Journal of Positive Psychology & Wellbeing
2023, Vol. 7, No. 2, 12 – 27
http://journalppw.com
ISSN 2587-0130

CONSTRUCTION PROCESS OF THE ROUGH WORK OF A WAREHOUSE TYPE BUILDING LOCATED IN THE CITY OF OCAÑA, NORTE DE SANTANDER, COLOMBIA

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Abstract

The construction processes of any building are the fundamental pillar for compliance with earthquake-resistant standards and the proper functioning of the civil works, involving architectural, structural and complementary designs along with the intervention of resources, human talent, tools and equipment. Compliance with these construction processes avoids penalties due to non-compliance with contracts and designs, suspension for breach of regulations, demolitions due to pathologies that put the life and safety of its users at risk. The purpose of this article is to illustrate in a pedagogical way the construction process of a medium and high complexity building of large spaces located in the city of Ocaña, in the department of Norte de Santander, from the foundations, columns, masonry and roof;likewise, the construction rules that govern itwill be described, in order to guide students in academic training in areas related toarchitecture, construction and civil engineering, to generate practical knowledge applied in the working world. It is important, during the execution of the works, to carry out a preliminary study of the designs and technical specifications, to fill out daily control forms, to write progress reports of the work and to complywith the technical standards that govern the Colombian territory. The study achieved the objectives and regulatory requirements established in the planning and design of theconstruction project, delivering the work within the time and costs established for the warehouse-type building located in the city of Ocaña.

Keywords: Construction process, pedagogical training, building.

1. INTRODUCTION

Civil works projects are based on a practical methodology that includes initial activities such as preliminary studies, which analyse the market, area conditions and design factorsinvolved in the project.

The architectural designs are developed in this way, structuraland complementary designs, which will be the base line in the construction (Campero & Alarcón, 2008). The construction process of any building comprises a series of phases in which resources, human talent, tools and equipment are involved, with the aim of fulfilling the development of civil works in terms of quality, time and costs (Hernández & Grettel, 2008).

Compliance with the construction processes ensures that the project is developed within the time and cost limits calculated, avoiding penalties due to breaches in contracts and designs, suspension for breach of regulations, demolitions and non-conformities due to delivery of works that present pathologies that place the life and safety of their users at risk (Álvarez Enciso, 2015). However, each project has its own particular requirements, although they have in common a methodology based on experience and research, which includes planning, design, resource management, execution, delivery and maintenance (Del Pino Calvo-Sotelo, n.d.).

In Colombia, many constructions are carried out with poor planning, causing cost overruns and schedule delays, so methodologies have been identified that focus on improving planning and monitoring processes in an effective manner, offering tools for decision-making, risk mitigation, reduced execution times and cost reduction (Gómez Cabrera et al., 2015). Given that Colombia, being located in a subduction zone between the Nazca, Caribbean and South American plates, makes it a potential scenario for seismic events (Alcaldía Mayor de Bogotá, 2016), it is therefore key to build under standards and processes that regulate and ensure resistance to these natural phenomena, as established by the seismic-resistant standard (NSR-10).

In Colombia, there are a total of 4,815,613 m^2 of completed civil works and 29,655,515 m^2 of area corresponding to works in the process of completion (DANE, 2022), of which, there have been reported approximately 200 buildings with structural problems across the country (Sociedad Colombiana de Ingenieros, 2019). In the Colombian capital, Bogotá, there are 2,363 homes and buildings at risk of collapse, due to poor construction processes and violation of civil construction standards (Bogotá Council, 2018).

In this order of ideas and in view of the current situation in the country in terms of construction, this article aims to illustrate in a pedagogical way the construction process of a medium and high complexity building of large spaces locatedin the city of Ocaña, in the department of Norte de Santander, from the foundations, columns, masonry and roof, so that interested parties acquire the basic knowledge about the phases that are addressed in any architectural and civil works project.

