

EARTHQUAKE RESISTANCE REGULATIONS IN FRANCE



Ministry for Ecology, Sustainable
Development, Transport and Housing

DGALN/DHUP

Quality and Sustainable Development in
Construction Division



Contents

- Recent changes in regulations
- Organisation of regulations
- Principles and innovations
- Monitoring compliance with regulations
- State support

Why do we need new regulations?

- Changes in regulations

- Organisation of the regulations
- Principles and innovations
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- Development of knowledge:
 - New techniques in earthquake-resistant building
 - New (probabilistic) approach to zoning
 - Consideration of recent earthquakes

} Greater awareness of the earthquake risk
- Drive for homogenisation on a European scale
 - Eurocode 8 rules for calculations and earthquake-resistant buildings:

New regulations (zoning + earthquake resistant construction) published in October 2010



Organisation of regulations

- Changes in regulations

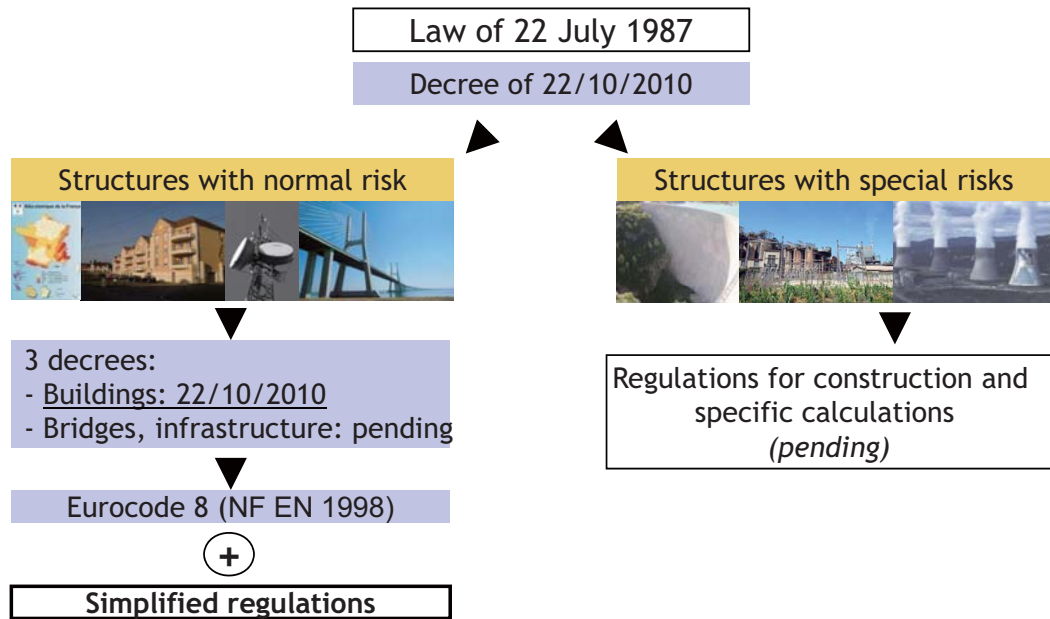
- Organisation of regulations
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- Law of 1987
- Decree determining seismic zoning (zones of increasing seismic risk)
- Decree determining the classification of buildings (in increasing order of importance)
- Decree (for each type of building) setting out the building regulations for each category of importance of building and seismic zone



Organisation of regulations

- Changes in regulations
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Principles behind the new regulations

