

INTERNATIONAL ARCHITECTURAL COMPETITION FOR THE NEW CYPRUS MUSEUM

Competition Number: A/10/2016

Part C4

Structural Design Guidelines

Nicosia
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1.0 GUIDELINES FOR THE STRUCTURAL/SEISMIC DESIGN

The guidelines' purpose is to orient and guide designer Civil Engineers in solutions/arrangements which will meet the requirements/ specifications of the building.

During the drawings preparation stage of the Architectural Competition it is expected by the contestants to describe in general the structural analysis methods, their assumptions and indicate on the drawings the position and expected size of the structural elements.

The design must take into consideration the geometry of the Buildings, the ground conditions, the functionality of the buildings, the requirements on earthquake resistance / fire resistance / environmental factors of the area.

The designers who will undertake the structural / seismic design of the Building should have in mind that they will conduct all the designs, drawings, details, terms and specifications for the construction, supervision and testing until the delivery of the Project.

2.0 GUIDELINES FOR THE BEHAVIOUR AND DESIGN OF THE BUILDING

2.1 Durability

The structure should have the ability to resist the environmental influences (physical and chemical) without losing its strength and functionality.

For this purpose:

- During the preliminary design, in addition to the mechanical actions, the environmental exposure as well as the expected influences must be taken into consideration in order to proceed with the preliminary durability design (eg. selection of suitable materials, selection of coatings and cover, selection of concrete and steel class).
- During the construction phase of the project the durability design should be implemented (eg. coatings, compaction and curing of concrete).

Based on:

- The above paragraphs,
 - The environmental influences and the potential deterioration mechanisms,
 - The required Design Working Life of the Building (see paragraph 2.3),
- the Civil Engineer is obliged to submit his designs and recommendations regarding the durability of the structure together with the schedule for the inspection, testing and maintenance of the structure.

2.2 Performance

The structure is required to fulfil the below requirements:

- Safety
Ability to withstand the imposed actions as well as fatigue.
- Functionality
eg. Minimize deformations, watertightness, minimize vibrations etc.
- Aesthetic Appearance
eg. Visible cracks avoidance, maintenance of geometrical characteristics etc.

2.3 Design Working Life of the Structure

The Design Working Life of the Structure or the Technical Service Life meaning the minimum time for which the structure will meet all performance requirements is set to at least 100 years.

2.4 Structural/Seismic Design

2.4.1 General

The Civil Engineer must submit for review the Structural / Seismic design, including the Geotechnical Design of the proposed buildings and other structures, including explanatory drawings of the structure and the foundations, as well as introductory report including:

- (i) The structural system of the structure,
- (ii) The loadings considered,
- (iii) The assumptions for the seismic actions and coefficients and the method of seismic analysis
- (iv) The standards used for the design
- (v) The foundation system (in accordance with the preliminary Geological - Geotechnical design) with its reinforcement, load spreading, stairwells, elevator shafts etc.
- (vi) The foundation design's assumptions and the ground-structure interaction system.

In addition, structural drawings with plans, layouts and sections of the structural system / retaining walls and foundations must be submitted for review. Where applicable, the waterproofing methods must be indicated.

2.4.2 Design Codes

In general, the latest versions of Eurocodes and their Cyprus National Annexes should be used.

(a) Code for the Calculation of Imposed Actions (or Loads)

The calculation of the imposed actions or loads will be based on CYS EN 1991 - Eurocode 1: Actions on Structures and its Cyprus National Annexes (NA to CYS EN 1991).

(b) Code for the Design of Reinforced Concrete Structures

The structural design of reinforced concrete structures will be based on CYS EN 1992 - Eurocode 2: Design of concrete structures in conjunction with the requirements of:

- i) CYS EN 1990: Basis of Structural Design
- ii) CYS EN 1991- Eurocode 1: Actions on structures
- iii) CYS EN 1997 – Eurocode 7: Geotechnical Design
- iv) CYS EN 1998 – Eurocode 8: Design of Structures for Earthquake Resistance

(c) Code for the Design of Steel Structures

The structural design of steel structures will be based on CYS EN 1993 - Eurocode 3: Design of steel structures in conjunction with the requirements of:

- i) CYS EN 1990: Basis of Structural Design
- ii) CYS EN 1991- Eurocode 1: Actions on structures
- iii) CYS EN 1997 – Eurocode 7: Geotechnical Design
- iv) CYS EN 1998 – Eurocode 8: Design of Structures for Earthquake Resistance

and in addition of CYS EN 1992 to CYS EN 1999 where there is reference to steel structures and / or their members.

