

Technical specifications for the construction of a two-story building with reinforced concrete

Especificaciones técnicas para la construcción de un edificio de dos pisos con hormigón armado

Liliana Lizbeth López López*
María Fernanda Pico Núñez*
Luis Leonardo Zambrano Salazar*
Ambar Carolina Yépez Intriago*

ABSTRACT

The objective of this experimental work is to develop technical specifications that serve as a guide for the construction of reinforced concrete buildings. To carry out the project, technical visits were made to buildings under construction and were complemented with bibliographic research in books, codes and standards, contrasting the field information with that obtained in technical documents. Before preparing the technical specifications, architectural, structural and hydro-sanitary and electrical installation plans were obtained. With these plans, the necessary components for the construction of the home were determined, including civil works, coatings, finishes and installations. Each technical specification includes: a description, the execution procedure detailing the requirements before, during and after the completion of

* Magister en Ingeniería Civil Mención Estructuras Metálicas
Universidad Técnica de Ambato, Facultad de Ingeniería Civil y Mecánica
Principal Grupo de Investigación GeReNIS, mf.pico@uta.edu.ec
<https://orcid.org/0000-0002-8468-3026>

* Magister en Ingeniería Civil Mención Estructuras Metálicas
Universidad Técnica de Ambato, Facultad de Ingeniería Civil y Mecánica
ll.zambrano@uta.edu.ec, <https://orcid.org/0009-0001-5966-8123>

* Magister en Ingeniería Civil Mención Estructuras Metálicas
Universidad Técnica de Ambato, Facultad de Ingeniería Civil y Mecánica
ll.zambrano@uta.edu.ec, <https://orcid.org/0009-0001-5966-8123>

* Magister en Mecánica Mención Manufactura
Universidad Técnica de Ambato, Facultad de Ingeniería Civil y Mecánica
ac.yepetz@uta.edu.ec, <https://orcid.org/0009-0006-8443-3269>

REVISTA TECNOLÓGICA
ciencia y educación
Edwards Deming

ISSN: 2600-5867

Atribución/Reconocimiento-NoComercial- CompartirIgual 4.0 Licencia
Pública Internacional — CC

BY-NC-SA 4.0

<https://creativecommons.org/licenses/by-nc-sa/4.0/legalcode.es>

Edited by: Tecnológico Superior Corporativo
Edwards Deming

July - December Vol. 8 - 2 - 2024

<https://revista-edwardsdeming.com/index.php/es>

e-ISSN: 2576-0971

Received: February 09, 2024

Approved: May 20, 2024

Page 96- 108

each component, the applicable regulations, safety measures to protect workers and the unit, materials, equipment, and labor. necessary. With this information, the unit price analysis of each component was carried out. The result acts as a guide that offers a clear description of the execution methods of the components, complying with the national and international regulations, codes and standards used in Ecuador, ensuring adequate control both in the execution and in the review of the construction site.

Key words: Construction, concrete buildings, technical specifications, construction standards.

RESUMEN

El objetivo de este trabajo experimental es desarrollar especificaciones técnicas que funcionen como guía para la construcción de edificaciones de hormigón armado. Para llevar a cabo el proyecto, se realizaron visitas técnicas a edificios en construcción y se complementó con una investigación bibliográfica en libros, códigos y normas, contrastando la información de campo con la obtenida en documentos técnicos. Antes de elaborar las especificaciones técnicas, se obtuvieron planos arquitectónicos, estructurales y de instalaciones hidrosanitarias y eléctricas. Con estos planos, se determinaron los componentes necesarios para la construcción de la vivienda, incluyendo obra civil, revestimientos, acabados e instalaciones. Cada especificación técnica incluye: una descripción, el procedimiento de ejecución detallando los requerimientos antes, durante y después de la realización de cada componente, la normativa aplicable, medidas de seguridad para proteger a los trabajadores y la unidad, materiales, equipo y mano de obra necesarios. Con esta información, se realizó el análisis de precios unitarios de cada componente. El resultado final actúa como una guía que ofrece una descripción clara de los métodos de ejecución de los componentes, cumpliendo con las regulaciones, códigos y normas nacionales e internacionales utilizadas en Ecuador, asegurando un control adecuado tanto en la ejecución como en la revisión de la obra.