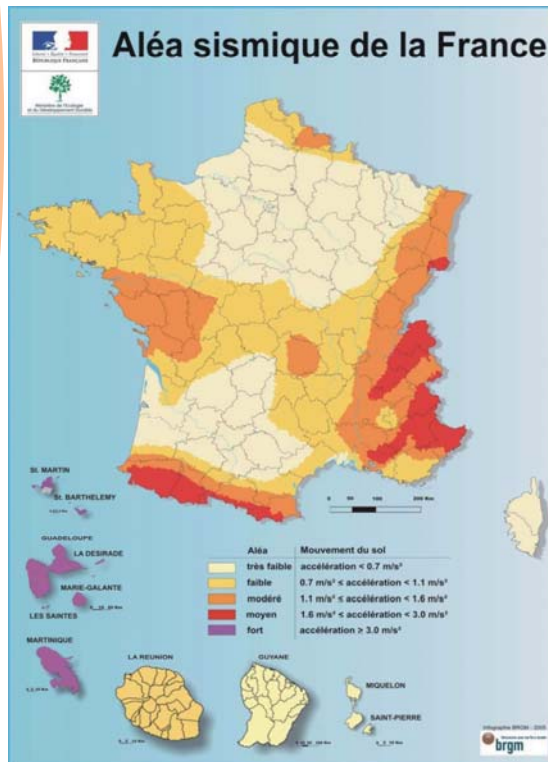
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- **Common points with current regulations:**
 - Basic principle behind the regulations: saving lives
 - No-collapse requirements for structures
 - Development of simplified, standard rules for existing buildings and detached houses
 - Local prevention of earthquake risk (national risk prevention plan, PPRN)
- **Major changes:**
 - Zoning based on a more probabilistic approach, for greater precision
 - Classification of buildings
 - Changes in parameters and adaptation to Eurocode 8
 - Reinforcement of existing buildings

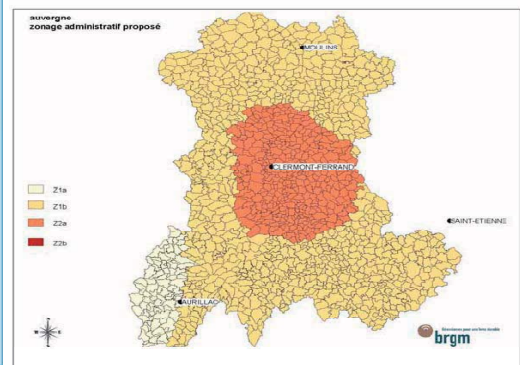


New earthquake zones

- Changes in regulations
- Organisation of regulations
- Principles and innovations
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- Probabilist zoning taking into account return periods
- 5 earthquake zones
- New municipality boundaries (better definition)



Classification of buildings

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	Catégorie d'importance	Description
	I	Pas d'activités humaines nécessitant un séjour de longue durée
	II	Habitations individuelles ERP de catégories 4 et 5 Habitations collectives de hauteur inférieure ou égale à 28 m Bureaux ou établissements commerciaux non ERP, de hauteur inférieure ou égale à 28m et pouvant accueillir un maximum de 300 personnes Bâtiments industriels pouvant accueillir un maximum de 300 personnes Parcs de stationnement ouvert au public
	III	ERP de catégories 1, 2 et 3 Habitations collectives et bureaux de hauteur supérieure à 28 m Bâtiments pouvant accueillir plus de 300 personnes Établissements sanitaires et sociaux Centres de production collective d'énergie Établissement scolaire
	IV	Bâtiments indispensables à la sécurité civile, la défense nationale et le maintien de l'ordre public Bâtiments assurant le maintien des communications, la production et le stockage d'eau potable, la distribution publique de l'énergie Bâtiments assurant le contrôle de la sécurité aérienne Établissements de santé (soins de courte durée, affection grave pendant la phase aiguë) Centres météorologiques



Construction regulations

for buildings at normal risk

- Changes in regulations
- Organisation of regulations
- Principles and innovations
- Monitoring compliance with regulations
- State support

- For new buildings:
 - In every case: Eurocode 8 regulations
 - For category II buildings (detached houses) subject to conditions, simplified regulations may apply
- For existing buildings:
 - In every case: non-aggravation of vulnerability
 - For structural work: graduated Eurocode 8 regulations or simplified regulations
 - For non-structural work (false ceilings, partition walls): compliance with Eurocode 8 provisions



Monitoring compliance with regulations

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- 3 different types of inspection mechanism:

Monitoring during the building work

- Technical inspection, obligatory since 2006, in medium and high risk earthquake zones (levels II and III):

- Buildings > 28 m
- Establishments which can house more than 300 people

Monitoring in connection with planning procedures

- Certificate of compliance with earthquake resistance regulations

- Certification at the planning permission stage: the contracting authority must be aware of the technical controller's recommendations concerning earthquake resistance regulations
- Certification on completion of work: the technical controller states that the contracting authority has observed the earthquake resistance regulations

Retrospective monitoring

- State inspections: inspections carried out by civil servants on projects selected at random

- Inspections extended to earthquake resistance category in 2006
- Inspection methodologies developed in 2009
- First earthquake resistance regulations inspections planned for 2011