(d) Code for the Design of Composite Steel and Concrete Structures

The structural design of composite steel and concrete structures will be based on CYS EN 1994 - Eurocode 4: Design of composite steel and concrete structures in conjunction with the requirements of:

- i) CYS EN 1990: Basis of Structural Design
- ii) CYS EN 1991 – Eurocode 1: Actions on structures
- iii) CYS EN 1992 – Eurocode 2: Design of concrete structures

- iv) CYS EN 1993 – Eurocode3: Design of steel structures
- v) CYS EN 1997 – Eurocode 7: Geotechnical Design
- vi) CYS EN 1998 Eurocode 8: Design of Structures for Earthquake Resistance

(e) Code for the Design of Timber Structures

The structural design of timber structures will be based on CYS EN 1995 - Eurocode 5: Design of timber structures in conjunction with the requirements of:

- i) CYS EN 1990: Basis of Structural Design
- ii) CYS EN 1991 – Eurocode 1: Actions on structures
- iii) CYS EN 1998 – Eurocode 8: Design of Structures for Earthquake Resistance

(f) Code for the Design of Masonry Structures

The structural design of masonry structures will be based on CYS EN 1996 - Eurocode 6: Design of masonry structures in conjunction with the requirements of CYS EN 1990 to CYS EN 1999.

(g) Code for the Design of Geotechnical Works

The geotechnical works' design will be based on CYS EN 1997 - Eurocode 7: Geotechnical Design in conjunction with the requirements of CYS EN 1990: Basis of Structural Design and also of the CYS EN 1991 to CYS EN 1999.

(h) Code for the Design of Aluminium Structures

The structural design of aluminium structures will be based on CYS EN 1999 - Eurocode 9: Design of aluminium structures in conjunction with the requirements of:

- i) CYS EN 1990: Basis of Structural Design
- ii) CYS EN 1991- Eurocode 1: Actions on structures
- iii) CYS EN 1998 – Eurocode 8: Design of Structures for Earthquake Resistance

5.7.3 Seismic actions

- (a) The seismic actions to be considered in the seismic design calculations will be based on the requirements of CYS EN 1998: Design of Structures for Earthquake Resistance in conjunction with the requirements of the national defined parameters as stated in the National Annex NA to CYS EN 1998-1.
- (b) The minimum parameters for the seismic design calculations of structures are the following:
- i) Seismic Zone and maximum reference peak ground acceleration on Type A ground (α_{gR}) based on the Seismic Zoning Map of Cyprus
 - ii) Importance class of building: III at minimum or as stated on Table 4.3 of CYS EN 1998-1.
 - iii) Importance factor of building γ_1 : 1.20 at minimum or as stated in NA 2.12 Clause 4.2.5(5)P of NA to CYS EN 1998-1.
 - iv) Ground Type: will be characterised based on Table 3.1 of CYS EN 1998-1 and the findings of the geotechnical investigation which will be executed by the Contractor.
 - v) Soil factor S and characteristic spectrum periods: will result from the ground type in accordance with Table 3.2 of NA to CYS EN 1998-1.
 - vi) The lower bound factor for the horizontal design spectrum (β): 0.2 in accordance with NA 2.9 Clause 3.2.2.5 (4)P of NA to CYS EN 1998-1.
 - vii) Vertical component of the seismic action: it must be taken into account when $\alpha_{vg} \geq 0.25g$ and in the cases listed below:
 - for horizontal or nearly horizontal structural members spanning 20m or more,
 - for horizontal or nearly horizontal cantilever components longer than 5m,
 - for horizontal or nearly horizontal pre-stresses components,
 - for beams supporting columns,
 - for elements supporting the abovementioned components,
 - in base-isolated structures

- viii) Ductility class: Ductility Class Medium (DCM) at minimum or as required according to NA 2.16 Clause 5.2.1 (5) of NA to CYS EN 1998-1.
- ix) Behaviour factor q for concrete structures:
- $q = q_0 \cdot K_w \geq 1.5$ (5.2.2.2 CYS EN 1998-1)
where q_0 = basic value of behaviour factor, in accordance with the ductility class and the structural system, based on Table 5.1, 5.2.2.2 of CYS EN 1998-1 and on NA 2.17 clause 5.2.2.2.1(10) of NA to CYS EN 1998-1. Note that for buildings which are not regular in elevation the value of q_0 should be reduced by 20% (see 4.2.3.1(7) and Table 4.1 of CYS EN 1998-1).
 - $K_w = 1$ for frame systems
 $0.5 < K_w \leq 1.0$ for wall and torsionally flexible systems. The value of K_w depends on the aspect ratio height / length of the walls and should be calculated in accordance with 5.2.2.2 (11P) of CYS EN 1998-1.
 - The value of α_u/α_1 , depending on the structural system's type and the regularity or not of the building in elevation, will range from 1.1 to 1.3 and should be calculated in accordance with 5.2.2.2 (5) and (6) of CYS EN 1998-1.
 - Higher values of α_u/α_1 are allowed provided they are confirmed through a nonlinear static (pushover) global analysis, with maximum allowed value equal to 1.5, in accordance with 5.2.2.2 (7) and (8) of CYS EN 1998-1.
- (c) Earthquake effects must be taken into consideration in the design of retaining walls.

2.5 Quality Control

The preparation of a quality control program is required in accordance with the provisions of the Contract. The Employer must be notified for the test results. The Designer Civil Engineers must notify the Employer of their opinion regarding the test results.