2. PROJECT DESCRIPTION

The project was developed for a building of medium and high complexity of large spaces in the municipality of Ocaña, in Norte de Santander, which consists of an area of 502.13 m^2 , which aims to illustrate the constructionprocess from the foundation, columns, masonry and roof. In the project, reinforced concrete was used for the construction, a duration of 3 months was established and human talent, skilled labour, 5 officers and 15 assistants were employed, led by a master builder and 2 engineers, under the supervision of the professional in charge of health and safety at work.

3. DEVELOPMENT OF CONSTRUCTIVE PROCESS OFTHE PROJECT

3.1. Geotechnical studies

The seismic-resistant standard (NSR-10) in numeral E.2.1.2 of Title E, preliminary activities such as geotechnical studies must be carried out, which allow the analysis of the mechanical behaviour of the foundation soils, as well as the study of the structures and the rock formations adjacent to the structure to be erected. Figure 1 shows the professional staff in the area of geotechnical engineering, carrying out the respective tests for the analysis of the behaviour of the foundation soil.

Figure 1. Testing for geotechnical studies

Some of the tests required by Title H of NSR- 10, developed in the course of the preliminary activities were: liquid and plastic limit of the soil, moisture content, shrinkage factors, granulometry, determination of the unit mass in the ground by the sand cone method, relative density of solids, soundings for the determination of the type of foundation, dimensions and depth of casting and shear strength.

3.2. Demolition of existing structures

Demolition consists of removing the previous works on the construction site, taking specialcare not to damage neighbouring structures and safeguarding the safety of the workers. The development of this activity was approached manually and mechanically, with the help of the backhoe, as illustrated in figure 2 and figure 3. This activity lasted approximately 5 days.

Figure 2. Manual demolition of existing buildingsite.

Figure 3. Mechanical demolition of existingworks

3.3. Clearing the land

Prior to the execution of the foundation activities, the construction site must be free of organic material, debris or rubble that could damage the behaviour of the materials, generate disorganisation in the work, and represent a source of risk for the safety of the workers and machines used, as established in section E.2.1.3 of title E of

NSR-10. To carry out this task, a backhoe and a 7 m3 dump truck were used, which placed the material in areas suitable for the deposit of debris (see figure 4).

Figure 4. Mechanical site clearance.

3.4. Location and staking out

In the location and staking out, axes and areas corresponding to the footings were traced, according to the structural plans, being necessary to indicate that, during this work, the level of the ground and the measurements, duly approved by the engineer in charge, the architect and the contractor, must be ensured. Figure 5 shows the layout of the axes on the cast iron floor. This activity lasted the equivalent of one and a half days.

Figure 5. Location and setting out of shafts and footings

3.5. Temporary enclosure

During the construction work, it is necessary to close the area to be intervened so that the activities carried out do not generate a dangerfor passers-by and drivers passing near the site, safeguarding the integrity of the entire community surrounding the site of execution of the work. Figure 6 illustrates the enclosure of the work using green tarpaulin type fabric, which has a duration equivalent to 1 day.

Figure 6. Temporary enclosure of the construction site in green tarpaulin.

3.6. Camp construction

The purpose of the construction of the camp is to store tools, store materials and provide stationery for those in charge of the work. It is a suitable site for the analysis of plans and the holding of staff meetings. In the case study, it is made of wood and green canvas, which will be dismantled at the end of the construction work.

3.7. Excavation manual from commonmaterial

This activity consists of excavating and compacting the level of the subgrade, i.e., by means of topographical surveys, to reach the level established in the plans, with the aim of The objective of proceeding with the continuous activities for the development of the building's foundations. For this purpose, the machinery corresponding to a backhoe and a vibratory compactor were used, disposing of the surplus material, which was disposed of in sites with legal permission for this process (see figure 7). This activity took 2 days.