State support

- Changes in regulations
- Organisation of regulations
- Principles and innovations
- Monitoring compliance with regulations
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- Launch in 2005 of a national earthquake risk prevention programme:
The Plan Séisme (Earthquake Plan) :

NATIONAL
PROJECTS

- Information and training for professionals
- Information on regulatory documents
- Publication of methodological guides (structural details, reinforcing existing structures)
- Consultations with professionals
- Tsunami risk prevention

LOCAL
PROJECTS

- Vulnerability diagnoses
- Reinforcement surveys (educational and medical establishments)
- Earthquake disaster exercises

- Launch in 2007, of a programme adapted for the French West Indies:
The French West Indies Earthquake Plan



THE NEW FRENCH EARTHQUAKE RESISTANCE REGULATIONS

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Since the 1950s, when the first recommendations for earthquake-resistant construction were drawn up, the regulations have regularly evolved as knowledge of the subject has improved and lessons have been learnt from destructive earthquakes occurring in other countries (Morocco, Algeria, Mexico and California).

The Eurocode, a corpus of European standards on the design and compliance of building and civil engineering structures produced from a consensus of European experts, means that a European-wide harmonised standard is already in existence. Eurocode 8 covers the design and assessment of structures for earthquake resistance and is now also accompanied by a set of national regulations since the appearance of new legislation on 22 October 2010.

I. Changes in legislation

A. The reasons for change

The introduction of new regulations has been determined by two main issues:

- Firstly, the need for harmonisation of calculation rules at European level: the 10 Eurocodes (from Eurocode 0 to 9), are the result of a commitment to standardise the design of structures and building works.

Earthquake resistance is covered by Eurocode 8 (EC8).

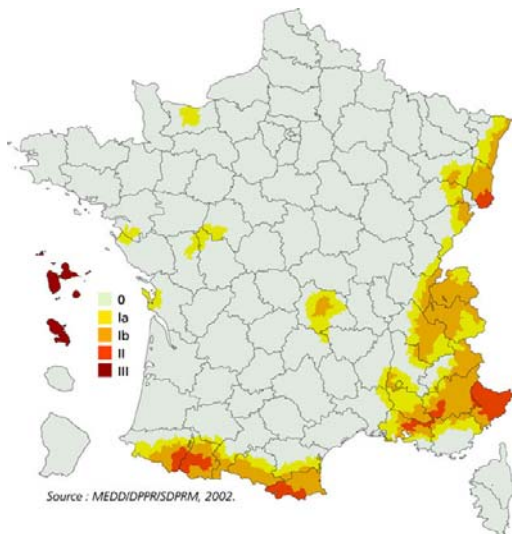
- Secondly, changes in scientific knowledge and earthquake resistance regulations at European level have required reassessment of zoning with use of a probabilistic type approach.

The probabilistic approach assesses the probability of a given seismic ground motion taking place at least once in a given location and over a given period of time, thus allowing calculation of the return period.

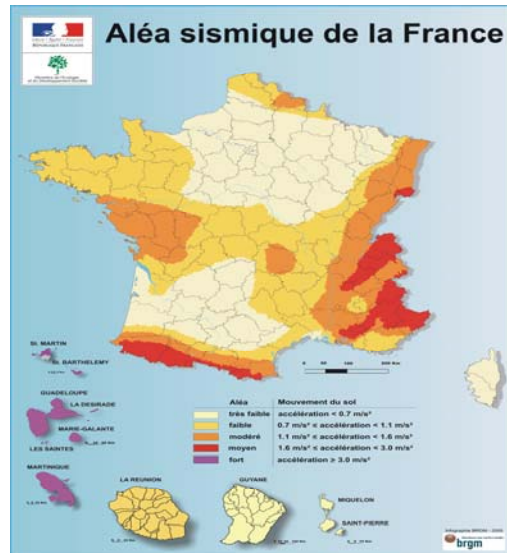
B. Transposing these advances to a national context

Changes in seismic zoning

This change in the concept of seismic hazard differs from the deterministic approach of the 1991 regulations, based on an analysis of historical seismic activity using statistical data. Zoning has therefore been reassessed, new seismic zones have appeared and 15,000 *communes*, not affected by the 1991 zoning, are now associated with a non-zero seismic zone. In addition, unlike the previous zoning which was based on the limits of the *canton* administrative district, these limits will now be defined in terms of the *commune*.