Quality control must be conducted by independent recognized private quality control laboratories or governmental services laboratories in Cyprus. Quality checks performed by laboratories who have direct or indirect relationship with the Contractor or the Consultants will not be accepted.

The above tests must be conducted in accordance with the local legislation and standards. Where there is no relating local legislation or standard, the European or other internationally recognised standards should be used.

2.6 Materials

In general all the materials must satisfy the purpose for which they are intended ensuring the requirements for safety, functionality, durability etc. as required by the legislation and standards.

2.6.1 Concrete must be at minimum of class C30 / 37 for all concrete structural elements.

2.6.2 Reinforcing steel must be of class B500C.

3.0 LOADS

3.1 Live Loads

TABLE 1: LIVE LOADS

General Areas	3 KN/m ²
Not accessible roofs	2 KN/m ²
Areas for storage use including storage of documents and other materials	10 KN/m ²
Machinery spaces	15 KN/m ²
Office areas	5 KN/m ²
Corridors	5 KN/m ²
Areas where people congregate	7.5 KN/m ²
Stairwells	5 KN/m ²
Meeting rooms	5 KN/m ²
Parking areas and underground ramps	10 KN/m ²

- 3.2 The above mentioned loads are the minimum.
- 3.3 In areas not mentioned in the above Table 1, live loads must be taken either by the abovementioned standards (CYS EN 1991 and NA to CYS EN 1991-1-1, Table 6.2) for areas with normal use, or by analytical calculations for areas of special use.
- 3.4 Loads for anticipated equipment and electromechanical machinery, will be calculated analytically taking into consideration their support conditions and all other characteristics (weight, moving masses, frequencies, transportation and assembly methods, maintenance methods etc).
- 3.5 Loads resulting from analytical calculations should be considered in structural calculations only in cases where they are higher than the relevant loads referred in the abovementioned paragraphs.
- 3.6 When determining equipment and machinery loads, their dynamic influence (if any) must be taken into consideration.

4.0 SUBMISSION CONTENTS

- 4.1 All Civil Engineering designs must be submitted to the Employer for review in two stages, Preliminary Design and Final Design.
- 4.2 For the Preliminary Design at least and without any limitation, the following must be submitted: the Geological and Geotechnical Investigation Report; the proposed structural system of the building including the proposed foundation type with documentation based on the assessment of the Geotechnical investigation results, carried out by the designer Civil Engineer; the proposed construction materials for the load bearing structure of the building; layout of the proposed load bearing structure with preliminary dimensions of the various elements; the proposed horizontal and vertical loads and the loading combinations including diagrams of permanent and live loads in every slab of the structure. Proposals for any retaining works or other geotechnical structures, permanent or temporary, must also be submitted, with documentation for their selection and preliminary dimensioning. Furthermore, a proposal for the protection system of foundations and basements (if any) from water and moisture penetration must be submitted, including a summary of the proposed construction method of a drainage system if required. The methodology for the construction of foundations, basements (if any) and the retaining works (if any), permanent or temporary, must also be submitted. If asked, the methodology for the construction of the above ground structure must be submitted.
- 4.3 For the Final Design the following must be submitted: all the above mentioned documents as revised taking into consideration the Employer's comments (except of the Geological and Geotechnical Investigation Report and the Laboratory Test Results Report for the materials of the existing building); printed structural calculations with all assumptions of the structural design, together with layouts of the components of the load bearing structure indicating the permanent and the live loads on every slab, the loads or the load combinations which cause the most adverse stresses on structural members and the dimensioning and reinforcement of all structural members. The Structural Design Assumptions Form (see Annex I) must be filled, signed and submitted. Full construction drawings and specifications must also be submitted as described above.

- 4.4 In case where the design includes road works or external parking spaces, survey drawings, horizontal and vertical alignments with draft drawings of services and structures and materials proposal (eg. parking spaces floorings) must be submitted in the Preliminary Design. For the Final Design, full construction drawings, specifications and structural designs of load bearing structures made of reinforced concrete or other materials must be submitted as required by the Tender Documents.
- 4.5 All the contents of the Preliminary and Final Design must be submitted for consent in 3 printed copies and in digital form (in a CD). The drawings must be submitted digitally in .dwg files (which can be edited) and .pdf files. The final approved for construction drawings as well as the "as-built" drawings must be submitted digitally in .dwg files (which can be edited) and .pdf files, in addition to the printed A1-sized copies in numbers specified in Chapter 1 of this Volume.
- 4.6 With Final Design submission the Consultants must submit a digital disk (CD) with the digital file of the structural model of the structure or structures, in the structural analysis and dimensioning software used for the design. The file to be submitted must be able to run in a PC on which the same structural analysis and dimensioning software has been installed. That digital file, including any amendments made during the construction stage, must be resubmitted with the submission of the as-built drawings at the completion of the project. If asked by the Employer, the digital file with the structural model must be submitted during the construction of the project in order to give his consent for any design amendments.