Figure 7. Excavation and compaction

3.8. Excavation of footings

This activity consists of the excavation of the demarcated areas where the footings (boundary and central) will be located, duly established in the axes of the structural plans. For this work,the workers excavated to a depth of 2 metres, taking into account the height of the footing, the pedestal and the foundation beam, as established in the design, illustrated in figure 8. Likewise,all the safety measures required by law were implemented, such as safety boots, helmet and gloves (see figure 9). It took 8 days to carry out this activity, as a total of 19 footings were excavated. Figure 8. Dimensions of theboundary footings and central construction footings

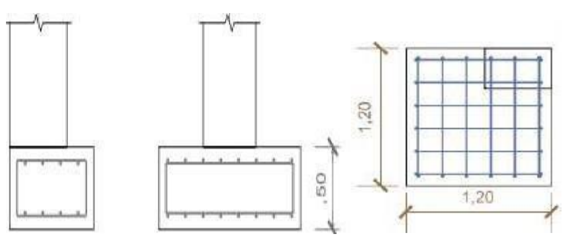

Figure 8. 2 metre deep footing design

Figure 9. Excavation of footings at a depth of 2 metres.

3.9. Excavation of foundation beams.

The excavated foundation beams have dimensions of 0.55 metres wide by 0.55 metres wide by 0.55 metres wide by 0.55 metres wide.

0.30 metres high, with the variation of the length, according to the specification of the plans (See figure 10). For the execution of this activity, minor tools such as picks and shovels were used, ensuring the integrity of the operators. Also, this excavation process improved its performance with the help of the backhoe, which completed this work (see figure 11). The duration of this activity was 8 days.

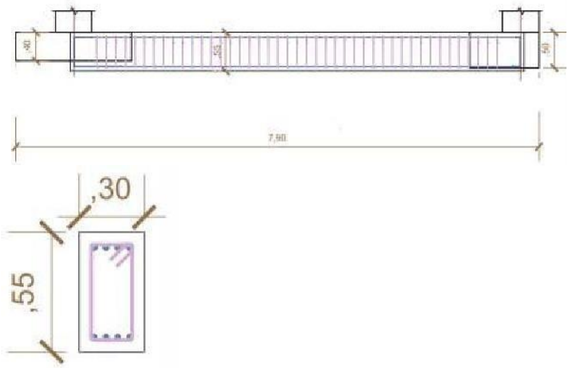

Figure 10. Dimensions of the foundation beam

Figure 11. Manual and mechanical excavation offoundation beams

3.10. Cleaning floors.

This activity consists of casting a small layer of mortar, 5 centimetres thick, with a dosage of 2000 PSI, over the entire surface corresponding to the footings and foundation beams, as shown in figure 12. This activity lasted 3 days.

Figure 12. Cleaning screeds

3.11. Shoes and counterweights

This phase of the project involves theshaping of the steel and casting of the footings. For this, 5/8 inch diameter rods were used, arranged in a grid pattern, as illustrated in Figure 13, with a concrete strength of 3000 PSI. The casting was carried out on site with a conventional mixer, paying special attention that the workers implemented all the personal protective equipment established in the safetyand health at work regulations (see figure 14). To complete the assembly and casting of the 19 footings, 10 days were spent.

Figure 13. Steel reinforcement of the footings.

Figure 14. Shoe casting

Note: The rods protruding from the footing castings correspond to the reinforcement of the pedestals, which are assembled with the steel of the footings and the foundation beams.

3.12. Reinforcement and casting offoundation beams.

This stage involves the use of 4 ¾ inch rods arranged in the upper face of the beam, and 45/8 inch rods arranged in the lower face of the beam, with 2 reinforcements of 3/8 inch in the central arrangement of the beam, as illustrated in the figure.15. Likewise, for its casting, pre-mixed structuralconcrete of 3000 PSI strength was used, using wooden formwork as shown in figure 16. This activity lasted 12 days.

Figure 15. Steel reinforcement of the foundation beams

Figure 16. Casting of foundation beams

3.13. Arming y casting of pedestals

In case the structure requires the installation of pedestals, these will be contemplated in the structural designs and depend on the complexity and magnitude of the loads that the buildingneeds to support. In the case study, 19 pedestals of 0.55 metres long, 0.35 metres wide and 0.7 metres high were used, using 4 rods of 5/8 of an inch and 4 rods of ¾ of an inch, arranged as shown in Figure 17 and Figure 18. These measurements are the same as those used in the reinforcement of the columns. Likewise, the concrete used for casting has a resistance of 3000 PSI (see figure 19).