Zoning associated with the 1991 regulations



Zoning associated with the 2010 regulations

Changes in legislation

In terms of legislation, the new zoning also facilitates application of the new earthquake resistance construction standards EC8 (Eurocode 8): these European rules are also based on a probabilistic approach and allow harmonisation of standards with other European countries.

Studies prior to the adaptation of EC8 to national regulations have been necessary in order to assess the scope and impact of the new regulations: the complexity and adaptability of the construction rules together with any additional costs for certain types of buildings are major challenges in transposing the European standard to French regulations.

The decree and its enforcement orders, drafting of which started in 2005, are now in force. The next chapter describes those principles taken from the previous regulations and reinstated in the new regulations, together with new factors introduced by Eurocode 8.

II. The new seismic regulations

A. The principles taken from the 1991 regulations

Basis of the regulations

In France, building regulations to prevent earthquake-related damage date back to 1955.

The principal objective of earthquake resistance regulations is to **save the maximum number of human lives** for an earthquake of which the magnitude is stipulated for each seismic zone. The building can suffer irreparable damage, but it **must not collapse on its occupants**. In cases of more moderate earthquakes, application of the provisions defined in the earthquake resistance regulations must also ensure limitation of damage and therefore of financial losses. Unlike other major natural risks, earthquake regulations are essentially implemented at national level, even if the possibility exists of drawing up risk prevention plans locally.

Regulatory organisation

The law of 22 July 1987 on organisation of civil protection introduces the principle of applying specific earthquake resistance rules to buildings in zones exposed to seismic risk.

Using the same principle as the previous regulations, the new legislation is organised as follows:

- zoning is determined by a decree,
- a second decree classifies buildings into two construction categories known as "normal risk" and "special risk" depending on whether or not the impact of an earthquake remains confined to their occupants and the immediate vicinity.
- the enforcement orders are specific to different building types (bridges, normal risk buildings, special risk buildings) and define the construction rules used.

The regulations are organised in such a way as to ensure well-defined zoning, clear classification of buildings and construction rules in the form of standards. The enforcement orders thus allow the expression of these three factors by indicating which earthquake-resistant construction rules should be adopted for a given building in a specific zone of the country.

The principle of non-collapse

The principal objective of the requirements defined by earthquake resistance regulations is to save the maximum number of human lives possible for a design basis earthquake: the building can suffer irreparable damage, but it must not collapse on its occupants.

In cases of more moderate earthquakes, application of the provisions defined in the earthquake resistance regulations must also ensure limitation of damage and therefore of financial losses. This requires the definition of limit states which make reference to the damage of structures.

For new constructions, two requirements must therefore be complied with:

- The non-collapse requirement: the structure shall be designed and constructed to withstand design seismic actions without local or global collapse, thus retaining its structural integrity and a residual load bearing capacity after the seismic events. This principle, which supports that of saving human lives, is identical in the previous regulations.
- The requirement of damage limitation is a new factor taken from Eurocode 8: the structure shall be designed and constructed to withstand a seismic action having a larger probability of occurrence than the design seismic action, without the occurrence of damage and the associated limitations of use, the costs of which would be disproportionately high in comparison with the costs of the structure itself.

Use of standardised and simplified construction rules:

The construction rules are taken directly from Eurocode 8 and are therefore different from the previous rules. However, use of construction rules in the form of standards and the possibility of using simplified rules in simple cases are principles taken from the old regulations and have been incorporated in the new ones:

Earthquake resistance rules are only applicable to the construction of **new buildings** or if an **existing building** has been **significantly modified**. These rules apply to buildings located in seismic zones Ia, Ib, II or III.

Construction rules differ depending on the type of work in question:

- Bridges are subject to an order of 15 September 1995 which defines three classes of bridge and also sets out the accelerations and construction rules applicable until a new order currently being drawn up is signed which will invoke Eurocode 8.
- So-called "special risk" constructions are governed by a specific order of 10 May 1993 which requires them to undergo a safety analysis and production of a specific response spectrum until a new order currently being drawn up is signed which will invoke Eurocode 8.
- "Normal risk" constructions are now regulated by the order of 22 October 2010, which stipulates for the 4 building importance classes, the seismic action values to be complied with in accordance with their location zone and requires compliance with the following:
 - In general cases, the earthquake resistance construction rules of **Eurocode 8** for all buildings
 - In the case of individual houses (and similar) located in seismic zones 3, 4 and 5, the calculation rules of Eurocode 8 are too complex given the construction in question and the chain of players involved in the project.

