Structural Design in Portugal

The present and the near future

Tiago Abecasis

Who and where are the structural designers in Portugal?

- PORTUGUESE DESIGN OFFICES – ESTIMATED 70* RELEVANT DESIGN OFFICES (SEE NOTE).
- DESIGN DEPARTMENTS OF SOME CONSTRUCTION COMPANIES, MAINLY THE STEEL STRUCTURES MANUFACTURES.
- DESIGN DEPARTMENTS OF SOME LOCAL AUTHORITIES.
- ISOLATED OR SMALL GROUPS OF ENGINEERS.
- WORKING FOR FOREIGN DESIGN OFFICES

Note*: This figure is based on the number of members of the GPPE (Portuguese Group of Structural Concrete) and the CMM (Portuguese Association for the Steel and Composite Construction).

Who and where are the structural designers in Portugal?

- There are not very large design offices in Portugal (with the dimension of some existing on other European and American offices).

PORTUGUESE DESIGN OFFICES:

- Large design offices that also dedicate themselves to other project specialities besides the structural design and occasionally to the architectural design, **with more than 100 engineers** – LESS THAN 5
- Near all the other design offices cover only the structural design and have less than 40 engineers. On the larger part of them work we find less than 15 engineers.

Who and where are the structural designers in Portugal?

- **Before the crisis** hit the public and private investment (2008-2010) only a small number of design offices (the larger ones) were involved on the design of structures for foreign countries. Due to the abrupt fall of the demand on the Portuguese market, even the very small offices began looking and trying to get work on other countries - in Europe, Africa (former portuguese colonies and North Africa countries) and South America, with a special focus on Brazil. A lot of them were successful and could compensate the reduction of the amount of work they were used to get in Portugal.
- Some of them established associations with local offices, other explored these markets alone and a small number worked for the portuguese construction companies that also had to “went abroad”.
- It is also important to refer that a large number of structural engineers, mainly the younger ones, emigrated and went to work on European design offices. Most of them are still there.

Who and where are the structural designers in Portugal?

São Paulo (Brazil) international terminal building, designed by the Brazilian branch of a portuguese design office

Who and where are the structural designers in Portugal?

What are our advantages that were very useful for that urgent internationalization?

Most of the portuguese structural designers are very well prepared to adapt themselves to a very large spectrum of:

- ***Design activities*** - Conception, preliminary design, preparing calculation models, performing safety calculations according to the recent *design* rules.
- ***Design environments with different requirements and legislations.***

Who and where are the structural designers in Portugal?

What are our advantages that were very useful for that urgent internationalization?

The reasons for this excellent preparation can be found on the following circumstances:

- A **long tradition of a high level and a very demanding** education at the portuguese technical universities;
- The civil engineering courses have always **allocated large periods to the teaching of the basic mechanical matters** such as statics and dynamic of the constructions, as well as to the study of the structural materials behaviour and the structural analysis classic methods and processes;
- On small offices (the larger part of the portuguese ones) the young engineers are very soon involved on all the sequence of activities of the project, since the first drafts to the final execution design, drafting control, quantities evaluation and documents preparation;
- Since more than 20 years all **the civil engineering courses teach the most relevant parts of the European Structural Eurocodes**.

The portuguese structural design codes

- Portugal is now on a turning point in what concerns the structural design rules. The legislation is on the verge of having a meaningful changing due to the official publication of some parts of the **EUROCODES**. These parts ***will substitute the existing legislation*** in order to become the legal framing of the structural design.

- Yet, the truth is that some design offices, local authorities and governmental departments are partially aware of the consequences of the new design rules, but a large majority of the national players have only a very superficial idea of the modifications and limitations that will forcibly result for the conception, structural arrangements, design criteria, safety checking and, at the end of the day, for the construction costs of the future structures.

The portuguese structural design codes

Particular relevant for these modifications is the specific geographical situation of Portugal.

A large portion of our territory is situated in a **intense seismic area** and the seismic design according to the Eurocode 8 will change the principles and restrictions to be respected on the structural conception, will impose several new safety checking calculations and require much more care on the structural detailing, specially on the connections details.

THE STRUCTURAL ENGINEERS WILL NEED TO CHANGE THE WAY THEY LOOK TODAY TO THE BUILDINGS SEISMIC DESIGN.

The portuguese structural design codes

- Evolution since 40 years ago (1979 – 2019)

Existing design codes IN 1979

- Design codes for the design of buildings structures *(Remark: In Portugal the design codes are government laws):*
  - Regulamento de Solicitações em Edifícios e Pontes (Regulation for the Loads on Buildings and Bridges), published on 1961, including 71 ARTICLES AND 2 ANNEXES.
  - Regulamento de Estruturas de Betão Armado (Reinforced Concrete Structures Regulation), issued on 1967/1968. It has 79 ARTICLES, 2 ANNEXES AND 110 PAGES. It doesn't cover the prestressed concrete structures, but includes 6 articles concerning the execution and the supervision of the construction works.
  - Regulamento de Estruturas de Aço para Edifícios (REAE) (Steel Structures Regulation for Buildings) issued on 1965 and its content has 87 ARTICLES, 2 ANNEXES AND 73 PAGES. It includes 10 articles dedicated to the fabrication, erection works and quality control of the steel structures.

