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211101

CHINA ROAD AND BRIDGE CORPORATION
NEW PORTO CAIO BUILDINGS - CABINDA

CABINDA - ANGOLA

ISPS BUILDING

Foundations and Structure
Execution Project

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DESCRIPTIVE AND JUSTIFICATIVE MEMORY



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1 INTRODUCTION

This Descriptive and Justified Report refers to the Foundations and Structures Project for Building No. 4 (ISPS Building), part of the group of buildings that make up the Port Complex of Porto Caio de Cabinda – Angola, requested by CRBC.

This document describes and justifies the sizing criteria and safety checks adopted in the structural calculation in the aforementioned discipline.

During the construction phase, the Contractor must be aware of all the constraints before starting work in order to plan the execution of the various tasks and size his work teams to ensure their full compliance.

In preparing the project, the applicable regulations were followed, taking as reference the structural Eurocodes and standards referring essentially to construction products and construction processes, which are listed below:

- Eurocode 0–Basis for the Design of Structures (EN 1990).
- Eurocode 1–Actions on Structures (EN 1991).
- Eurocode 2–Design of Concrete Structures (EN 1992-1-1:2010).
- Eurocode 7–Geotechnical Design (EN 1997).

2 CHARACTERIZATION OF THE PROPOSAL

We sought to find suitable structural solutions that guarantee the building's structural performance and that integrate perfectly into the Architecture.

The reinforced concrete structure is fundamentally made up of pillars and beams, which are arranged in different ways to meet the needs of the architectural project.

Regarding raised floors, a solution of beamed slabs is proposed, with thickness adapted to the structural requirements of the building, generally 0.16m thick.

The building's foundations will be built with reinforced concrete footings set at a depth of 2.10m, considering the soil's resistant tension of 120kPa in accordance with the geotechnical study data.

3 MATERIALS

3.1 Concrete

The selection and specification of the concrete was made based on the environment to which the structure will be exposed. This specification complies with the provisions of standards NP EN 1992, NP EN 206-1 and E464.

The table below specifies the concrete to be used in the various structural elements and the recommended nominal coverings, with the structure designed for a useful life of 50 years.

MATERIALS	STANDARD	CLASS
Shoes	NP EN 206-1	C35/45
Foundation Lintel	NP EN 206-1	C35/45
Pillars	NP EN 206-1	C30/37
Beams	NP EN 206-1	C30/37
Slabs	NP EN 206-1	C30/37
Steps	NP EN 206-1	C25/30

3.1 Steel

Reinforcement for reinforced concrete follows the characteristics indicated in the table below.

MATERIALS	STANDARD	CLASS
Steel in Ordinary Armor	LNEC E 460	A500 NR
Electro-insulated network	LNEC E 457	A500 NL

4 MODELING AND ANALYSIS

To calculate the efforts, stresses, displacements and deformations, as well as to obtain the geometry of the structural elements to simulate the behavior of the structure, the automatic calculation program CYPECAD V2025.c was used, whose calculation philosophy is based on the finite element method.

The calculation models used in the dimensioning of the structure considered its discretization, in three-dimensional models, through finite bar elements in the case of columns and beams, and shell finite elements in the case of slabs, walls and fences, with the characteristics of the represented element.



4.1 Actions

Own Weight

- Specific gravity of steel.....78.50 kN/m³
- Specific weight of reinforced concrete.....25.00 kN/m³
- Specific weight of concrete for fillers.....20.00 kN/m³
- Volumetric weight of soil.....18.00 kN/m³

Non-structural self-weight

- Coverage.....2.60 kN/m²
- Floor 1.....2.60 kN/m²
- Steps.....1,00 kN/m²
- Weight of the walls.....10.80 kN/m

Usage Overload

- Coverage.....0.40 kN/m²
- Floor 1.....3.00 kN/m²
- Steps.....5.00 kN/m²

Horizontal Actions

With regard to horizontal actions, the following parameters are considered:

The wind action adopted was that recommended by the regulations;

- Eurocode 1: Actions on Structures, General Actions - Wind actions. NP EN 1991-1-4 (2005);
- National Implementation Document for Portugal (NP EN 1991-1-4/NA (2010))

Zone: A (30 m/s)

Land category: I

Payback period (years): 50

The action of the earthquake was not considered in the analysis, as there are no significant records of seismic activity in Cabinda.

4.2 Action Combinations

This section presents the combinations of actions carried out with a view to determining the forces in the sections of the structure for subsequent verification of safety in relation to the limit states to be considered.

