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Lean Production Applied in Civil Construction: Application of the Last Planner System Methodology

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Abstract:

The objective of this research is to elaborate a proposal for the application of the Last Planner System (LPS) methodology in the planning of a medium-sized civil construction work, with repeated production scale, presenting a project, spreadsheets and weekly monitoring model. This methodology was applied as a model for planning the construction of popular 45m² houses following the same pattern. A three-level LPS sequence was used, namely Initial Planning, Lookahead Planning and Commitment Planning. The first level was a form of master planning, where the initial information of the work is collected. This level is used to facilitate the identification of the main objectives of the work and to define the rhythms of the main production process. In the second level, an adjustment is made to the initial plan and its detailing is improved, it also serves as a form of protection for production, a restriction that prevents the release of activities that do not comply with the quality criteria, controlling the release of activities of the mediumfor the short term only after analyzing and removing all possible impediments at each stage. The third level happens according to weekly work plans, in which the execution of the construction is directly guided, through the assignment of service packages to the teams, observing their commitment to carry them out. The elaborated proposal improved the process management, reduced material waste and served as a pattern for the construction of other buildings.

Keywords:Last Planner System, Lean Construction, Planning.

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1. INTRODUCTION

The need to develop sustainable construction methods and environments is increasingly emphasized by several scholars and professionals, consequently improving people's living conditions, the scarcity of natural resources and the profits of companies. Keeping social, environmental and economic factors interdependent, called the triple bottom line, is not an easy task [1]. It can be argued that “the economy exists in society and society exists in the environment” [2].

In 1992 the Finnish scholar Koskela [3] first proposed the use of Lean Production in construction, calling it Lean Construction. Lean thinking provides a way to accurately define the value of the final product, reduce unnecessary interference to increase efficiency, do more with less, to target products more to the user's needs and eliminate waste by creating value (from the customer's point of view), value flow (aligning the activities that create value in the best sequence), continuous flow (carrying out activities without interruption), hard production (whenever requested) and perfection

(increasingly effective), using the five Lean principles [4].

Traditionally, the concept of lean construction always focused on the elimination of production waste during the construction process, while environmental waste was considered less frequently, however, as the concept evolved, the production waste produced during construction was considered to be related to environmental waste [5].

Tommelein [6] pointed that the use of several standardized materials can alleviate the problems of variations and losses, in order to reduce waste. Ghosh et al. [7] investigated the environmental benefits of lean construction, and the mitigating results that a large number of materials were saved in the case study project, when lean construction tools were implemented. Gbadamosi et al. [8] concluded that the correct selection of materials is an essential parameter to perform a lean construction. As a cleaner production method, lean production applied to civil construction played an important role in reducing environmental waste, among other benefits.

There are several tools and methods for applying lean construction and one of them is the Last Planner System (LPS), presented by Glenn Ballard and Greg Howell. It is a tool developed to control production at construction sites and has become the most popular of the tools based on the principles of Lean Construction. This is due to the fact of its implementation in civil construction, where it has shown successful results [9].

The Last Planner System addresses short-term planning and control operations. The objective is to ensure, through various procedures and tools, that all the prerequisites and conditions of a certain activity are resolved when it starts, in order to allow it to be carried out without disturbance and completed according to plan. With this tool it is proposed to carry out weekly planning, based on the activities whose execution will actually have to happen. At the end of the week, the percentage of activities completed during the week is calculated. This index is called PPC - Percentage of Completed Plans [10]. The reasons that led to the non-execution of what was planned are also investigated, on the basis of which an analysis is carried out and, consequently, an increase in the degree of accomplishment of the weekly plan (process improvement). Control thus appears as a starting point for prevention and correction for continuous improvement.

Based on this, the objective of this research is to develop a proposal for the application of the Last Planner System methodology in the planning of a medium-sized civil construction work, with repeated production scale, presenting a project, spreadsheets and weekly monitoring model.

