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THE PROCESS TIMELINE FOR SUSTAINABLE CONSTRUCTION MANAGEMENT: CASE STUDY IN THE CONSTRUCTION OF AN EDUCATIONAL CENTRE

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ABSTRACT

Entrepreneurship is hard work, especially when it comes to the creation of an innovative, ecologically correct and sustainable project, and the small entrepreneur, in addition to facing bureaucratic and fiscal obstacles, has great difficulty in running his business, planning and optimizing his production for lack structured management knowledge. This is what happens with the company studied, where the construction of an educational centre, thought to be a model of ecological and sustainable building, did not have a schedule of execution, thus becoming dependent on very short term planning, accomplished at each step, rather than a structured action as a whole. In this sense, the Critical Path Method (CPM), which uses simple estimates for the duration of the building stages and the PERT technique, was implemented among a variety of schedules and methods for planning and control of works execution.

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This method is suitable and simple to use by small businesses. This methodology, easy to be understood and implemented, generated benefit to the company, allowing planning, predictability and control of the works.

Keywords: planning, control, sustainability, CPM, PERT.

1. INTRODUCTION

The process of controlling the work reflects directly on the performance of the production; with the most commons shortcomings in the construction process the low productivity, waste and quality (BRITO; FERREIRA, 2015).

Brito and Ferreira (2015), points out that the role of production is to know and correct the deviations in relation to planned, before they occur, and continuously evaluating the quality of the planned project. The timelines, the network diagrams and the balance lines are used as the main planning techniques.

In this way, the schedules are the most common tool used in building construction management, although there are some limitations in the activities that cause changes in critical paths.

Creating a sustainable educational Centre requires a lot of determination from the managers and workers which are involved in this project. The company, in which the study was developed, started the process of building the sustainable educational Centre from the decision of changing the production of ornamental plants from a site located in the neighborhood of Pindorama, in Mogi das Cruzes, to this Centre.

Thus, the study is part of a process of implementation of the program to optimize and accelerate the educational Centre construction. A program of planning and control was started to organize the activities on a schedule, which was structured to be used in the creation process, organizing and establishing goals for the construction stages, which, originally, was not part of the building activities. The absence of this method was causing overtime for the job conclusion and consequently some delay in obtaining the expected results.

This is the structuring of an educational Centre by the bioconstruction process, which means it was based on natural resources sustainable. This methodology is slower than the conventional ways of constructions, once it is necessary to be carried out in stages. The project of the educational Centre is

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divided in 20 structures, three of which are already in progress. The others will be built within an estimated deadline of 24 months.

The objective of this research was to develop a mechanism to accelerate the production orders and to increase the efficiency of this process. The management of this operation covers a wide variety of subjects, including construction processes, agribusiness processes, small business processes and so on. Moreover, from the premise that operational processes require control, direction, planning and action, it was verified the necessity of the search for automation of the planning and control of the construction stages.

2. LITERATURE REVIEW

2.1. Social entrepreneurship

According to Oliveira (2004), the concept of social entrepreneurship is recent, with less than 30 years; it is a concept very close to volunteering or charity. Some scholars point to Luther King, Gandhi, among others, as social entrepreneurs, as a result of their leadership and innovation capacities for large-scale change.

Airo (2012) defines social entrepreneur as someone working in an entrepreneurial way to benefit the social, without aiming at maximizing profits. They are innovative, visionary, creative and determined, eventually, they are leaders working in all types of companies. They are important agents of social change.

The definition of social entrepreneurship varies from its broadest form to the most restricted one. Broadly speaking, social entrepreneurship refers to innovative activities with a social purpose in their profitable form (as in social and commercial investments, or in their corporate social entrepreneurship strand), in their non-profit form, or in mixed forms (such as hybrid structures formed by unprofitable and profitable approaches simultaneously). From a more restricted perspective, social entrepreneurship usually refers to the phenomenon of applying knowledge of business competencies to the nonprofit sector, as it happens in organizations that find innovative ways to make money (FÉLIX et al., 2012).

2.2. Schedules

In line with the study by Codas (1987), World War II required the creation of more effective planning methods, since, besides the large quantity of data, they

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involved the military, navy and army of at least three countries. Thus, the operational research was created to supply this need and the concept of project management emerged in the USA at the end of the 1950s, applied to implementation of enterprises and analysis of computer systems development.

According to Silva Júnior and Santos (2015), projects are currently considered as a dominant form of work in organizations, once the project management is one of the means to reach the company goals that have origins from various market stimuli and requests or from the offers of new products or services.

The schedule can be seen as a refinement of the network data, since it, according to Silva Júnior and Santos (2015), includes information, resources (material and human) to carry out each task and constraints, limitations and assumptions.