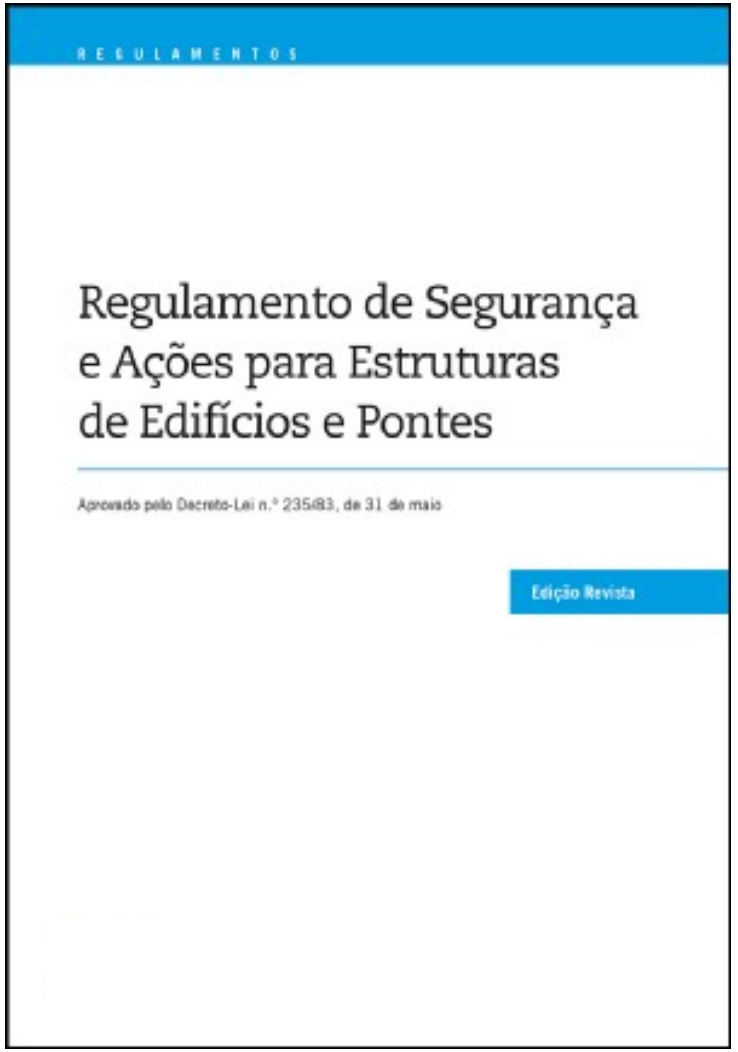
The portuguese structural design codes

In 1983 two most important design codes were published:

- Regulamento de Segurança e Ações para Estruturas de Edifícios e Pontes (R.S.A.) (Regulation for the Safety and Actions on Buildings and Bridges Structures) - 59 ARTICLES, 3 EXTENSIVE ANNEXES AND 114 PAGES.
- Regulamento de Estruturas de Betão Armado e Pré-Esforçado (REBAP) (Regulation for the Reinforced and Prestressed Concrete Structures), with 176 ARTICLES, 2 EXTENSIVE ANNEXES AND 213 PAGES. The second annex contains some explanations and simplified rules dedicated to the safety checking for the fatigue ultimate limit states. The last 36 articles are concerned to the execution and the quality control of the reinforced and prestressed concrete structures.

Regulation for the Reinforced and Prestressed Concrete Structures

Regulation for the Safety and Actions on Buildings and Bridges Structures



The portuguese structural design codes

- The publication of the R.S.A introduced, at the time, a new philosophy on the structural safety checking: THE ULTIMATE LIMIT STATES CRITERIA.
- The necessity to adapt the existing design rules to this new criteria led to the simultaneously edition of the REBAP.
- In what concerns the buildings steel structures a simple adaptation of the existing law – REAE – to these ultimate limit states criteria was performed and some additional information, concerning the seismic action on steel structures was added. The values of the admissible stresses were substituted by the resisting design stresses.
- This republished REAE has 74 ARTICLES AND 2 ANNEXES. It keeps the same articles concerning the execution works and adds some dedicated to the quality control.

The portuguese structural design codes

Being **TODAY** responsible for the design of a building structure an engineer needs to be aware of:

- **236** regulations articles, for a CONCRETE STRUCTURE.
- **133** regulations articles, for a STEEL STRUCTURE.