2. METHODOLOGY

2.1 METHODOLOGICAL PROCEDURES

The research was developed with a qualitative approach, because, according to Mauch and Birch [11], it depends of deductions, requires the involvement of the researcher, demonstrations of assumptions that are behind the actions and in a descriptive way.

Descriptive research requires from the researcher a series of information about what he wants to research, having to gather and analyse enough points for the study. This type of study aims to describe the facts and phenomena of a given reality [12]. Thus, it aims to identify improvements in the process, the advantages of implementing lean production in civil construction, as well as being an exploratory research with a case study in the construction of model houses and standardized size. This involves building 45m² houses (Figures 1 and 2), where the Last Planner System methodology will be applied.

The data collected are budget spreadsheets, schedules, construction projects and construction stages carried out by the construction company, in order to carry out a study for continuous improvement of the construction processes by preparing planning sheets and a weekly monitoring model.

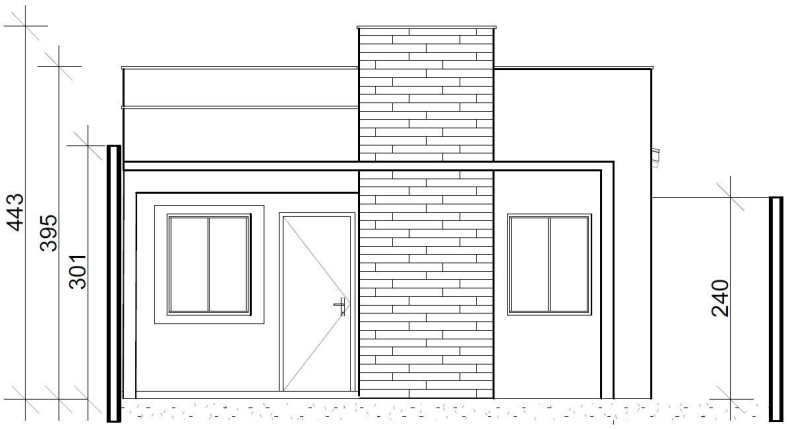

Fig. 145m² building facade

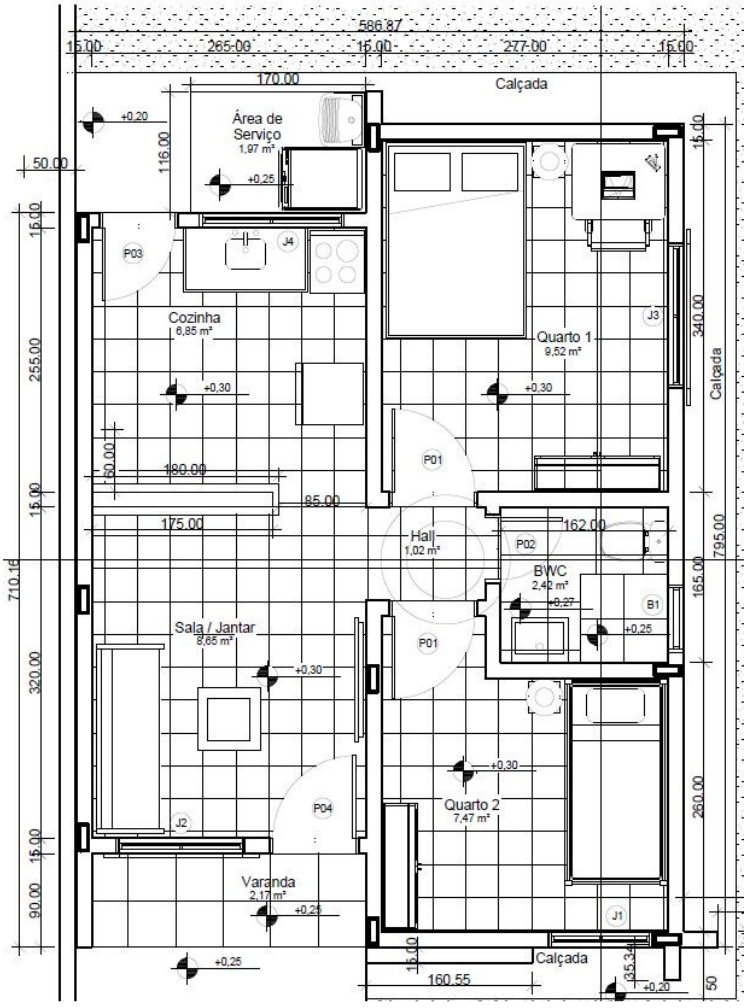

Fig. 2 45m² building floor plan

2.2DESCRIPTION OF THE STUDY AREA

This research was carried out in the city of Teresina (Figure 3), located in the State of Piauí, between the geographical coordinates 5 ° 00'25.5 "S and 42 ° 49'19.5" W. The Lean Construction tool was applied to a medium-sized project, consisting of single-family residential houses.

Fig. 3 Location of the city of Teresina, Piauí, Brazil

In the city where this study was carried out, there are several works of the same type, but no tools for continuous improvement are used, only empirical methods are used, which over time has been adapting to the best forms of execution without the concern of continuous improvement of the process.

3. RESULTS AND DISCUSSIONS

A proposal and implementation of a model was prepared following the principles and methodologies of the Last Planner System, in order to improve process management and reduce waste. It is essential to point out that there is a certain difficulty in adapting the LPS concepts in the Civil Construction industry, taking into account that each work has its particularities and the processes do not follow the same level of repetition compared to a factory.

Initially, it will be shown in Table 1 the comparison of the Conventional vs. Lean Construction System, according to Abdelhamid et al.[13], in order to perceive the differences in the standard execution with which it would make a work more productive and lean.

TABLE 1
COMPARISON OF THE CONVENTIONAL SYSTEM VS. LEAN SYSTEM

Conventional System	Lean System
We know how to turn materialsinto fixed structures.	We still know how to transform materials into fixed structures.