Ultimate Limit States

Fundamental Combination

$$\sum_{j \geq 1} \gamma_{G,j} G_{k,j} + \gamma_{Q,1} Q_{k,1} + \sum_{i > 1} \gamma_{Q,i} \psi_{0,i} Q_{k,i}$$

Combinations for Accidental Project Situations

$$\sum_{j \geq 1} G_{k,j} + A_d + \sum_{i > 1} \psi_{2,i} Q_{k,i}$$

Serviceability Limit States

Characteristic Combination of Actions:

$$\sum_{j \geq 1} G_{k,j} + Q_{k,1} + \sum_{i > 1} \psi_{0,i} Q_{k,i}$$

Frequent Combination of Actions:

$$\sum_{j \geq 1} G_{k,j} + \psi_{1,1} Q_{k,1} + \sum_{i > 1} \psi_{2,i} Q_{k,i}$$

Quasi-permanent Combination of Actions:

$$\sum_{j \geq 1} G_{k,j} + \sum_{i \geq 1} \psi_{2,i} Q_{k,i}$$

In the combinations made, the parts corresponding to the variable actions are or are not additive, depending on whether or not they contribute to increasing the calculation efforts.

4.3 Safety factors and reduced values

In calculating the combination values of the various actions, the following safety coefficients and coefficients were considered: Ψ to obtain the reduced values:

Permanent Actions:

- Structural Dead Weights: $\gamma_g = 1.35$ or 1.00
- Non-Structural Dead Weights: $\gamma_g = 1.50$ or 1.00
- Retraction: $\gamma_g = 1.00$ or 0.00

Variable Actions

- Uniform Temperature: $\gamma_q = 1.50$
 $\psi_0 = 0.60; \psi_1 = 0.50; \psi_2 = 0.00$
- Overloads in Buildings: $\gamma_q = 1.50$

Category B: (Offices)

$$\psi_0 = 0.70; \psi_1 = 0.50; \psi_2 = 0.30$$

Type 1 Overload (Category H: Roofs):

$$\psi_0 = 0.00; \psi_1 = 0.00; \psi_2 = 0.00$$

4.4 Section Analysis

The load-bearing capacity of reinforced concrete elements was determined assuming the plasticization of the section, ensuring a ductile failure mode whenever possible. Linear analyses with limited stress redistribution may be performed, within the limits defined in NP EN 1992.

The load-bearing capacity of the metal elements was determined by combining the load-bearing capacity of the sections and the susceptibility of the elements to instability phenomena. In the case of class 1 and 2 sections, the plastic load-bearing capacity of the section was used. In the case of class 3 and 4 sections, the elastic load-bearing capacity of the section was used, although reduced in the latter case to take into account the effects of local buckling.

4.5 Calculation Models

To calculate the forces, stresses, displacements and deformations, calculation models that simulate the behavior of the structure were used. The software used was CYPE 3d, whose calculation philosophy is based on the finite element method.

The calculation models used in the design of the structure considered its discretization in three-dimensional models, through finite bar elements in the case of columns and beams, and shell finite elements in the case of slabs, walls and fences, with the characteristics of the represented element. The foundations were, in general, modeled by an embedment.

Loads, whether point, linear or distributed, are applied to the various finite elements, or are directly recorded by the software, as in the case of the self-weight of structural elements. Response spectra are automatically entered by the software, through the prior definition of the parameters required for their definition.