The portuguese structural design codes

WHAT WILL BE THE SITUATION ON THE NEAR FUTURE?

Remark: Structural Eurocodes are not yet incorporated on the Portuguese law but they will be before the end of 2019.

- ALTHOUGH THE EUROCODES ADOPTED THE SAME STRUCTURAL SAFETY CHECKING PRINCIPLES OF THE ACTUAL PORTUGUESE LEGISLATION (ISSUED ON 1983), THEY INCLUDE MUCH MORE DESIGN AND DETAILING REQUIREMENTS. THESE AND THE INCREASING NUMBER OF RESTRICTIVE CONCEPTION AND DESIGN RULES ARE SPECIALLY EVIDENT IN WHAT CONCERNS THE SEISMIC DESIGN - EUROCODE 8.
- **TODAY IT IS ENOUGH TO OBTAIN, FOR EVERY STRUCTURAL MEMBER, A DESIGN STRENGTH LARGER THAN THE MAXIMUM APPLIED INTERNAL FORCES (INCLUDING THE ONES DUE TO THE SEISMIC LOAD COMBINATIONS).**
- TOMORROW , ADDITIONALLY ,WE WILL NEED TO ASSURE THAT THE OVERSTRENGTH OF SOME MEMBERS, OR SECTIONS, IS LARGER THAN THE OVERSTRENGTH OF OTHER MEMBERS, OR SECTIONS – **THE DISSIPATIVE ZONES**. THE OVERSTRENGTH OF THESE DISSIPATIVE ZONES MUST BE CAREFULLY CALIBRATED.

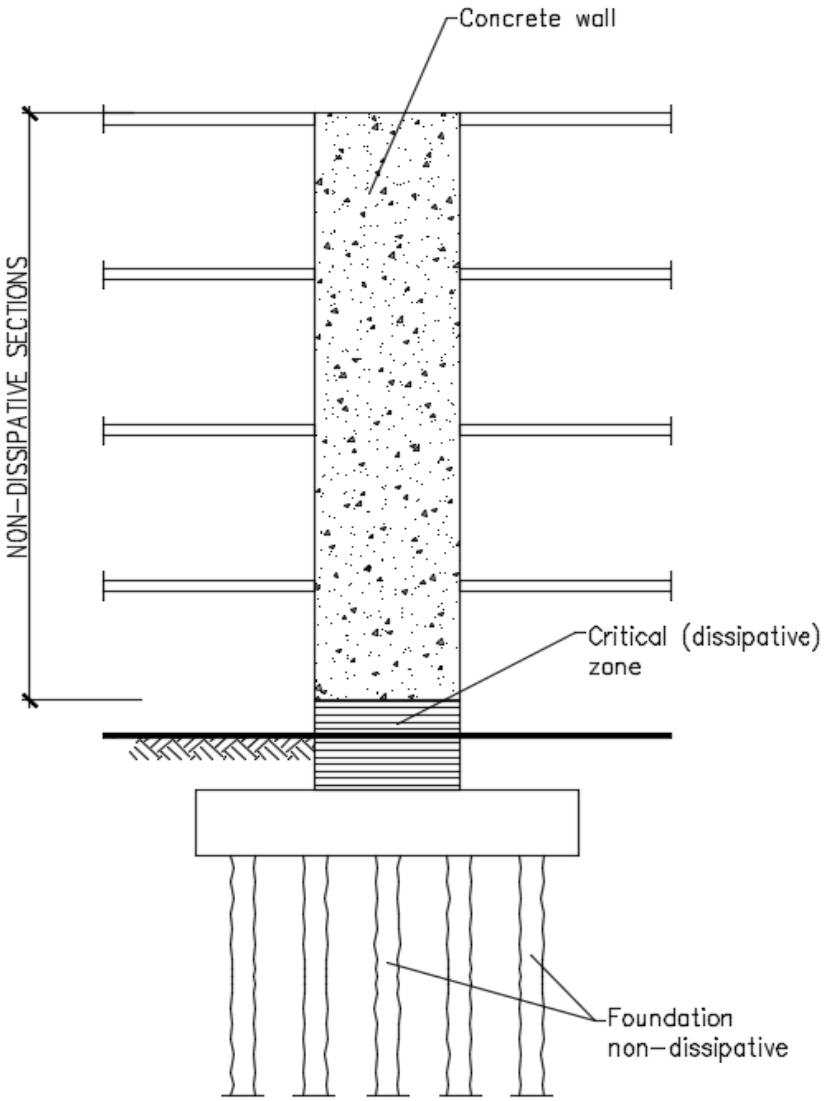
The portuguese structural design codes

WHAT WILL BE THE SITUATION ON THE NEAR FUTURE?