The manager is solely responsible for planning	Managers are primarily responsible for planning processes and their phases. Supervisors and operators are also in the planning process, in this case as the last planners
The process is managed using the elements that refer to the evolution of costs, which are the basis of payments	Cost evolution elements are used as input for planning and controlling operations at the construction site
It is guided by the returns paradigm in terms of time, cost and quality	The payback paradigm is challenged in terms of time, cost and quality by removing sources of waste in the design and production processes in order to promote a better and more reliable workflow
It is considered to provide value to the customer when maximizing performance in relation to cost, that is, with lower costs	It is considered to provide value to the customer when the value of the product is increased (when it effectively corresponds to the customer's needs) through the management of the construction value process
It is assumed that reducing the cost of a part will reduce the cost of the entire project → the whole is the sum of the parts	The project is treated as a system and Target Costing is used to achieve project cost reductions → the whole is more than the sum of the costs of its parts
Scope changes and design failures are expected to occur during construction, however these will only be resolved when they occur, reactively	The product and the construction process are designed collaboratively in order to avoid errors and omissions in design and dimensioning that would lead to future construction problems

A sequence of LPS was used, according to Moura [14], in three levels, for the work under study, according to the order below:

a) Initial or long-term planning;
b) Lookahead or medium-term planning;
c) Commitment or short-term planning.

3.1 INITIAL PLANNING

It is common to carry out a master plan when starting a work in civil construction with regard to the entire construction phase, however due to the uncertainties inherent in the beginning of development of the construction project it is possible that there is a lack of information about the real durations, showing a low degree of detail. The Initial Planning was used to facilitate the identification of the main objectives of the work and also to define the rhythms of the main production processes.

For this study, the Initial Planning was subdivided into 4 different stages, namely:

a) Cash flow;
b) Projects and Technical Specifications (use of BIM technology - Building Information Modeling);
c) Detailed executive budget;
d) Strategic planning for the execution of the work.

With these sub-items, workloads and production teams were defined based on the construction budget spreadsheet and the company's cash flow according to the generated revenue and expense forecasts.