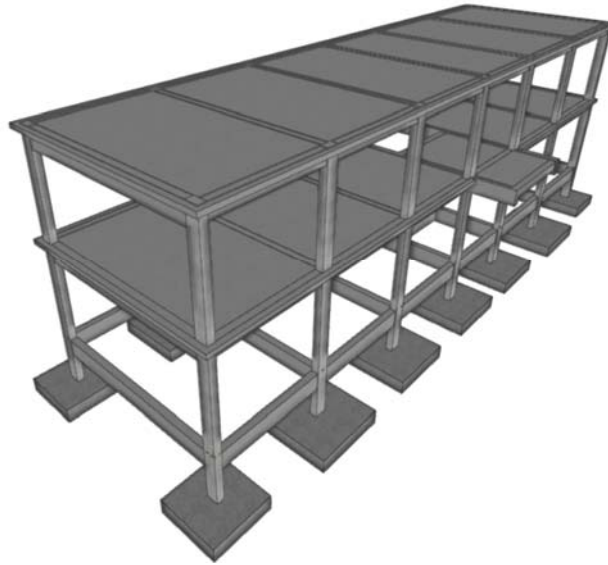


Fig. 01–Structural Model of the Building

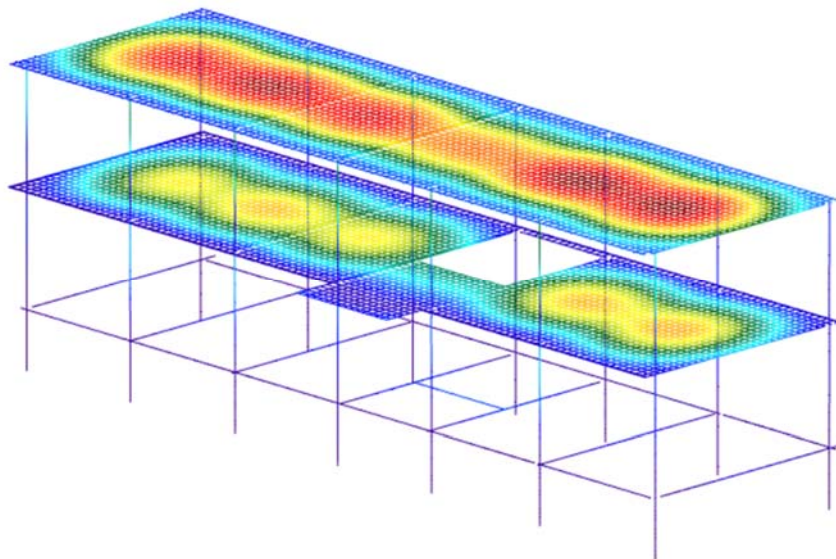


Fig. 02 – Analytical model of the structure

5 CRITERIA FOR VERIFYING THE SAFETY OF ELEMENTS

The objectives of structural safety verification are:

- Ensure an adequate level of safety in relation to failure situations compatible with the type of structural design adopted during the construction phase of the structure, after its entry into service and during the predefined useful life period;

- Ensure that it behaves properly after it is put into service.

To this end, the philosophy of limit states was used, which, through the comparison of action values or other quantities that can be related to resistance values, ensures the verification of the various structural elements and their respective sections considered critical.

In terms of ultimate limit states (1st objective), the upper characteristic values were adopted for the effects of the actions (S_k) and the lower characteristic values for the resistances (R_k). Partial safety factors were also adopted to increase the effects of the actions (γ_f) and reduce resistance (γ_m). Finally, the effects of the increased actions (S_d) were compared with the reduced resistances (R_d):

In the case of serviceability limit states (2nd objective), levels of expected actions on the structure (through combinations of actions) and average characteristics for the behavior of the materials were adopted, and it was verified whether the values of the effects of the actions do not exceed admissible values for the levels of actions considered.

5.1 ULTIMATE LIMIT STATES

5.1.1 Reinforced Concrete Structure and Metal Structures

The verification of the various reinforced concrete elements and steel structures at the Ultimate Limit State followed the definitions in Chapter 6 of NP EN 1992-1 and NP EN 1993-1, respectively. In detailing the elements, the construction provisions and specific rules contained in Chapter 9 of NP EN 1992-1 were considered, as well as the provisions relating to reinforcement contained in Chapter 8.

The verification of sections in case of fire was automatically dimensioned, using as a reference a fire exposure time of Class R60.

5.2 LIMIT STATES OF USE

5.2.1 Displacements

The verification of the vertical deformation of the various reinforced concrete elements followed the limits suggested in NP EN 1992-1, namely $L/250$ for quasi-permanent combinations of actions, and $L/500$ for the post-construction portion, also for the quasi-permanent combination of actions. In both cases, the deflection is calculated in relation to the supports. The verification of the deformation of the various elements of steel structures followed the limits suggested in NP EN 1090-1, namely: $L/250$ for vertical displacements, $L/300$ for horizontal displacements and $L/200$ for vertical displacements in facade and roof purlins.

5.2.2 Limitation of Stresses and Crack Widths

The verification of the various reinforced concrete elements in terms of Stress Limitation and the Crack Opening Limit State followed that defined in Chapter 7 of NP EN 1992-1, namely in points



7.2 and 7.3. In this last aspect, whenever possible the indirect crack control method was followed.

6 FINAL CONSIDERATIONS

Before execution, all dimensions (altimetric and planimetric) must be confirmed by the Architecture.

The Works and Quantities Map complements the project in the description of the structure and the solutions adopted.

In all cases that are omitted or unclear, all current legislation and good construction standards will always be followed.

Luanda, January 20, 2025

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