1st example: Ductile structural walls foundations design

TODAY: According to the actual legislation the foundations are designed to resist the same loads as the bottom of the vertical structural elements they support.

FUTURE CODE: If the resistance of the wall bottom exceeds the applied design forces, the foundation shall have the same overstrenght, at least.



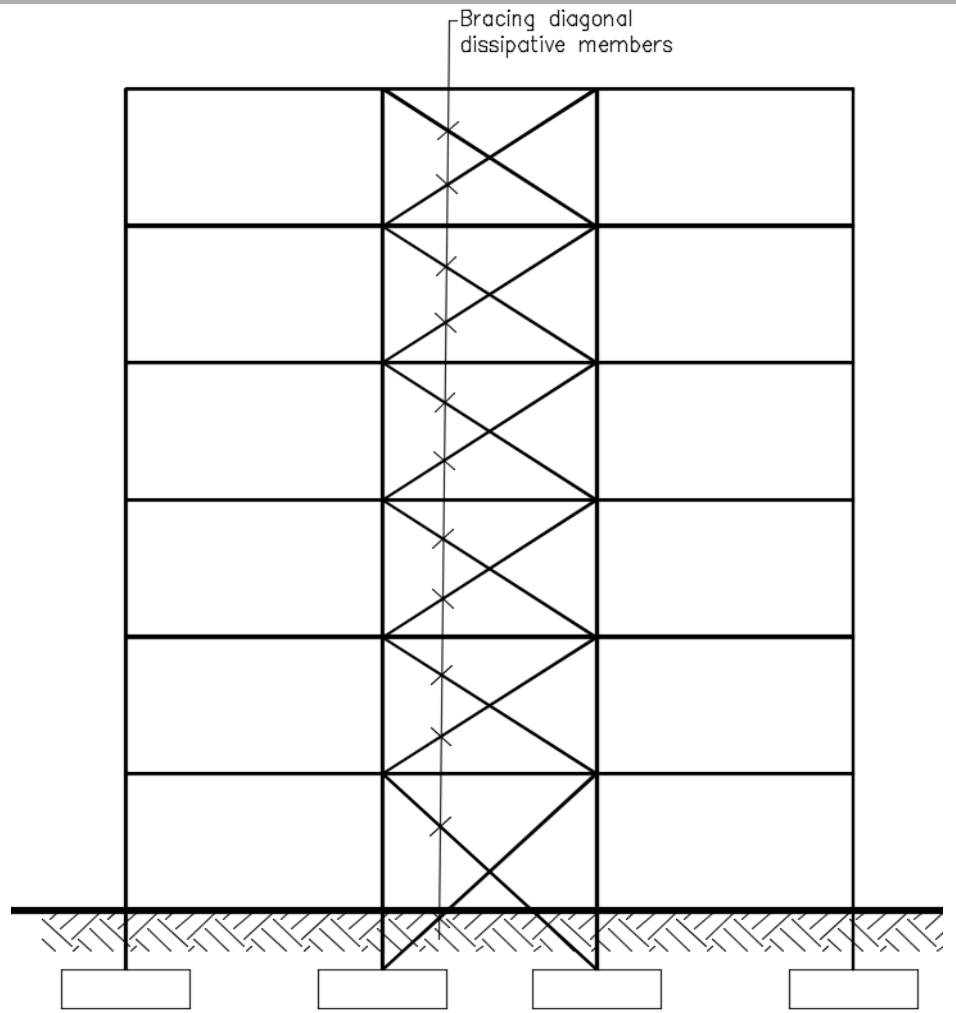
The portuguese structural design codes

WHAT WILL BE THE SITUATION ON THE NEAR FUTURE?

2nd example: Steel frame with concentric bracing

TODAY: According to the actual legislation, all the diagonal bracings can have any design strength, since it is larger than the maximum applied internal forces.

FUTURE CODE: The maximum overstrength of the diagonal bracings shall be smaller than the 1,25 x the minimum overstrength of them.