3.1.1 CASH FLOW

This stage is the dissemination of the information collected and prepared up to that moment in order to promote alignment among all those involved in the work. With that, it was possible to schedule the purchase of materials and equipment rental with long term delivery, hiring of own or outsourced labor and also of supplies and human resources that must be programmed to deliver such resources.

3.1.2 PROJECTS AND TECHNICAL SPECIFICATIONS

At this stage, the study was carried out to prepare the executive project and technical specifications. The studies of the projects were made with the use of tools with BIM technology to avoid interference between the architectural project and the auxiliary projects and thus make the service steps continuously.

3.1.3DETAILED EXECUTIVE BUDGET

In order that the cost of the work does not cost much and that the manager is able to execute without lacking funds when building, it is important that the budget of the work is as detailed as possible, well broken down and the amounts are corrected, if the work exceeds the period of 1 year based on INCC (National Index of Civil Construction). A detailed budget avoids wasting time in the construction supply sector, which does not need to buy the same material several times. Another problem due to a non-detailed budget is the uncertainty in the managers' decision making as they do not understand what type of service will be performed and the cost for doing so.

3.1.4 STRATEGIC PLANNING FOR CONSTRUCTION EXECUTION

With the steps of cash flow, projects and technical specifications, and detailed budget, it was possible to start the strategic planning for the execution of the work, using the general work schedule, defining important dates, including delivery dates ofservices and conclusion of construction.

3.2 LOOKAHEAD PLANNING

At this level, a link was made between long- and short-term planning, where the initial plan is adjusted and detailed. The managers of the work, from better access to information, take the appropriate actions for the execution of the selected tasks, as well as the reprogramming of those that could not be executed until that moment, for some specific reason. In this way, Lookahead planning serves as a means of protection for production, a restriction that prevents the release of activities that

do not meet the quality criteria, controlling the release of activities from the medium to the short term only after analyzing and removing all possible impediments at each stage.

For this study, Lookahead Planning was subdivided into 4 different stages, namely:

a) Organization of "construction kits"

b) Purchase schedule using CRSO - Construction Supply Schedule

c) Programming of services using CLS - Release and Services Schedule

d) Calculation of PPC - Percentage of Completed Planned

With these subitems it is possible to define the quantity of materials for a construction, using one as a standard for the execution of the others, making an adjustment until reaching a common quantity for all, with this it is possible to organize the so-called "construction kits" (Annex 1) that for the construction of houses under study, it would be the quantity of basic materials, for example, bags of cement, wood, bricks, roof, ceramic floor, among others, per built house, this makes the construction more effective.

The materials that are not listed have less importance in relation to the impact of your purchase or not, that is, if it is not on the construction site, it is easy to purchase and will not hinder progress, such as the water tank, connections, pipes, drains, where it can be purchased at low cost in the local market.

It was also possible to execute the purchase schedule for these materials based on the CRSO (Work Supply Schedule), a document that explains the deadlines for purchasing the materials for the work and the beginning of the services where it will be used, depending on the type of material delivery time is already considered so that there are no delays in the execution of the work, according to Annex 2.

After the supply schedule is defined, the work must be trained for the material acquisition process according to the dates provided in the CRSO for each stage of the construction so that there are no delays. These steps are shown below in Table 2.

TABLE 2
MATERIAL PROCUREMENT PROCESS

Material requisition	Survey of needs and quantity of works
	Survey of project specifications
	Two-way RM filling (construction and purchase)
Inventory control	Checking the stock of requested materials
	Release of existing materials
	Release of the total order to the missing
Price taking	Analysis of requested materials
	Survey of potential suppliers
	Price quotation with at least three suppliers
	Choice of supply with lowest total cost
Purchase	Purchase order release
	Closing negotiation with chosen supplier
	Renegotiation of purchase conditions
Transport	Transport forwarding by the supplier
	Search and transport of material by the company
Receipt	RM and invoice Conference
	Verification of the material delivered with the invoice (quantity and quality)
Payment	Verification of release of payment for received material
	Archiving of procurement documents
	Forwarding of information for accounting survey

For the scheduling of services, the SRS (Launching and Services Calendar) was used, as shown in Annex 3. This document makes it possible to see which services to perform during construction as

well as their launch dates. In addition, it is possible to have a sense of the restrictions of the services, that is, which service should be done for the other to start, this is important to study the critical path to be taken.