As in the old regulations, in these cases the new regulations offer the possibility of non-compliance with general cases by applying simplified construction rules:

- the rules entitled "PS-MI 89 révisées 92", a set of global rules based essentially on construction provisions for category II buildings (individual houses) in metropolitan France (seismic zones 3 and 4)
- the rules entitled "CPMI Antilles" for the same types of buildings (category II) located in the West Indies in seismic zone 5, these rules also being based on construction provisions adapted to the seismic hazard of this region, the highest in the national territory.

The principle of the option to apply simplified rules therefore continues to exist and studies are underway for individual houses, for which a specific guide stipulated in the regulations (in a similar format to those of the current rules "PSMI 89 révisées 92" and "CP-MI Antilles") will set out the global rules for compliance with the provisions of Eurocode 8 without the need for complex calculations.

Local prevention of seismic risk

Local consideration of the seismic hazard, a principle implemented in the previous regulations, is maintained in the new ones given the diversity of the land encountered in metropolitan France and its overseas departments and territories.

At local level, environment, construction and housing codes can be used in zones identified as being of particular risk to stipulate specific rules through local prevention plans.

The foreseeable natural risk prevention plan (seismic PPR) can stipulate better adapted construction rules than those defined in a general context. The PPR can therefore propose different protection levels from the global levels defined on a national scale and in particular more accurate hazard zoning. These levels are the result of a technical analysis conducted at the level of the *commune* and are therefore considered to be better adapted to the local seismic context. They replace the national regulations.

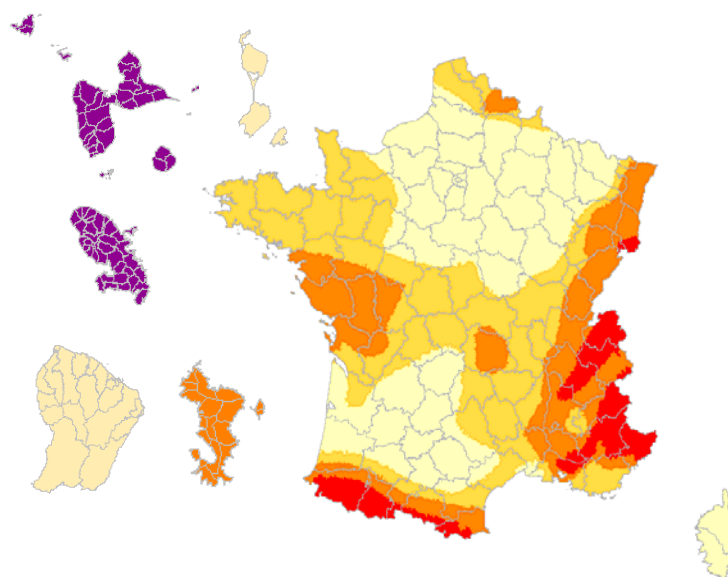
B. The changes and new factors introduced by Eurocode 8

Zoning

The principal parameter used to describe seismic hazard at national level is peak ground acceleration on rock (ground with the best earthquake resistance, class A, on a scale from A to E). This acceleration underlying the regulations and calculations of Eurocode 8 is known as the reference peak ground acceleration on rock (a_{gr} in m/s^2).

On the basis of this parameter, the regulatory zoning defines five zones of increasing seismic activity based on communal divisions. Zone 5 covering the islands of the West Indies is the highest hazard level within the national territory. Metropolitan France is divided into four seismic zones, from zone 1 of very low seismicity (Picardy, Aquitaine basin, Parisian basin) to zone 4 of average seismicity (part of the Rhine trench, the Alps and Pyrenees).

Seismicity zone	Hazard level	a_{gr} (m/s ²)
Zone 1	Very low	0.4
Zone 2	Low	0.7
Zone 3	Moderate	1.1
Zone 4	Average	1.6
Zone 5	High	3



New French seismic zoning

Classification of buildings

For normal risk buildings, the level of earthquake protection is adjusted to the seismic consequences associated with the building. Buildings are therefore categorised into importance classes depending on certain parameters such as the activity taking place in the building or the number of people it can accommodate.

