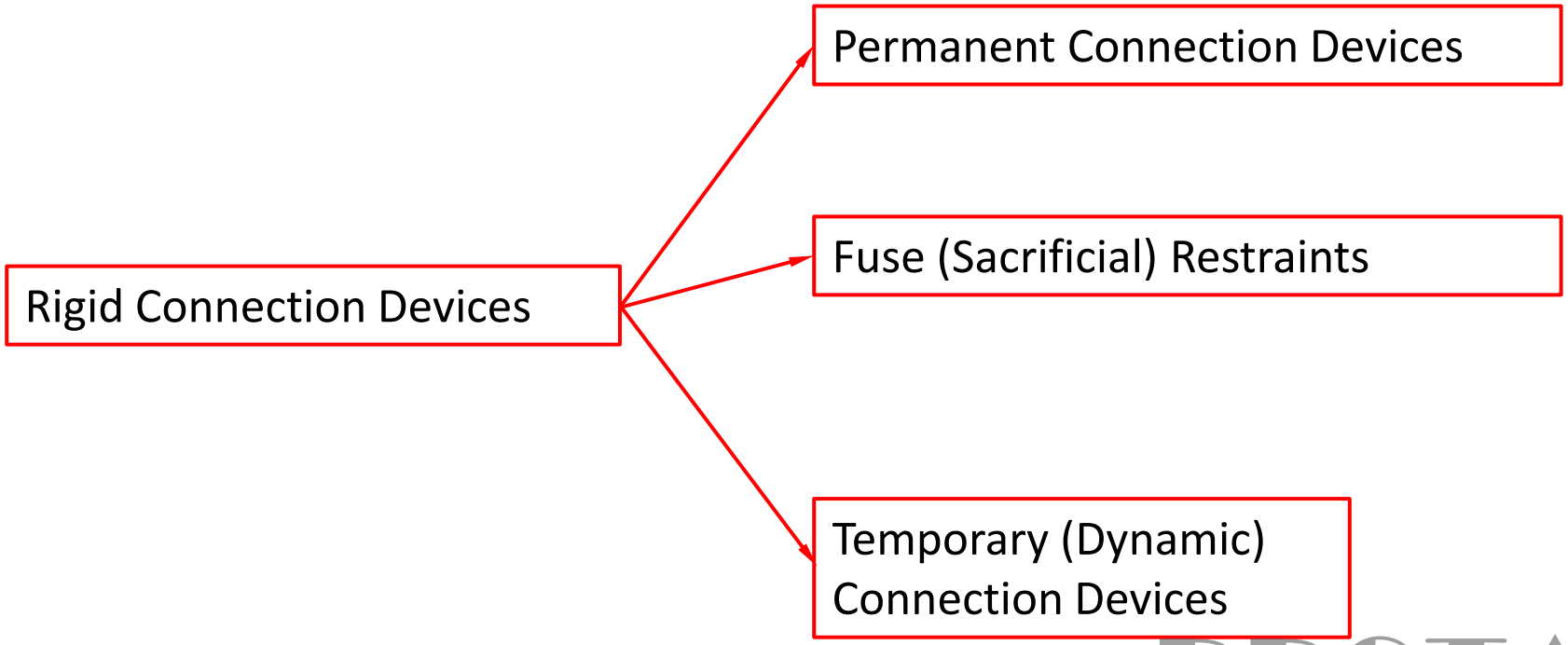
Hydraulic Viscous Damper, an example of Velocity Dependent Devices

- Isolators: devices that support the gravity load of a structure and accommodate the large horizontal displacements produced by seismic actions