Palabras Claves: Construcción, edificaciones de hormigón, especificaciones técnicas, normas de construcción.

INTRODUCTION

Since ancient times, mankind has fought an uphill battle for survival, seeking to obtain shelter and erect spaces that provide security and shelter, in other words, a place to live. Over the centuries, human beings have progressed and the demands to improve their places of residence have increased significantly (Fitchen, 1986).

Activities such as surveying and inspection have been closely linked to man's efforts to create and improve his environment. Regulations and legal codes emerged, one of the most recognized being the Code of Hammurabi. This set of laws was written around 1760 BC, with the purpose of regulating various activities of daily life in ancient Mesopotamia (Van De Mieroop, 2005). Among the provisions established were those related to the construction of buildings of the time.

From the second half of the 19th century, a significant transformation began in the field of building construction, driven by the adoption of new materials such as concrete and steel. William Wilkinson, considered a pioneer in the discovery of reinforced concrete, obtained a patent in 1854 for a system incorporating iron reinforcement, which revolutionized housing construction in general (Palley, 2010).

Subsequently, in France, Edmond Coignet and De Tédesco published a method that took into account the elastic behavior of concrete in tests, thus contributing to lay the theoretical foundations of construction systems and their respective technical specifications. These procedures were considered as execution memory (Coignet & De Tédesco, 1984).

Since its beginnings, engineering has been a discipline dedicated to improving the living conditions of mankind, focusing on satisfying fundamental needs such as the protection and mobility of people and, consequently, their comfort. Progress in this science is closely linked to the creation and updating of construction regulations, which seek to ensure the safety and durability of structures over time. This has given rise to the issuance of new codes and has generated the need to establish mandatory systems for their application and follow-up, being this a common practice in several countries, including ours.

The Ecuadorian Construction Standard incorporates new variables, such as life safety and accessibility, seismic resistance and energy efficiency, among others, which are fundamental requirements to consider during design to ensure excellence in construction (MTOP, Norma Ecuatoriana de Construcción, 2016).

However, there is often a lack of clarity in the application of these concepts during the execution of activities, which makes it difficult to obtain the expected results. In many countries, the advancement of these regulations has been accompanied by the implementation of new construction processes. In the case of Ecuador, most of the works are carried out without adequate technical direction and control, which is

attributed in part to the lack of requirements by the sectional and national governments, which approve incomplete designs and obvious flaws. In many cases, technical specifications are insufficient and there is no adequate analysis of unit prices, resulting in deficient projects and, as a consequence, in the deterioration of buildings (Rodas, 2013). According to the 2015 Building Survey conducted by INEC (National Institute of Statistics and Census), there is a 29.2% increase in building permits in the last 15 years at the national level. In the province of Tungurahua, these permits represent 8.3% of the total, placing it in third place nationally in terms of concentration of construction permits (INEC, 2015).

The Building Survey also reveals that Reinforced Concrete is the most used material in the construction of foundations, structures and roofs in Ecuador, which demonstrates the predominance of this type of buildings in the country. Unfortunately, the true test of a structure's resistance occurs during a seismic event. A few months ago, Ecuador experienced a 7.8 magnitude earthquake, which revealed serious deficiencies in many buildings. Upon inspection, it was determined that many buildings collapsed due to construction defects. This problem is attributed not only to non-compliance with construction standards and codes, but also to the informality of construction, where responsibility falls on master builders rather than engineers or architects. In addition, the lack of quality control of materials is a critical factor in construction.

To avoid these problems, it is essential to comply with technical specifications, which are the provisions that regulate the materials used in a specific activity, as well as the procedures for the execution of the works to ensure that they meet the established requirements. Technical specifications can be considered as the "rules of the game" in construction, since they indicate how the work should be carried out and what materials should be used.

MATERIALS AND METHODS

This project will use explanatory levels of research with a technical approach. The approach will be explanatory because it will detail step by step the different construction activities necessary for the execution of each component, always trying to follow the guidelines and regulations in force.