The application conditions of the regulations depend on the importance class of the building, both for new buildings and existing ones. In addition, the design seismic action used to model a building is also adjusted to the seismic consequences associated with the building.

Normal risk buildings are categorised into four classes of increasing importance, from category I low importance to category IV which covers strategic buildings and those vital for crisis management.

Importance class	Description
I	No human activity requiring significant time spent in the building
II	Individual dwellings Class 4 and 5 buildings open to the public Communal dwellings less than or equal to 28 m high Offices or commercial premises not open to the public, less than or equal to 28 m high, accommodating a maximum of 300 people Industrial buildings accommodating a maximum of 300 people Car parks open to the public
III	Class 1, 2 and 3 buildings open to the public Communal dwellings and offices more than 28 m high Buildings accommodating more than 300 people Healthcare and social facilities Communal energy-generating facilities Educational establishments
IV	Buildings vital for civil protection, national defence and maintenance of public order Buildings essential for maintaining communications, production and storage of drinking water and public distribution of power Buildings essential for controlling air safety Medical establishments (intensive care) Weather centres

The most restrictive building class is used in cases where the building is made up of parts categorised under different importance classes. Regarding application of the regulations to existing buildings, the structure class used is that resulting from classification after works have been carried out or the purpose of the building has changed.

Changes in parameters

In order to be able to apply Eurocode 8 and in particular the formulae it contains, the parameters intrinsic to the calculations must be modified as they are taken from the previous regulations and are no longer appropriate. The accelerations underlying the calculations have therefore been assessed and adapted to French territory, and the type of ground used in most earthquake resistance calculations is better defined.

The local nature of the ground (tens of metres closest to the surface) has a strong influence on the stress levels buildings are subjected to. Eurocode 8 and the new regulations based on it distinguish 5 main types of ground (from type A for rock formations to type E for soft ground) for which a soil factor *S* is defined. This soil factor *S* is used to translate amplification of the seismic stress exerted by certain soils.

Ground types	S (zones 1 to 4)	S (zone 5)
A	1	1
B	1.35	1.2
C	1.5	1.15
D	1.6	1.35
E	1.8	1.4

Classification is now in terms of the *commune*, which is a more accurate reflection of reality than the use of *cantons*. 20,000 *communes* are now affected and some regions have seen a change in the status of their seismic risk: the Northern Alps zone is now one of the most exposed in metropolitan France and other regions (Nord, Pays de la Loire) have changed from zones with practically zero seismic activity to moderate seismicity.

The importance placed on strengthening existing buildings

The third part of Eurocode 8 deals with the problem of strengthening existing buildings, an issue which is not included in the current regulations.

It is, however, difficult to establish a regulatory framework governing the strengthening of existing buildings. The context is not the same as for new buildings: firstly, the many different types of construction seen in existing buildings require a panel of highly diverse strengthening solutions making any regulatory mechanism complex. Secondly, the cost of strengthening existing buildings is much greater than that incurred for new earthquake-resistant construction. Finally, any strengthening measures require specific knowledge of the existing structure (materials, connecting elements) which is not necessarily easy for old buildings.

Using the same principle, future regulations will also cover strengthening of existing buildings. The degree of strengthening applied to existing buildings, in the sense of Eurocode 8 part 3, would be the choice of the project owner or contracting authority from the three design options proposed by the European standard:

- design for near collapse,
- design for significant damage,
- design for damage limitation.

These design concepts which make reference to damage of the structure must comply with the three corresponding building performance requirements stipulated in Eurocode 8.

Reducing seismic risk therefore involves reducing the vulnerability of buildings and this will require the provision of simple vulnerability assessment methods. These assessment methods and a methodology for strengthening existing buildings are being studied upstream of the release of the new regulations.

C. Application arrangements

Eurocode 8 will therefore replace the previous PS 92 rules from 1st May. The latter can, however, be applied for a transitory period of 2 years from October 2010.

Similarly, the PSMI rules will remain applicable until the new simplified rules have been tested and validated.

III. Monitoring compliance with the regulations

A. Mandatory technical inspection

Technical inspectors are independent specialists accredited by the ministry in charge of construction. They are commissioned by the project owner or contracting authority to help prevent technical hazards and therefore carry out inspections on the solidity of building works and the safety of people inside them. Their remit is defined in standard NF P 03-100.