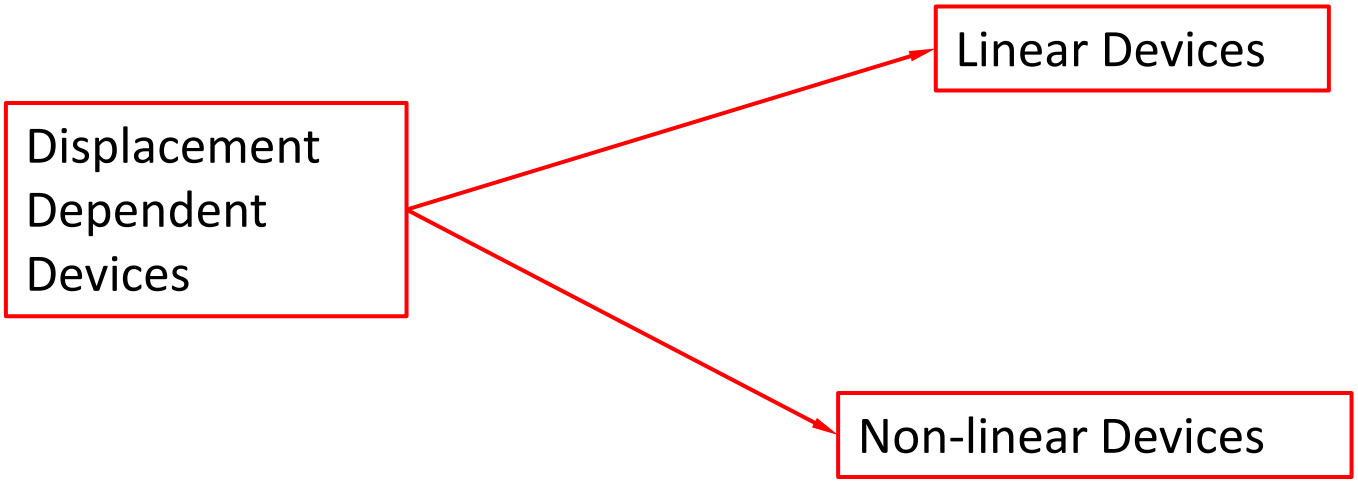


Sliding Isolation Pendulum, an example of Seismic Isolator

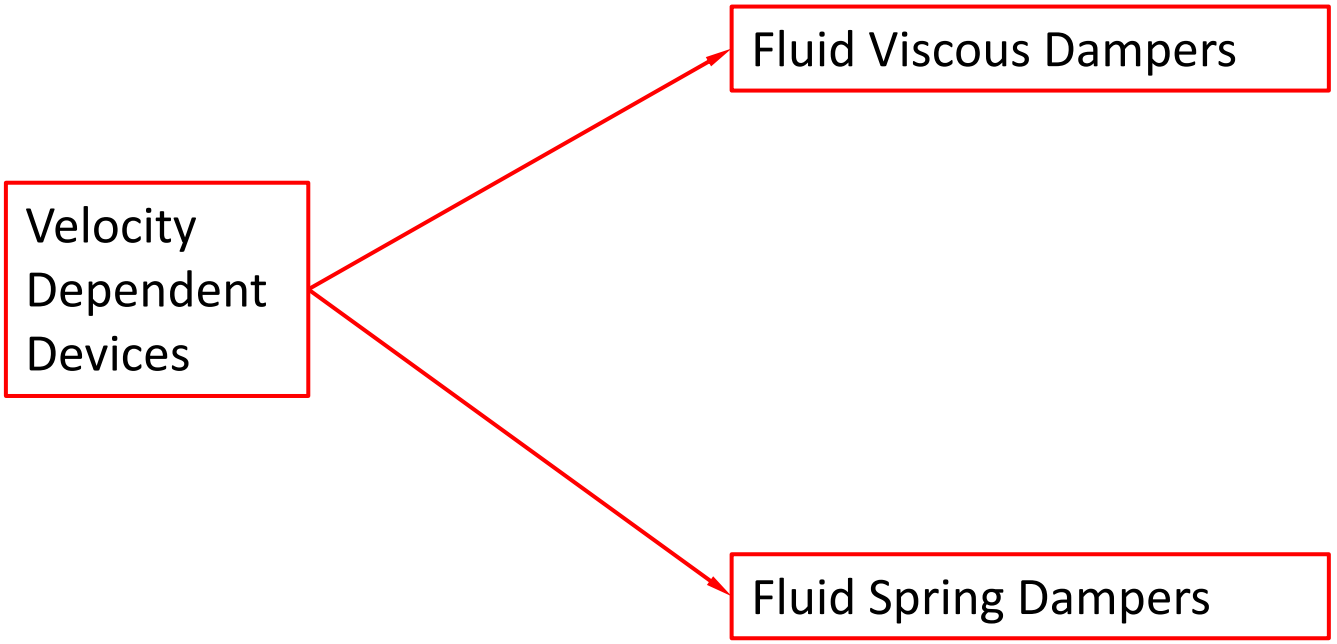
Each group has been further sub-divided.