2.2.1. Program Evolution and Review Technique (PERT) / Critical Path Method (CPM)

According to Codas (1987), the planning methods developed were those of network analysis, such as CPM (Critical Path Method, 1957) by Dupont, and PERT (Program Evolution and Review Technique, 1958), by the Office of Special Projects US Navy. The PERT method was intended for the implementation of industrial projects and the CPM for military projects linked to the space race. From the combination of the two techniques came the PERT-CPM technique.

CPM (Critical Path Method), on the other hand, is the result of studies in an area of the operational research that has been called "flows in graphics", and that has received dissemination, by mathematical affinity, as a topic allied to linear programming. Studies in CPM began around 1956 by J.E. Kelley for DuPont and were completed with the model developed by Ford and Fulkerson for the Rand Corporation.

In the PERT system, the deadlines for completing the tasks are treated probabilistically while in the CPM system the deadlines for performing the tasks are treated in a deterministic manner. As the methods were used, the characteristics that previously distinguished them were incorporated from one method to another, so that, due to this integration today, these methods are known as the PERT/CPM system (PEINADO; GRAEML, 2007).

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In consonance with Miranda et al. (2003), in the PERT/CPM, a project can be visualized as a set of operations conducted in a certain sequence to reach some goals. Once activities have been identified, they can be represented and ordered in a Network Diagram. The PERT/CPM technique can be used in conjunction with a multicriteria decision support methodology, incorporating the critical aspects of the projects and, in this way, allowing a more realistic treatment of the problem. In this case, the project's critical activities are determined so that the manager can concentrate his efforts on the control and monitoring of these activities with a bigger chance of presenting problems during execution.

2.2.2. Gantt

The Gantt chart is a tool developed by the North American Henry L. Gantt in 1917. It is a graph of matrix form of the activities of the project and a time line where, for each task is assigned a length bar proportional to the time of the duration of the task. The Gantt chart is now used in project control due to its ease and excellent visual communication (PEINADO; GRAEML, 2007).

3. METHODOLOGY

Conducting a survey assumes a series of decision-making at the beginning and in the course of the research, that are related to the way in which data and theory will be used to meet the empirical and objective characteristics of science (COELHO, 2004).

The methodological approach is the applied case study, using participant observation and semi-structured interview with the entrepreneur.

Acoording to Yin (2013), a case study is an empirical investigation that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly defined.

The case study has different purposes, one of them, it is explore real life situations and the object of studied is unique, but one of the objections is the difficulty of generalizing the results of the study (GIL, 2002).

In the first stage, a meeting with the centre managers was held to analyze and meet the real needs of the company, in order to understand the priorities of the

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buildings and the order of execution of the project. For this purpose, the meeting was elaborated by the Design Thinking method.

Mota et al. (2015) defines how a user-centered approach, established from a cyclical perspective, divided into three big steps. Inspiration: when research is motivated in the search for solutions; Ideation: to generate, make and test the ideas and solutions identified; Implementation: raises the perception of the market and realizes the commercial and industrial implementation; also enables the start of a new development cycle. At this stage it was still possible to define the research question.

The second stage, after knowing that the real problem was the difficulty in organizing a schedule, some bibliographical researches were done on sustainable schools, permaculture and bioconstruction, social entrepreneurship and types of schedules more used in the construction organization, among them PERT and CPM, Gantt Diagram and the BIM System, which composed the theoretical reference of this research project. Then, the results of this theoretical research were presented to the company for discussion and validation.

The third step was to prepare a list in order of execution of the works; this list was organized according to the priorities of the entrepreneur.

In the fourth stage, the scheduling techniques, Gantt, PERT and the BIM System were analyzed.

The fifth step was elaborated in a practical way, by the application of the scheduling techniques. Initially, the list of structures was transformed into a PERT/CPM diagram, it is worth mentioning that the lead time of each structure is based on events, since the construction process takes place through groups of volunteers, courses and workshops.

4. ANALYSIS OF RESULTS

The property analyzed has an area of 20,200 m² that was used in the production and sale of ornamental plants in Pindorama (Rural Zone of Mogi das Cruzes, SP), an excellent location, with an asphalted road connected to the Engenheiro Cândido do Rêgo Chaves Highway, SP-39, Rota do Caminho do Mar.

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The owners of the property worked for twenty-three years as producers of ornamental plants, being permission holders in the Companhia de Entrepostos e Armazéns Gerais de São Paulo (CEAGESP).

CEAGESP is a government warehouse for marketing between producers and traders of products like vegetables, fruits, flowers and grains. They rent two sale shops, one in the night market, from 10 pm to midnight, on Mondays and Thursdays and the other one in the early morning market from 02:00 am to 10:00 am on Tuesday and Friday.

However, the long distance from this site and the mentioned market place, 80 km, and considering to cost of transport, maintenance of the vehicle, the high rent cost of the shops and poor quality of life were the causes that make them give up selling at CEAGESP eight years ago. In this period, in which Mr. Francisco sold at CEAGESP, lacked time to produce and sell with dedication. Currently, the commercialization of the production is made only on the croft.