COLUMNS AND BEAMS – NON–DISSIPATIVE MEMBERS

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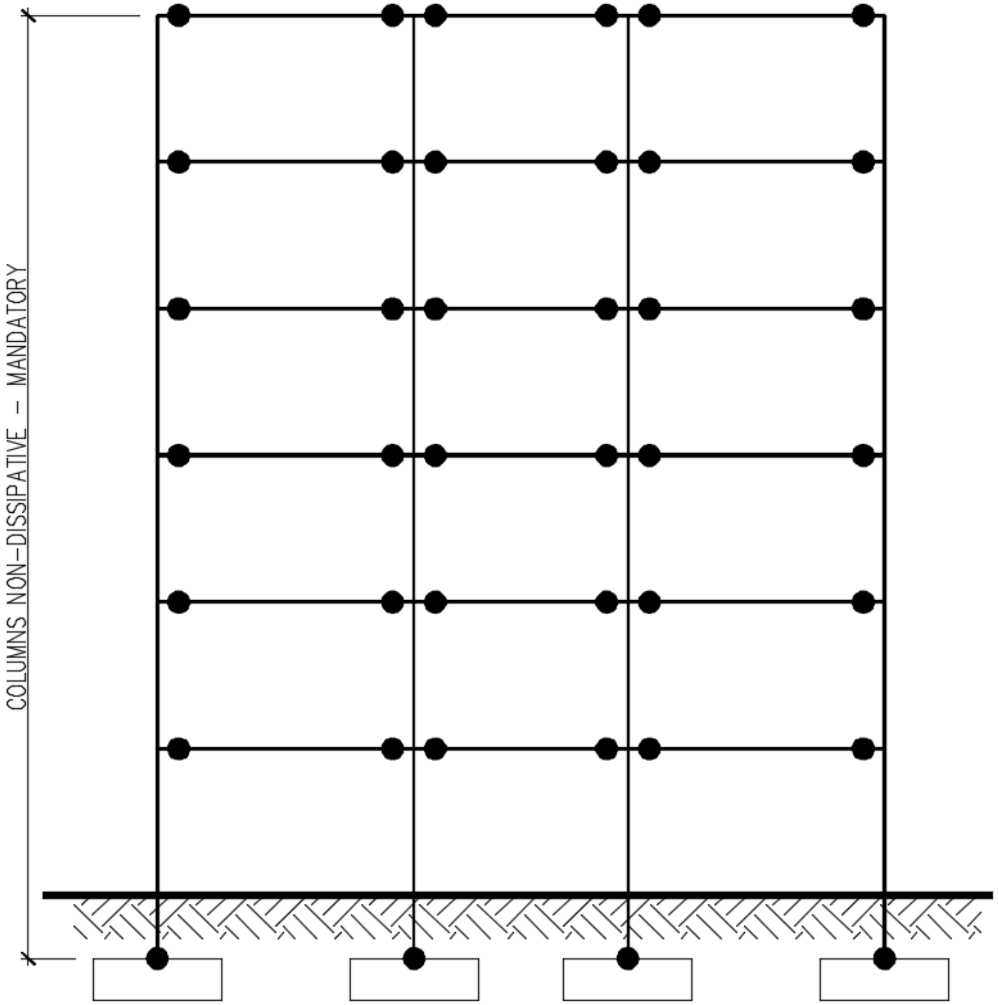
WHAT WILL BE THE SITUATION ON THE NEAR FUTURE?

3rd example: Concrete frame system

TODAY: The design strength of every column and beam only need to be larger than the maximum applied internal forces.

FUTURE CODE: The overstrength of the columns that connect to one joint shall be larger than the overstrength of the beams that are connected to the same joint. To define the necessary shear resistance of a beam one has to assume the magnitude of the bending moments at their extremities is equal to the section plastic resistance – to avoid a shear failure.



• Admissible plastic hinge locations

The portuguese structural design codes

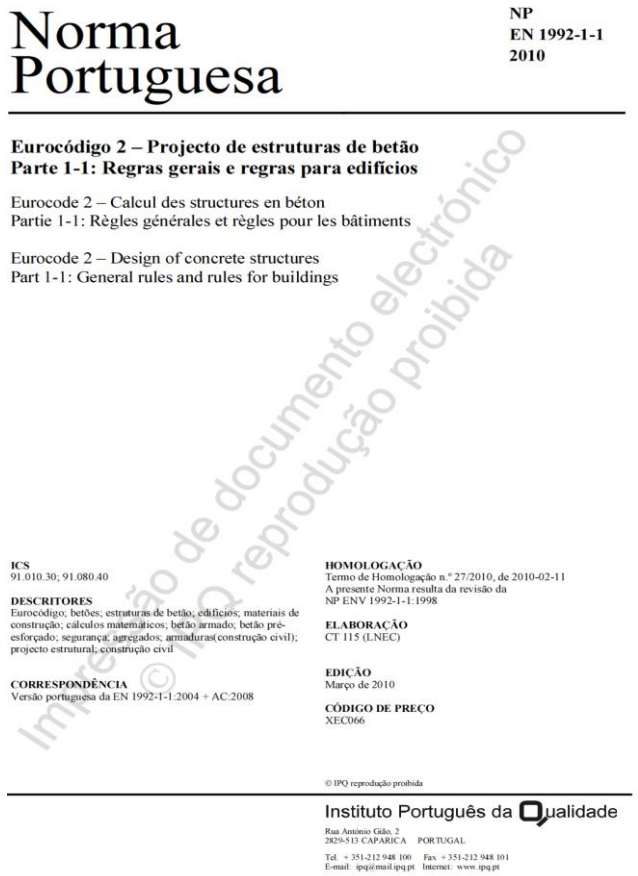
WHAT WILL BE THE SITUATION ON THE NEAR FUTURE?