In addition, it will have a technical approach, since it seeks to promote the unification of construction processes and the control of the execution of works for two-story reinforced concrete buildings.

The housing model for this research is a two-story reinforced concrete single-family building. This construction presents a modern style architectural design. It consists mainly of two floors: the first floor has an area of 116.60 m² and the upper floor has an area of 100.15 m². In addition, it has a garage with capacity for two family cars. It also has green areas, one located at the back and the other in front of the main facade. The roof is tile, designed with four falls.

On the front façade of the house, there is the main door that gives access to the living-dining room, as well as a secondary door that allows quick access to the kitchen from

the garage. In addition, there are circular columns that support the garage roof and the porch. The facade includes ten windows, between fixed and sliding; six of them are square and the rest are rectangular.

On the right side façade, there is a sliding aluminum partition that provides access to the dining room, in addition to two sliding windows and four fixed windows. The left lateral facade has eight windows, two sliding and six fixed. The rear façade has twelve windows, of which two are sliding and ten are fixed, in addition to a door that gives access to the rear garden.

The first floor consists of four rooms: in the first room is the living-dining room with parquet floor and a social bathroom. The second room includes the laundry room, equipped with the necessary facilities for a washing machine, dryer and a small laundry room, with high traffic non-slip porcelain tile floor. The third room is the kitchen, which includes a breakfast area and also has high traffic non-slip porcelain tile flooring. The last room is the guest room, which includes a private bathroom.

Upstairs there are three bedrooms with parquet floors. One of them is the master bedroom, with a private bathroom, while the other two are standard bedrooms that share a general bathroom. There is also a small living room on this floor. The house is equipped with a U-shaped staircase, with an intermediate landing, for the connection between the floors.

RESULTS

In order to prepare the technical guide, a structured plan was followed as follows:

- Technical information required for execution.
- Literature review (Ecuadorian Construction Code, NEC, ACI 318, INEN, ASTM).
- Development of technical specifications.

The results are shown below:

ITEM: STAKEOUT AND LEVELING

NEVI MTOP: Ecuadorian Road Standard. Ministry of Transportation and Public Works of Ecuador. Section 2A.311 "Stakeout of Road Works - General Aspects". Topographic stakeout corresponds to the set of operations aimed at marking on the ground the location of engineering works, whose physical characteristics are contained in the project plans (MTOP, Norma Ecuatoriana Vial NEVI-12-MTOP, 2013).

- Unit: Square meter (m²).
- Minimum materials: Stake.
- Minimum equipment: Minor tool 5% of M.O, Topography equipment.
- Minimum Qualified Labor: Topographer 2: Degree with more than 5 years of experience (Estr. Oc. C1), Cadenero (Estr. Oc. D2), Master in execution of civil works (Estr. Oc. C1).

ITEM: MANUAL LAND CLEARING.

NEVI-12 MTOP: Section 302 "Land clearing". Consists of extracting and removing from the designated areas all trees, stumps, plants, weeds, brush, fallen timber, debris, garbage or any other undesirable material as per the project or at the discretion of the Inspector.

- Unit: square meter (m²).
- Minimum Equipment: Minor tool 5% of M.O.
- Minimum qualified labor: Laborer (Estr. Oc. E2 I and II), Senior Master in execution of civil works (Estr. Oc. C1).

ITEM: MANUAL EXCAVATION

NEVI-12 MTOP: Section 303 "Excavation of earthworks and borrow pits". It consists of the set of operations to excavate and level.

AASHTO: American Association of State Highway and Transportation Officials.
AASHTO-180-01: Method A "Modified Proctor". This method describes the procedure for determining the relationship between moisture content and density of compacted soils.

ASTM: American Society of Testing Materials or American Society for Testing Materials.
ASTM D1557-78: Method A "Modified Proctor". This laboratory compaction test determines the relationship between moisture content and density of soils and soil-aggregate mixtures. Degree of compaction at 95% of the maximum density determined in the laboratory.