Finally, the Calculation of the PCP (Percentage of Completed Plan), an important monitoring tool that is done every weekend, based on the information collected during the entire week. Figure 4 illustrates a model of a PCP follow-up spreadsheet proposed for the company responsible for construction.

Client logo					Company logo
Theme / Title:	Percentage of completed plans (PCP) - Week 2 - September 16 to 20, 2019				
Unit:	Work identification			Date:	20/09/2019

Participants					
Name	Company	Signature	Name	Company	Signature
Henrique	Company A		Francisco	Company D	
Carlos	Company B		Jorge	Company E	
Antônio	Company C		Victor	Company F	

CAUSES							
	1	Project Change - Client	9	Licenses	17	Priority change - Company
	2	Project Change - Company	10	Specifications	18	Miss of project
	3	Labor - Construction	11	Material - Construction	19	Sequencing error
	4	Labor - Contractor	12	Material - Contractor	20	Overestimated productivity
	5	Equipment	13	Disagreement inspection	21	Miss of energy and/or water
	6	Work Safety	14	Priority change - Customer	22	Miss of commitment
	7	Clime	15	Previous task not completed	23	Activity interference - Customer
	8	Customer approval	16	Interference from another activity	24	Hiring issues - Company

Work front	DAY							Responsible Company	PCP			CAUSES
	M	T	W	T	F	S	S		0%	20%	100%	
	1	2	3	4	5	6	7					
Activity 1	X	X	X					Company E			X	
Activity 2			X	X				Company C		X		16
Activity 3		X	X	X	X	X		Company B	X			17
Activity 4		X	X					Company A	X			4
Activity 5	X	X	X	X	X	X		Company C			X	
Activity 6				X	X			Company D			X	
Activity 7	X	X	X	X	X	X		Company A			X	
Activity 8	X	X	X					Company C		X		20
Activity 9				X	X			Company D			X	
Activity 10	X	X						Company F			X	
Activity 11			X	X	X			Company B			X	
Activity 12		X	X					Company D	X			22
Activity 13		X						Company A			X	
Activity 14	X	X	X	X				Company B		X		4
Activity 15					X			Company C	X			15

Fig. 4 Worksheet PCP

3.3COMMITMENT PLANNING

Usually, this step happens according to weekly work plans, in which the execution of the construction is directly guided, through the assignment of service packages to the teams, observing their commitment to carry them out. This level involves the operational team and is the last stage of the planning process and in order to have a good result, the effective commitment of all involved is necessary.

The teams' commitment was made through the participation of a representative or person in charge of each service team in the weekly planning meeting since each one has knowledge about the capacity of their team and their restrictions for the execution of tasks, establishing a connection in the team. communication with other construction workers. The tasks must meet the quality requirements, must be sequenced and need to be consistent with the production capacity of the teams according to the time available for the execution of the work, in view of this it is necessary that the projects are complete and the materials are available on the job at the right time, otherwise the causes of their failure should be monitored.

4. FINAL CONSIDERATIONS

The elaboration of the proposal to apply the Last Planner System methodology to be used in the planning of the construction work was successful because it has the characteristic of a systematic work, that is, repetitive processes where continuous improvements can be applied. The division of the LPS into a sequence of 3 levels contributed to better planning of the work.

Initial or long-term planning was essential for identifying the main objectives of the work and defining the rhythms of the main production processes as well as the workloads, the production teams based on the budget spreadsheet and the cash flow accordinglyrevenue and expenditure forecasts. In Lookahead or medium-term planning, it was possible to make a link between long and short-term planning and adjust and detail the initial planning, facilitating better access to information for managers, taking the appropriate actions for the execution of the selected tasks, as well as reprogramming those that could not be executed. In this second level planning, “construction kits” can be organized, the Work Supply Schedule, Service Release Schedule and the spreadsheet for calculating the Percentage of Completed Planned, where they could assist in better execution of services. In Commitment Planning, it is important to involve the operational team together with their supervisors, where they participate in the weekly planning meetings so that they can pass it on to the entire team.