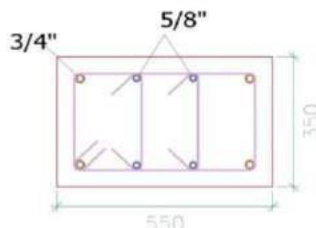

Figure 17. Design and measurement of thepedestals.

Figure 18. Assembly of the pedestals

Figure 19. Cast pedestal.

3.14. Filled compacted manual fillers.

After casting the footings, foundation beams and pedestals (if required), the remaining spaces of the excavation are backfilled, this process can bedone in the following ways

The same material obtained from the removal of earth was used for backfilling, or supplemented with sub-base material or gravel, depending on the technical specifications of the structural designs.

For the case study, the common material extracted on site was used for backfilling, using BOBCAT machinery in order to speed up the work (see Figure 20), and the respective soil compaction was carried out with the help of a kangaroo type rammer, up to the specified height of the tie beam, as shown in Figure 21.

Figure 20. Mechanical backfilling of the excavation with common material

Figure 21. Compaction of the backfill with akangaroo rammer.

3.15. Concrete structures

3.15.1. Reinforcement and casting of tie beams

For the tie beams, 8 ½ inch rods were used, with 3/8 inch stirrups, at a distance of 10 centimetres each. The dimensions of thesebeams correspond to a width of 0.30 metres and a height of 0.45 metres, as shown in figure 22. Figure 23 shows the steel construction process of the tie beams.

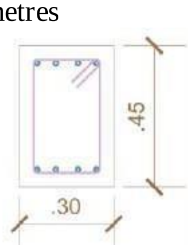

Figure 22. Tie beam dimensions

Figure 23. Assembly of the tie beams

After reinforcing the steel, the structures were then formed. In this case, wooden formworks were used, which were covered with a chemical called release agent, with the aim that, after casting the beams, the stripping process would not generate problems of adhesion and damage to the structure. The concrete used has a strength of 3000 PSI, prepared on site with the help of a conventional mixer and implementing operational and worker safety measures (see Figure 24 and Figure 25).

Figure 24. Assembly and casting of the tie beams

Figure 25. Tie beam casting with 3000 PSI concrete

3.15.2. Assembly and casting of columns

For the construction of the columns, 4 ¾ inch rods were used at the ends of the column and 4 5/8 inch rods in the centre of the column, in the same arrangement as the pedestals, as illustrated in the figure.

17. These corrugated steel rods are reinforced with 3/8" stirrups, in a rectangular shape with 7.5 centimetre hooks and C-shaped stirrups, anchored to the 5/8" rods at a distance of 15 centimetres each and must be anchored to the tie beams (see figure 26). Likewise, their structural dimensions correspond to a length of 0.55 metres, a width of 0.35 metres and a height of

2.95 metres. The duration of this activity was 7 and a half days. Once the casting of the beams was ready, the columns were assembled, as shown in figure 27.

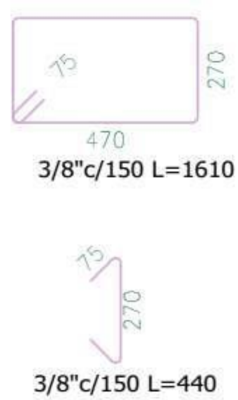

Figure 26. Dimensions of the stirrups used to reinforce the columns.

Figure 27. Steel reinforcement of columns

After reinforcement, the columns are formed with metal formwork. The cast concrete used forthe 19 columns of the project has a resistance of 3000 PSI. It is important to bear in mind that all concrete pouring processes require vibrating in order to reduce porosities that could affect the strength of the concrete and ensure a more compact mix. Figure 28 shows this process.

Figure 28. Column casting

Note: After the columns are cast, they must be covered with plastic, in order to ensure a correct setting of the columns, which guarantees the maximum expected resistance.