These examples illustrate only a small, yet important, number of design rules.

IT IS NOT ENOUGH TO GET A STRUCTURE WHERE THE STRENGTH OF ALL ITS MEMBERS IS LARGER THAN THE APPLIED LOADS.

EUROCODE 8 SPECIFIES MANY MORE NEW DESIGN RULES (MORE THAN ONE HUNDRED), CONCERNING THE DESIGN AND DETAILING OF STRUCTURAL MEMBERS, BASED ON THE SAME PRINCIPLES OF **DESIGN CAPACITY**, BOTH FOR CONCRETE AND STEEL STRUCTURES, THAT NEED TO BE RESPECTED.

The portuguese structural design codes



Norma Portuguesa

NP EN 1992-1-1 2010

Eurocódigo 2 – Projecto de estruturas de betão
Parte 1-1: Regras gerais e regras para edifícios

Eurocode 2 – Calcul des structures en béton
Partie 1-1: Règles générales et règles pour les bâtiments

Eurocode 2 – Design of concrete structures
Part 1-1: General rules and rules for buildings

ICS
91.010.30; 91.080.40

DESCRITORES
Eurocódigo; betões; estruturas de betão; edifícios; materiais de construção; cálculos matemáticos; betão armado; betão pré-esforçado; segurança; agregados; armaduras(construção civil); projecto estrutural; construção civil

CORRESPONDÊNCIA
Versão portuguesa da EN 1992-1-1:2004 + AC:2008

HOMOLOGAÇÃO
Termo de Homologação n.º 27/2010, de 2010-02-11
A presente Norma resulta da revisão da NP ENV 1992-1-1:1998

ELABORAÇÃO
CT 115 (LNEC)

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CÓDIGO DE PREÇO
XEC066

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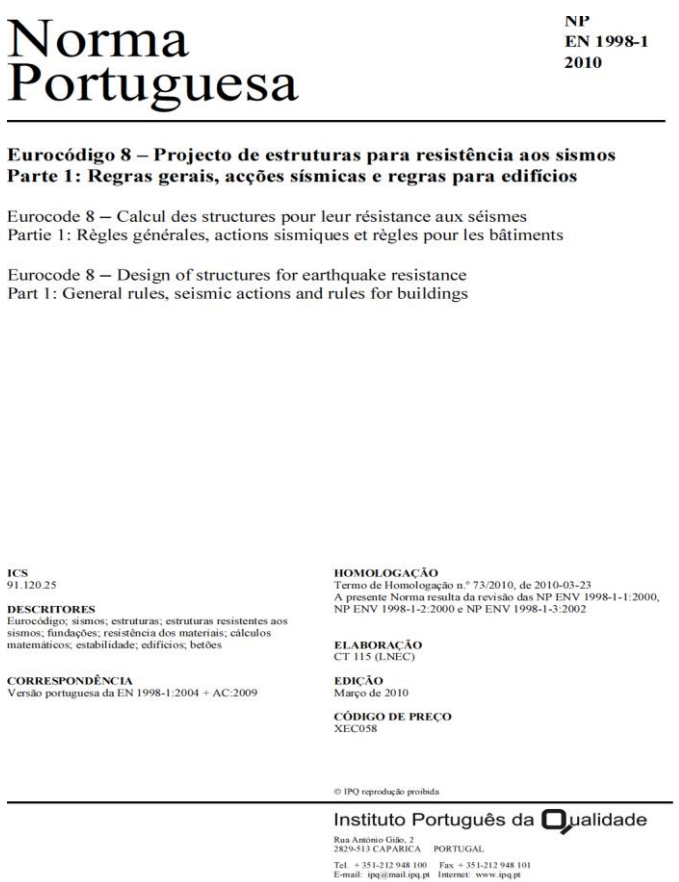

Norma Portuguesa

NP EN 1998-1 2010

Eurocódigo 8 – Projecto de estruturas para resistência aos sismos
Parte 1: Regras gerais, acções sísmicas e regras para edifícios

Eurocode 8 – Calcul des structures pour leur résistance aux séismes
Partie 1: Règles générales, actions sismiques et règles pour les bâtiments

Eurocode 8 – Design of structures for earthquake resistance
Part 1: General rules, seismic actions and rules for buildings

ICS
91.120.25

DESCRITORES
Eurocódigo; sismos; estruturas; estruturas resistentes aos sismos; fundações; resistência dos materiais; cálculos matemáticos; estabilidade; edifícios; betões

CORRESPONDÊNCIA
Versão portuguesa da EN 1998-1:2004 + AC:2009

HOMOLOGAÇÃO
Termo de Homologação n.º 73/2010, de 2010-03-23
A presente Norma resulta da revisão das NP ENV 1998-1-1:2000, NP ENV 1998-1-2:2000 e NP ENV 1998-1-3:2002

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The portuguese structural design codes

WHAT WILL BE THE SITUATION ON THE NEAR FUTURE?