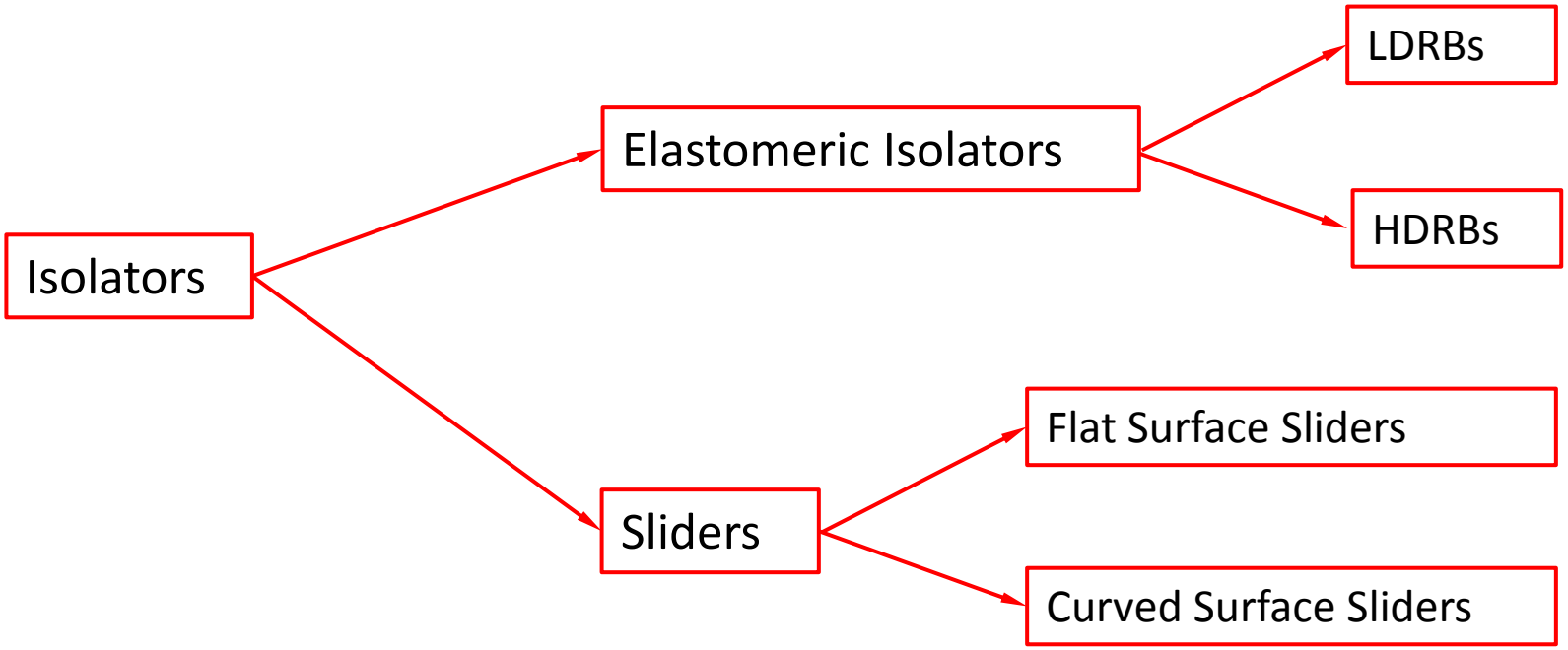
Displacement Dependent Devices have been subdivided as follows.



Velocity Dependent Devices have been subdivided as follows.



Isolators have been subdivided as follows.



It's not worth the trouble to dwell in detail upon the sections dedicated to single types of devices.

It is important to keep in mind the fact that the Norm takes into consideration **all the types of devices** presently in existence on the European market – even those developed outside Europe, e.g. Lead Rubber Bearings and Friction Pendula®.

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 a **European Technical Approval (ETA).**

7.- 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.

8.- Evaluation of Conformity

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

The difference between the two is explained as follows:

- *"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.

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

There are three organisms involved in the CE marking procedure, namely:

- The Notified Body (testing laboratory)
- The Inspection Body
- The 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).

A Factory Production Control (FPC) system conforming to the requirements of the relevant part(s) of EN ISO 9001:2008, and made specific to the requirements of EN 15129, is necessary to satisfy this procedure.

Thus the manufacturer shall establish, document and maintain a FPC system to ensure that the manufactured products conform to the stated performance characteristics.

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.

The manufacturer shall be responsible for organising the effective implementation of the Factory Production Control system.

9.- Norm Approval Procedures

Eighteen years have transpired from the beginning on the drafting work of the EN 15129 (Sept. 1993) and its coming into effect (August 1st, 2011).

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 Public Inquiry (January – June 2005).

Public Inquiry (now referred to as CEN Inquiry) represents an important stage in the drafting process of an 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 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.

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.

Thus, the Norm became effective and mandatory in all the CEN Member States on August 1st, 2011.

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.

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 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 a guarantee of equity between the various systems that may be used as alternatives

- 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.

- 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.

I GREATLY APPRECIATED

YOUR ATTENDANCE

İlginize Teşekkürler !