It was not possible to have more than one sample of houses built for the methodology to be applied, being limited to a single building. It is recommended for future studies to apply this proposal in at least 5 samples so that adjustments can be made from the first to the last and that it can further improve this method.

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Annex 1: Construction Kits Worksheet (45m² house)

Item	Description	Unit	Quantity	Place of use
1	8-hole ceramic brick (walls)	und	5000	Internal and external area
2	9-hole ceramic brick (foundation)	und	1700	Internal and external area
3	Mixed sand	m³	10	Internal and external area
4	Gravel	m³	4	Internal and external area
5	Clay (landfill)	m³	15	Internal and external area
6	50 kg cement bag	und	95	Internal and external area
7	6.3 mm CA-50 steel bollards, 4.2 mm stirrup, 3m (7x14)	und	49	Internal and external area
8	8.0mm CA-50 steel baldrame beam, 5.0mm stirrup, 3m (14x9)	und	42	Internal and external area
9	Mixed wooden board (20x300)	und	30	External area
10	Mixed Wooden Frechal (6x300)	und	10	External area
11	Roman ceramic tile	und	840	Roof
12	Slats (2.5x5 cm)	dozen	5	Roof
13	Ridge (120 cm)	und	2	Roof
14	Ream (200 cm)	und	3	Roof
15	Ridge (300 cm)	und	16	Roof
16	Rails (350 cm)	und	21	Roof
17	Wood line (275 cm)	und	1	Roof
18	Wood line (235 cm)	und	1	Roof
19	Wood line (255 cm)	und	1	Roof
20	Wood line (270 cm)	und	1	Roof
21	45x45 ceramic floor (1.62 m² per box)	box	28	Internal area
22	Ceramic wall cladding 45x45 (1.62 m² per box)	box	38	Internal area
23	15 kg AC-1 grout bag	und	40	Internal area
24	1 kg gray grout bag	und	16	Internal area
25	Spacer bag for 3 mm ceramic - 100 pieces	und	3	Internal area
26	1.5 mm red flexible cable (lighting) - 100 m roll	und	1	Internal area
27	1.5 mm white flexible cable (lighting) - 100 m roll	und	2	Internal area
28	1.5 mm blue flexible cable (lighting) - 100 m roll	und	1	Internal area
29	1.5 mm green flexible cable (lighting) - 100 m roll	und	1	Internal area
30	2.5 mm red flexible cable (sockets) - 100 m roll	und	1	Internal area
31	2.5 mm green flexible cable (sockets) - 100 m roll	und	1	Internal area
32	2.5 mm blue flexible cable (sockets) - 100 m roll	und	1	Internal area
33	4.0 mm red flexible cable (general frame) - 25 m roll	und	1	Internal area
34	4.0 mm blue flexible cable (general frame) - 25 m roll	und	1	Internal area
35	4x2 boxes for sockets and switches	und	21	Internal area
36	4x4 Boxes	und	5	Internal area
37	Parallel switch	und	2	Internal area
38	Simple switch coupled with socket	und	1	Internal area
39	Simple switch	und	4	Internal area
40	Simple socket	und	14	Internal area
41	Plasterboard 60x60	und	125	Internal area
42	Galvanized wire 1 kg	und	1	Internal area
43	40 kg plaster bag	und	6	Internal area
44	Cisal	kg	1	Internal area
45	Waterproofing for baldrame and wall - 18 L	und	1	Internal area
46	Acrylic sealer - 18 L	und	4	Internal and external area
47	PVA running mass - 27 kg	und	4	Internal area
48	White Acrylic Latex Paint - 18 L	und	2	Internal area
49	Water-based synthetic enamel paint - 3.6 L	und	2	Internal and external area
50	Cream-colored texture - 18 L	und	3	Internal area
51	Sandpaper n ° 120 for wall	und	25	Internal area
52	Sandpaper n ° 100 for wall	und	8	Internal area
53	Wooden door (80 cm)	und	2	Internal area
54	Wooden door (60 cm)	und	1	Internal area
55	Iron door (80 cm)	und	1	Internal area
56	Iron door (70 cm)	und	1	Internal area
57	Aluminum and glass windows (100x120 cm)	und	1	Internal area
58	Aluminum and glass windows (125x120 cm)	und	1	Internal area
59	Aluminum and glass windows (140x120 cm)	und	1	Internal area
60	Aluminum and glass windows (140x62 cm)	und	1	Internal area
61	Entrance gate (280x235 cm)	und	1	Internal area
62	Bathroom tipper (65x40 cm)	und	1	Internal area
63	Toilet	und	1	Internal area
64	Kitchen sink	und	1	Internal area
65	Bathroom washbasin	und	1	Internal area
66	Service area tank	und	1	External area