- Unit: Cubic meter (m³).
- Minimum materials: Water.
- Minimum equipment: Minor tool 5% of M.O.
- Minimum Qualified Labor: Senior Master in execution of civil works (Estr. Oc. C1), Laborer (Estr. Oc. E2 I and II), Mason D2 (Estr. Oc. D2).

ITEM: MANUAL BACKFILL COMPACTED WITH ON-SITE MATERIAL

NEVI-12 MTOP: Section 303-1.02 "Tests and Tolerances". For control of compaction of foundation soils at subgrade level, according to moisture-density tests.

AASHTO-180-01: Method A "Modified Proctor". This method describes the procedure for determining the relationship between moisture content and density of compacted soils.

ASTM D1557-78: Method A "Modified Proctor". This laboratory compaction test determines the relationship between moisture content and density of soils and soil-aggregate mixtures. Degree of compaction at 95% of the maximum density determined in the laboratory.

- Unit: Cubic meter (m³).
- Minimum materials: Water.
- Minimum equipment: Minor tool 5% of M.O, Toad type compactor.
- Minimum Qualified Labor: Senior Master in execution of civil works (Estr. Oc. C1), Laborer (Estr. Oc. E2 I and II), Mason D2 (Estr. Oc. D2).

ITEM: REMOVAL OF EXCAVATION MATERIAL

NEVI-12 MTOP: Section 303-2.01.2.4 "Excavation in Soil". Includes the excavation and removal of all materials encountered during the work, in any type of terrain.

- Unit: Cubic meter (m³).
- Minimum equipment: 8m³ dump truck, front loader.
- Minimum qualified labor: Driver: Dumper (Str. Oc. C1), Operator: Front loader (Str.

Oc. C1).

ITEM: CYCLOPEAN CONCRETE F'C= 180 KG/CM² (60% S.H. - 40% P.), (INCLUDES FORMWORK AND STRIPPING).

NEC-SE-HM 2015: Ecuadorian Construction Standard. Reinforced Concrete Structures.

- Section 9, "Quality Control of Concrete Works".
- Section 9.2: Specifies the requirements for the acceptance of concrete materials such as cement, aggregates, water, additives, etc.
- Section 9.3: Specifies the control of batching, measuring and mixing of the components for site-mixed concrete.
- Section 9.4: Establishes all previous requirements before pouring concrete, whether in excavations or foundations and in structures with formwork. It also presents the minimum time for stripping vertical and horizontal elements.
- Section 9.5: Details the appropriate processes for concrete transport, concrete pouring, concrete compaction, as well as the equipment and techniques that can be used.
- Section 9.6: Defines the proper curing process and materials used to reduce water loss by evaporation.
- Section 10, "Requirements and standards to be met by construction materials".
- Section 10.1: Determines the requirements and standards to be met by the following materials: hydraulic cement, aggregates, water, additives.

NTE INEN: Ecuadorian Technical Standard. Ecuadorian Institute of Normalization.

- NTE INEN 1855-2: "Concrete. Concrete prepared on site. Requirements". This standard defines the specifications for the production of concrete prepared on site in its fresh state.
- NTE INEN 152: "Portland Cement. Requirements". This standard establishes the physical and chemical characteristics and requirements to be met by portland cement.
- NTE INEN 696: "Granulometric Analysis of Aggregates, Fine and Coarse". Establishes the test method to determine the particle size distribution of fine and coarse aggregate particles, by sieving.
- NTE INEN 872: "Aggregates for Concrete. Requirements". Establishes the requirements of granulometry and quality for fine and coarse aggregate, to be used in concrete.
- NTE INEN 1578: "Hydraulic Cement Concrete. Determination of Settling". Establishes the test method to determine the slump of concrete in the laboratory or in the field.
- NTE INEN 1576: "Hydraulic Cement Concrete. Elaboration and Curing of Specification Specimens for Testing". It establishes the procedures to elaborate and cure the cylinders taken from respective samples of fresh concrete, used on site.
- NTE INEN 16: "Practical Guide for the Design and Construction of Formwork". Establishes the procedures to guarantee the assembly of formwork.
- Unit: Cubic meter (m³).
- Minimum materials: Portland type cement, Washed sand, Crushed riprap, Ball stone, Water, Hard formwork board 2.4m x 0.25m, Nails 2" to 3 1/2", Eucalyptus props 4 to 7 m, Formwork quarts.