Since 1 March 2006, the technical inspection is now mandatory for projects with certain levels of seismic risk. These are:

- buildings over 8 m high in seismicity zones II and III
- tower blocks over 28 m high
- buildings open to the public or buildings accommodating more than 300 people in non-zero seismicity zones.

B. Certificates of regulatory compliance

Since 2007, technical inspectors must attach their certificate to planning documents upstream and downstream of project implementation. The certificate covers the same field of constructions as the mandatory technical inspection:

More specifically, two certificates showing that earthquake resistance rules have been taken into account must be produced by the technical inspector:

- one attached to the planning application certifying that the technical inspector has given the project owner or contracting authority his opinion regarding compliance with earthquake resistance rules,
- the other with the work completion report certifying that the technical inspector has included his opinions on compliance with earthquake resistance construction rules.

C. Government inspections: compliance with building regulations

The inspection to ensure compliance with building regulations (CRC) is implemented through annual inspection campaigns conducted by certified and commissioned civil servants responsible for checking compliance with construction regulations over a sample of new buildings.

This possibility of inspection and sanctions has been extended to earthquake resistance regulations since 2006.

A reliable methodology has been drawn up and it should be possible to conduct the first inspection campaign in the individual houses sector in 2011.

IV. Government support

Appropriation of the regulations by stakeholders in the construction industry is one of the French government's current concerns.

The Plan Séisme (Earthquake Plan), introduced in 2005 for a period of 5 years, has resulted in a number of major projects with the priority objectives of training and provision of information. The Plan strategy consists of raising awareness of citizens, construction companies and public authorities, but also of implementing, through the mobilisation of various stakeholders, the construction provisions essential to building resistance while also pursuing the improvement of expertise.

A. Training of construction industry stakeholders

Initial and further training of stakeholders in earthquake resistance construction (architects, tradesmen, site managers, engineers, labourers, etc.) is still underdeveloped. It should go beyond simple awareness-raising of the difficulties and constraints of earthquake resistance design. Project owners and contracting authorities must be made more aware and trained so that they can incorporate seismic risk into their investment policies and property planning.

Several initiatives have been undertaken in this direction:

- provision of information on technological and regulatory developments to allow trainers to incorporate them in due course into initial training programs for building professionals.
- production of earthquake crisis scenarios used to organise simulation exercises in zones II and III of national seismic zoning and thus raise the awareness of local decision-makers and populations in relation to seismic risk.
- specific training courses offered to public service agents playing a role in the prevention of seismic risk based on tools for decision-making, for assessment of seismic risk in development, and for diagnosis and strengthening of built heritage.

B. Provision of information to construction industry stakeholders

Prevention of seismic risk means informing citizens of the risks they run in zones covered by a foreseeable natural risk prevention plan (PPR). There are still very few seismic PPRs in existence and seismic zoning is still in the process of evolving. Information is

currently widely dispersed and not readily accessible; it should be made available to citizens, local authorities and construction professionals.

This information should be provided at two levels:

- for citizens and professionals:
 - through planning requirements and planning permission orders;
 - by keeping professionals informed of new regulatory provisions;
 - by keeping inhabitants of seismic zones informed of the risk, in particular when microzoning has been carried out, of the diagnosis and strengthening measures of buildings, and of the behaviour to be adopted in the event of a crisis.
 - by informing tenants and purchasers of the risks when making a property transaction.

- for local authorities:
 - by organising the information available into databases;
 - by providing local authorities with information documents on the level of hazard written specifically for them;
 - by providing local authorities with information on legislation in relation to seismic risk.

C. The challenges of Plan Séisme

In addition to training and information initiatives, Plan Séisme also encompasses other challenges:

The objective is to improve consideration of seismic risk in construction and the aforementioned regulatory issues are therefore an essential part of the framework it defines: development of effective regulation, inspections to ensure compliance with regulations, and guides explaining the diagnostic and strengthening methods available through use of scientific knowledge are all issues incorporated in the Plan.

In addition, a necessary objective of the Plan is close dialogue with regional and local authorities as well as construction professionals.

Information on the initiatives in this national programme can be consulted on the following website: **www.planseisme.fr**