Annex 2: Construction Supplies Schedule Worksheet

Item	Description	Unit	Quantity	Deadline for the start of purchase	Deadline for the start of execution
2	9-hole ceramic brick (foundation)	und	1700	12/08/2019	09/09/2019
3	Mixed sand	m³	10	12/08/2019	09/09/2019
4	Gravel	m³	4	12/08/2019	09/09/2019
6	50 kg cement bag	und	95	12/08/2019	09/09/2019
7	6.3 mm CA-50 steel bollards, 4.2 mm stirrup, 3m (7x14)	und	49	12/08/2019	09/09/2019
8	8.0mm CA-50 steel baldrame beam, 5.0mm stirrup, 3m (14x9)	und	42	12/08/2019	09/09/2019
9	Mixed wooden board (20x300)	und	30	12/08/2019	09/09/2019
10	Mixed Wooden Frechal (6x300)	und	10	12/08/2019	09/09/2019
45	Waterproofing for baldrame and wall - 18 L	und	1	31/08/2019	23/09/2019
1	8-hole ceramic brick (walls)	und	5000	31/08/2019	24/09/2019
5	Clay (landfill)	m³	15	03/09/2019	30/09/2019
35	4x2 boxes for sockets and switches	und	21	14/09/2019	07/10/2019
36	4x4 Boxes	und	5	14/09/2019	07/10/2019
11	Roman ceramic tile	und	840	07/10/2019	28/10/2019
12	Slats (2.5x5 cm)	dozen	5	07/10/2019	28/10/2019
13	Ridge (120 cm)	und	2	07/10/2019	28/10/2019
14	Ream (200 cm)	und	3	07/10/2019	28/10/2019
15	Ridge (300 cm)	und	16	07/10/2019	28/10/2019
16	Rails (350 cm)	und	21	07/10/2019	28/10/2019
17	Wood line (275 cm)	und	1	07/10/2019	28/10/2019
18	Wood line (235 cm)	und	1	07/10/2019	28/10/2019
19	Wood line (255 cm)	und	1	07/10/2019	28/10/2019
53	Wooden door (80 cm)	und	2	14/10/2019	01/11/2019
54	Wooden door (60 cm)	und	1	14/10/2019	01/11/2019
55	Iron door (80 cm)	und	1	14/10/2019	01/11/2019
56	Iron door (70 cm)	und	1	14/10/2019	01/11/2019
57	Aluminum and glass windows (100x120 cm)	und	1	14/10/2019	01/11/2019
58	Aluminum and glass windows (125x120 cm)	und	1	14/10/2019	01/11/2019
59	Aluminum and glass windows (140x120 cm)	und	1	14/10/2019	01/11/2019
60	Aluminum and glass windows (140x62 cm)	und	1	14/10/2019	01/11/2019
61	Entrance gate (280x235 cm)	und	1	14/10/2019	01/11/2019
62	Bathroom tipper (65x40 cm)	und	1	14/10/2019	01/11/2019
41	Plasterboard 60x60	und	125	14/10/2019	04/11/2019
42	Galvanized wire 1 kg	und	1	14/10/2019	04/11/2019
43	40 kg plaster bag	und	6	14/10/2019	04/11/2019
44	Cisal	kg	1	14/10/2019	04/11/2019
21	45x45 ceramic floor (1.62 m² per box)	box	28	21/10/2019	08/11/2019
22	Ceramic wall cladding 45x45 (1.62 m² per box)	box	38	21/10/2019	08/11/2019
23	15 kg AC-1 grout bag	und	40	21/10/2019	08/11/2019