- In order to respect the new design codes a structural engineer involved on the design of a building needs to study and apply the following European standards:
  - EN 1990 – **Eurocode 0** – Basis of Structural Design with 36 design rules and 2 relevant annexes on 57 pages.
  - EN 1991 – **Eurocode 1** – Actions on Structures with 72 design rules and 4 annexes, over more than 200 pages, applicable to the building structure design.
  - EN 1992 – **Eurocode 2** – Design of **Concrete** Structures: Part 1.1 – General rules and Rules for Buildings with 141 design rules and 10 relevant annexes on 200 pages.
  - EN 1993 – **Eurocode 3** – Design of **Steel** Structures: Part 1.1 – General Rules and Rules for Buildings with 61 design rules and 4 relevant annexes on 114 pages ; Part 1.5 – Plated elements with 42 design rules and 4 relevant annexes on 58 pages ; Part 1.8 - Connections with 82 design rules and 1 relevant annex on 145 pages.
  - EN 1998 – **Eurocode 8** - Design of Structures for Earthquake Resistance: Rules applicable to the design of building **concrete** structures with 51 design rules and 2 relevant annexes on 138 pages; Rules applicable to the design of building **steel** structures with 53 design rules and 2 relevant annexes on 110 pages.

- For every part of the Eurocode one also needs to know the corresponding national annex's articles.

The portuguese structural design codes

WHAT WILL BE THE SITUATION ON THE NEAR FUTURE?

SUMMARY

According to the new Portuguese codes the same engineer responsible for the design of a building structure needs to be aware of a minimum of:

- **300 rules for a concrete building.**
- **346 rules for a steel building.**

	Concrete	Steel
Existing Codes	236	133
Future Codes	300	346

The portuguese structural design codes

WHAT WILL BE THE SITUATION ON THE NEAR FUTURE?

Adding to the increases on the design rules, a structural designer must be familiar with the specific European standards for the execution of the concrete or steel structures:

- EN 13670, where some **40** rules are of relevant importance for a structural designer.
- EN 1090, where some **35** rules are of relevant importance for a structural designer.

The portuguese structural design codes

The always increasing extension and complexity of the codes to be respected have, probably, the same expression on others professional activities but what reasons can we find for these evolutions on the rules concerning the structural design?

How shall we look to them?

- There is no doubt that they correspond to the evolution on knowledge of the materials and structures behaviour that happened on the last thirty years.
- The tools now available for the structural analysis and the design of structures are completely different and more sophisticated that the ones used thirty years ago. Today it is possible to perform much more complex analysis using software that is users friendly and ease to obtain.
- As a consequence, the way we think and design the structures has changed. Design methods and processes had also an unquestionable evolution. Today they are much more automatic with an increasing reduction on the direct interference of the designer.
- THE DESIGN RULES NEEDED, OBVIOUSLY, TO BE ADAPTED TO THE ACTUAL CIRCUMSTANCES.

The portuguese structural design codes

- BUT THE AMOUNT OF NEW RULES AND RESTRICTIONS RAISE SOME PERTINENT QUESTIONS :

- *Are ALL the requirements of the codes strictly necessary to guarantee the safety of the people and the functionality of the constructions? Could the number of rules de diminished?*
- *Does a structural engineer needs to have a deep knowledge of the structural design rules? Can he rely, more and more, on the design software to check the structural safety, even ignoring their fundamentals?*
- *Do we want to have engineers that thoroughly understand and, when involved on the structural conception and design, respect the construction materials own mechanical characteristics and respective behaviours?*
- *Or, what we want is engineers that are specialist on the codes rules, limitations and required safety checking?*
- *Can we have both professionals on the same person and, simultaneously, a sensible and creative engineer?*
- *What is the role of the teaching institutions: to raise students that know the maximum possible amount of the design rules or to raise students that are very aware of the structural materials behaviours and limitations and can adapt themselves to future code changing?*

STRUCTURAL ENGINEERS OR STRUCTURAL CODES SPECIALISTS?

The portuguese structural design codes

And, according to what is already known, the next editions of the Structural Eurocodes will have even more parts or more articles on the same parts.

MORE RULES TO BE STUDIED AND INCORPORATED ON THE STRUCTURAL DESIGN.