3.15.3. Assembly and pouring of area beams.

After casting the 19 columns, we proceed to the assembly and casting of the area beams, which have modular dimensions of 0.30 metres wideby 0.45 metres high, with reinforcements of 8 ½ inch rods, in corrugated steel, with 3/8-inch reinforcement stirrups every 10 centimetres, as shown below. in figure 29. This activity lasted 10 days and its construction process is shown in figure 30.

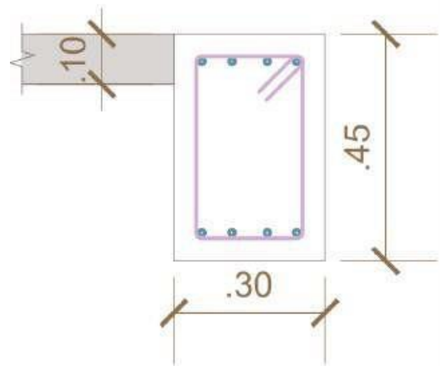

Figure 29. Dimensions and reinforcing steel of the overhead beams

Figure 30. Assembly and formwork of the overhead beams

Note: It is important that when the overheadbeams are assembled, they have enough joints to be anchored to the columns, so that this linkallows a rigid structure to be obtained. In addition to this, after the assembly and installation of the metal formwork, it is necessary to use parallels that present optimal quality conditions, and that allow the graduation of their height to ensure the design levels of the overhead beams.

Finally, the beams are cast with pre-mixed concrete with a strength of 3000 PSI, as shown in Figure 31.

Figure 31. Casting of overhead beams

Note: All casting processes must be controlled by testing. These consist of extracting a sample of the on-site concrete mix and pouring it into a cylindrical mould, which shall be cured for a time interval of 28 days before testing. The test consists of applying a perpendicular load to the top face of the dried specimens until a fracture occurs in the sample, which will indicate themaximum stress that the concrete cylinder will withstand before reaching its failure point. Fromthese results, it can be verified if the strength requirements established in the designs are met. The standard that supports these tests in Colombia is the NTC 673 test of compressive strength of concrete cylindrical specimens and Title C of the seismic resistant standard NSR-

10. See figure 32.

Figure 32. Sampling of concrete mixes for compressive strength tests

3.16. Floor plate

This activity involves the manual levelling of the land where the concrete slab will be located. To do this, the workers used small tools such as picks and shovels, tracing axes that allowed the measurement of the excavations and fillings at the same height, being compacted with a compacting frog. Subsequently, the concrete mix type MR 41, with the addition of synthetic fibre, was mixed. Depending on the design specifications, electrowelded mesh or fibres can be used to increase the load capacity, increasethe tenacity and avoid the cracking of the slab. The thickness of this slab was 13.5 centimetres, the concrete being made on site as shown in Figure 33 and Figure 34.

Figure 33. Levelling of the terrain

Figure 34. Casting of the floor plate

Note: Before pouring the concrete, it is recommended to place a moisture insulating material on the floor. As shown in figure 34, a thick black plastic sheet was placed on the casting floor, which prevents capillary dampness that could affect the floor of the building due to possible movements of underground water.

It is important that, during the mixing of the concrete, the Abrams cone test is carried out. This test allows the consistency of the concrete in its fresh state to be measured by pouring a quantity of concrete into a mould of established measurements, compacting the mixture with 25 blows with a rod. After the mould is removed, the slump of the concrete is measured, which should not exceed 10 centimetres (see figure 35).

Figure 35. Abrams cone test

3.17. Masonry

After completion of the foundation and concrete structure of the building, the internal and external walls are erected according to the specifications of the structural and architectural designs. For the case study, smooth cement block (9cm x 19cm x 39 cm) with seismic reinforcement of 3/8 of an inch every 60 centimetres was used. In addition to the above, the expansions have a measurement of 1.5 centimetres, insulated with Icopor, in accordance with structural technical specifications (see figure 36).

Figure 36. Masonry work

3.18. Cover

The roof used in the warehouse was a self-supporting roof in grade 40 galvanised structural steel, which has a slope of 20% and is anchored to the reinforced concrete support beams. It is important to install the gutters, which will be responsible for collecting the rainwater and placing it in the drainage pipes, thus preventing damp leaks that cause inconvenience and material damage to the owners (see figure 37).