24	1 kg gray grout bag	und	16	21/10/2019	08/11/2019
25	Spacer bag for 3 mm ceramic - 100 pieces	und	3	21/10/2019	18/11/2019
46	Acrylic sealer - 18 L	und	4	31/10/2019	18/11/2019
47	PVA running mass - 27 kg	und	4	31/10/2019	18/11/2019
48	White Acrylic Latex Paint - 18 L	und	2	31/10/2019	18/11/2019
49	Water-based synthetic enamel paint - 3.6 L	und	2	31/10/2019	18/11/2019
50	Cream-colored texture - 18 L	und	3	31/10/2019	18/11/2019
51	Sandpaper n ° 120 for wall	und	25	31/10/2019	18/11/2019
52	Sandpaper n ° 100 for wall	und	8	31/10/2019	22/11/2019
26	1.5 mm red flexible cable (lighting) - 100 m roll	und	1	28/10/2019	22/11/2019
27	1.5 mm white flexible cable (lighting) - 100 m roll	und	2	28/10/2019	22/11/2019
28	1.5 mm blue flexible cable (lighting) - 100 m roll	und	1	28/10/2019	22/11/2019
29	1.5 mm green flexible cable (lighting) - 100 m roll	und	1	28/10/2019	22/11/2019
30	2.5 mm red flexible cable (sockets) - 100 m roll	und	1	28/10/2019	22/11/2019
31	2.5 mm green flexible cable (sockets) - 100 m roll	und	1	28/10/2019	22/11/2019
32	2.5 mm blue flexible cable (sockets) - 100 m roll	und	1	28/10/2019	22/11/2019
33	4.0 mm red flexible cable (general frame) - 25 m roll	und	1	28/10/2019	22/11/2019
34	4.0 mm blue flexible cable (general frame) - 25 m roll	und	1	28/10/2019	22/11/2019
37	Parallel switch	und	2	01/11/2019	25/11/2019
38	Simple switch coupled with socket	und	1	01/11/2019	25/11/2019
39	Simple switch	und	4	01/11/2019	25/11/2019
40	Simple socket	und	14	01/11/2019	25/11/2019
63	Toilet	und	1	01/11/2019	02/12/2019
64	Kitchen sink	und	1	01/11/2019	02/12/2019
65	Bathroom washbasin	und	1	01/11/2019	02/12/2019
66	Service control	und	1	01/11/2019	02/12/2019

Annex 3: Execution schedule - Single family house

ITEM	DESCRIPTION	MONTH 1		MONTH 2		MONTH 3		MONTH 4	
		PLANNED (%)	EXECUTED (%)	PLANNED (%)	EXECUTED (%)	PLANNED (%)	EXECUTED (%)	PLANNED (%)	EXECUTED (%)
1	PRELIMINARY SERVICES	100	100						
2	INFRASTRUCTURE	55	65	45	35				
3	SUPRASTRUCTURE	35	35	65	65				
4	WALLS AND PANELS	70	70	30	30				
5	FRAMES	30	30			50	50	20	20
6	GLASS AND PLASTICS							100	100
7	ROOF			25	25	75	75		
8	WATERPROOFING	50	50	50	50				
9	INTERNAL COATINGS					50	50	50	50
10	LINER					100	100		
10	EXTERNAL COATINGS			50	50	50	50		
10	PAINTING					25	25	75	75
10	FLOORS			25	25	75	75		
10	FINISHES							100	100
10	ELECTRICAL AND TELEPHONE INSTALLATIONS	30	30	50	50	10	10	10	10