- Minimum equipment: Minor tool 5% of M.O, Concrete mixer, Vibrator.
- Minimum qualified labor force: Senior master in execution of civil works (Estr. Oc. C1), Laborer (Estr. Oc. E2 I and II), Mason D2 (Estr. Oc. D2), Carpenter (Estr. Oc. D2).

DISCUSSION

The completion of this work provides training on the correct execution of the various construction processes required to build a two-story reinforced concrete house.

The final result of this project provides a precise description of the methods to execute the different components, complying with the regulations, codes and standards in force in Ecuador, ensuring an efficient control of the work both in its execution and in its revision.

The technical specifications presented in this document include a detailed description of each component, explaining the preliminary activities required before starting construction. In the execution phase, the work to be carried out is detailed step by step and, subsequently, the necessary care to ensure the durability of the building over time is described.

The various visits to construction sites allowed us to collect the essential information to prepare this document, observing the set of activities necessary for the creation of each technical specification and the unit price analysis. This allowed us to differentiate each activity and its correct process, avoiding possible errors during construction.

In the creation of this technical manual, we have included a section on occupational safety to provide information that protects the labor conditions of the workers. This work is practical and based on a good control to avoid improvisation during the execution of the project.

One of the main objectives of this project has been to optimize the execution of the components so that, during construction, the work is carried out in a way that does not present problems in the future.

On site, it is recommended to strictly comply with the regulations described in this manual to ensure that the buildings provide safety and comfort to their inhabitants. It is advisable to update the regulations included in this manual if modifications occur.

This technical specifications document is the result of a thorough analysis of the components used for a reinforced concrete house. It may be necessary to include other components, which should be developed by the contracting entity following the established format.

Before using this manual, it is recommended to have the complete set of drawings (Architectural, Structural, Hydrosanitary and Electrical) in order to develop the necessary components according to the requirements of the house to be built.

It is recommended that all site personnel be familiar with the manual for the application of good construction practices. Prior authorization from the contracting entity must be obtained before starting the execution of each component. Likewise, upon completion of the component, the contracting agency will conduct a final review and approval.

REFERENCES

- Coignet, E., & De Tédesco, N. (1984). Du calcul des ouvrages en ciment avec ossature métallique. *Mémoires de la Société des ingénieurs civils de France*, (págs. 282-363). Paris.
- Fitchen, J. (1986). *Building Construction Before Mechanization*. Massachusetts: MIT Press.
- INEC. (2015). *Encuesta de edificaciones*. Obtenido de Instituto Nacional de Estadísticas y Censos del Ecuador: https://www.ecuadorencifras.gob.ec/documentos/web-inec/Estadisticas_Economicas/Encuesta_Edificaciones/2015/2015_EDIFICACIONES_PRESENTACION.pdf
- MTOP. (2013). *Norma Ecuatoriana Vial NEVI-12-MTOP*. Obtenido de Ministerio de Transporte y Obras Públicas del Ecuador: https://www.obraspublicas.gob.ec/wp-content/uploads/downloads/2013/12/01-12-2013_Manual_NEVI-12_VOLUMEN_2A.pdf
- MTOP. (2016). *Norma Ecuatoriana de Construcción*. Obtenido de Ministerio de Transporte y Obras Públicas del Ecuador: https://www.obraspublicas.gob.ec/wp-content/uploads/downloads/2016/04/MTOP_NEC-SE-DS.pdf
- Palley, R. (2010). *Concrete: A Seven-Thousand-Year History*. Massachusetts: Harvard University Press.
- Rodas, B. (2013). Guía para la redacción de especificaciones técnicas particulares para obras civiles. *Estoa*, 1(3), 45-52.
- Van De Mieroop, M. (2005). *King Hammurabi of Babylon: A Biography*. New York: Wiley.