The portuguese structural design codes

THE PREDICABLE EVOLUTION

a) Much more specialization will be required for the individual structural engineers. Probably a structural engineer that designs concrete buildings will not have the necessary expertise to design steel buildings.

b) Small design offices will have to dedicate themselves to only one of the two main structural materials: concrete or steel.

c) A complete separation between:
   - The conceptual design, made by one design office that provides only a preliminary design together with a rough cost estimation and,
   - The detailed designer, that will get the responsibility to carry out all the safety checking and the detailed structure design.

The portuguese structural design codes

THE PREDICABLE EVOLUTION

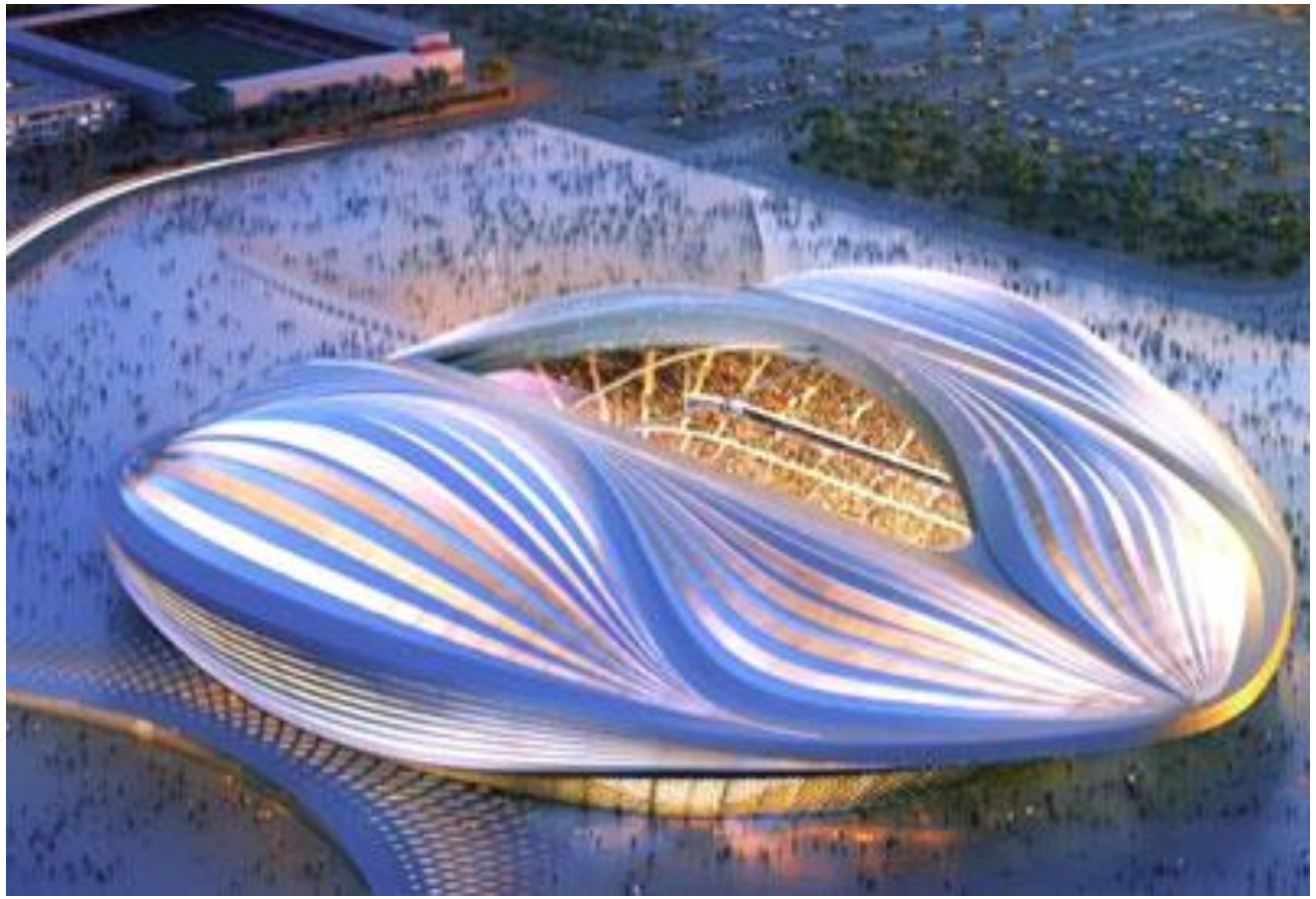
e) Regular structures safety checking, assembly drawings, reinforced concrete drawings and connections details (for steel structures) will be, more and more, allocated to specific software tools.

f) Special structures – irregular, complex and including two or more structural materials –will be designed by large design offices where all the capacities can be put together.

g) Progressive rationalization of the project and its integration with the construction process.

BUILDING REGULAR STRUCTURE

IRREGULAR AND COMPLEX STRUCTURE



THE END

THANK YOU!