Figure 37. Installation of self-supporting roof

CONCLUSIONS

1. During the execution of the works, it is important to carry out a preliminary study of the designs and technical specifications to understand the tasks to be carried out in order to ensure the correct management of resources, time and the hiring of qualified personnel for the execution of the work. Likewise, the constant accompaniment and supervision of the works committee is fundamental to the success of the project.

2. It is important to fill in daily controlforms, with the objective of writing weekly and monthly reports that allow tounderstand the progress of the work, identifying delays and problems that require the implementation of solution strategies.

3. Compliance with the regulations governing the Colombian territory is key to the achievement of safe, resistant and durable civil works, therefore, an exhaustive review of the methods, procedures, dimensions, requirements, performance and quality of materials, personnel, equipment and machinerymust be carried out to ensure compliance with all the requirements of the law.

4. Finally, the objectives and regulatory requirements established in the planning and designs of the project wereachieved, delivering the work in the time and costs delimited for the warehouse type building located in the city of Ocaña, as requested by the contractor.

REFERENCES

[1] Alcaldía Mayor de Bogotá (2016).

[2] General Characterisation of the Seismic Risk Scenario. Retrieved from https://www.idiger.gov.co/rsismico

[3] Álvarez Enciso, J. J. (2015). WHAT IS HAPPENING WITH BUILDING CONSTRUCTION STANDARDS IN COLOMBIA?

[4] Retrieved from https://360enconcreto.com/blog/detalle/normas-construccion-edificaciones-en-colombia/

[5] Colombian Chamber of Construction CAMACOL (January 2023). 72% ofthe of the dwellings marketed during the last 12 months were of social interest. Retrieved from https://camacol.co/actualidad/noticias/cifrascu012023

[6] Campero , M., & Alarcón , L. F. (2008).

[7] Administration of civil projects (E. U.Chile, Ed.) Santiago de Chile , Chile : Editorial Ediciones UC. Retrieved from https://books.google.es/books?hl=es&lr=&id=3XCMDwAAQBAJ&oi=fnd&pg=PT11&dq=projects+of+civil+works+&ots=Kpntg-oQxS&sig=j1-zp7ppObYXdHRzurFETge8DP8#v=onepage&q=projects%20of%20civil+works%20c ivil&f=false

[8] Council of Bogotá (19 September 2018).

[9] 2,500 BUILDINGS IN BOGOTÁ ARE AT RISK OF COLLAPSE.

[10] Retrieved from https://www.metrocuadrado.com/noticias/actualidad/2500-edificaciones-en- bogota-estan-en- riesgo-de-colapso- 3478/

[11] DANE, National Administrative Department of Statistics (2022). Census of buildings (CEED). Retrieved from https://www.dane.gov.co/index.php/estadisticas-por-tema/construccion/censo- de-edificaciones

[12] Del Pino Calvo-Sotelo, R. (n.d.) What are

constructive processes? Retrieved from https://www.ferrovial.com/es/stem/proc esos-constructivos/

[13] National Administrative Department of Statistics (DANE). (2022). Vivienda VIS y NO

[14] VIS - Históricos. Retrieved from Vivienda VIS y NO VIS - Históricos

[15] Gómez Cabrera, A., Quintana Pulido, N., & Ávila Díaz, J. O. (2015). Discrete event simulation and balance lines applied to the improvement of the construction process ofa building foundation. Engineering and Science, 11(21), 157- 175. https://doi.org/10.17230/ingciencia.11.21.8

[16] Hernández, L., & Grettel, A. (September 5, 2008). Improving construction processes. Tecnología en Marcha, 21(4), 64-68. Retrieved from https://dialnet.unirioja.es/servlet/articulo

[17] ?code=4835615 Colombian Society of Engineers (8

[18] November 2019). 200 buildings to be investigated for possible structural problems: SCI. Retrieved from https://sci.org.co/se-investigaran-200- buildings-for-possible-structural- problems-sci/