On the other hand, the school centre, which operates since 2012, was idealized by young friends who seek to create a sustainable school. Focusing on the idea of creating a space to receive children and adults who may actually have contact with the land, in this way, the idea of a school being totally sustainable.

The process of creation of the sustainable school occurs in a gradual way, with courses of bioconstruction for the sustainable construction preserving the environment, teacher training courses for the vegetable garden project, volunteers' group experiences to complete the school works.

The first course was held in March 2016, in partnership with the Institute of Permaculture and Ecovilas da Mata Atlântica (IPEMA), when construction of a dry ecological toilet was started, with the construction technique with raw soil - COB, a technique of construction with earth that allows to use a lot of creativity and freedom, since it consists of going to shape the house like a great sculpture. After this construction, other structures were started, such as a wooden pallet kiosk and a greenhouse made of treated bamboo.

Broadly speaking, the school would focus on sustainability, a space where people have the opportunity to learn how to deal with a vegetable garden and practice it, have direct contact with the land and nature, which stimulates the

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consumption and production of healthy foods and approaching permaculture and, eventually, learning sustainable building techniques.

From the construction of the physical structure to the cleaning and management of environmental resources, there is concern for the environment and the well-being of all involved. All activities of the school will be directed to all people involved in order to develop collective daily attitudes related to sustainability and respect, both with colleagues and the environment, as well as to arouse interest in environmental projects.

4.1. School deployment schedule

In order to carry out the construction of the Sustainable School, a schedule (table 1) was drawn up in order to monitor the evolution of the works. Based on this schedule, it will be set the calendar of activities to continue the construction, which activities will occur in parallel. At the outset, the estimated completion of the works was December 2018, but the activities of the sustainable school may begin before this deadline, once the main structures are ready and the site has been legally approved for operation.

Table 1: Construction schedule

Activity	Description	Previous	Lead Time
A	Toilet construction	-	10
B	Vegetable garden	-	4
C	Wooden kiosk	A	4
D	Greenhouse	B	4
E	Vivarium	D	4
F	Agroforestry planting	B	4
G	Toilets	C	2
H	Trail	E	4
I	Bicycle park	H	4
J	Treehouse	G	8
K	Camping	F	2
L	Canebreak	K	2
M	Picnic	L	2
N	Headquarters	J	15
O	LAB	M	15
P	Party room	A	40
Q	Classrooms	A	40
R	Three little pig's house	I	8
S	Gazebo	R	8
T	Carps tanks	S	6

Source: the authors, 2017

For better visualization, the Gantt Chart (figure 1) was used, which aims to illustrate the progress of different stages of a project, since it visually organizes the

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tasks and deadlines that must be fulfilled, according to the Diagram below, provided by the company.

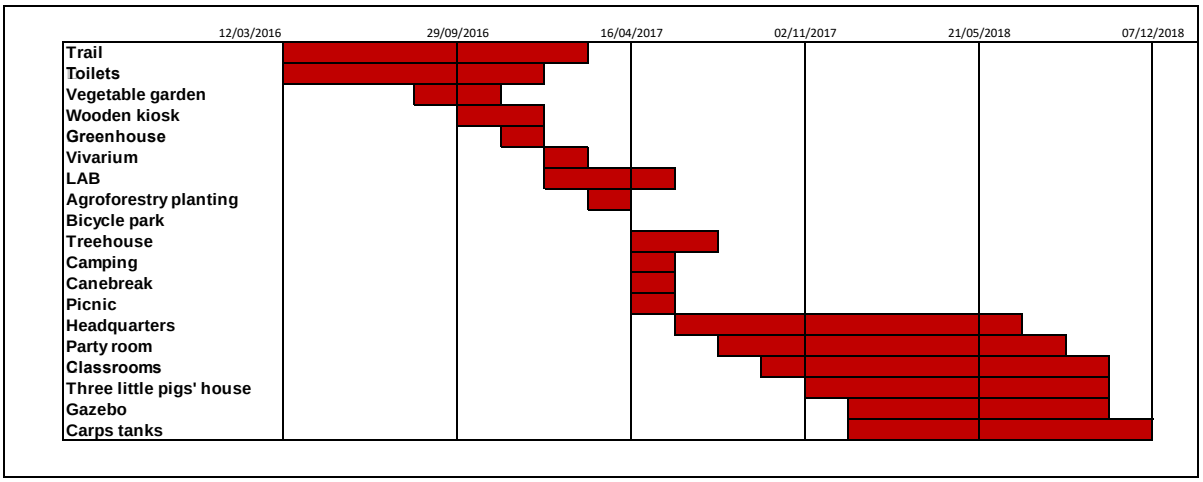

Figure 1: Gantt chart
Source: the authors, 2017

Below, the development of the PERT/CPM Diagram (figure 2) applied to the company is showed. This diagram was prepared by the author according to the data provided by the entrepreneur.

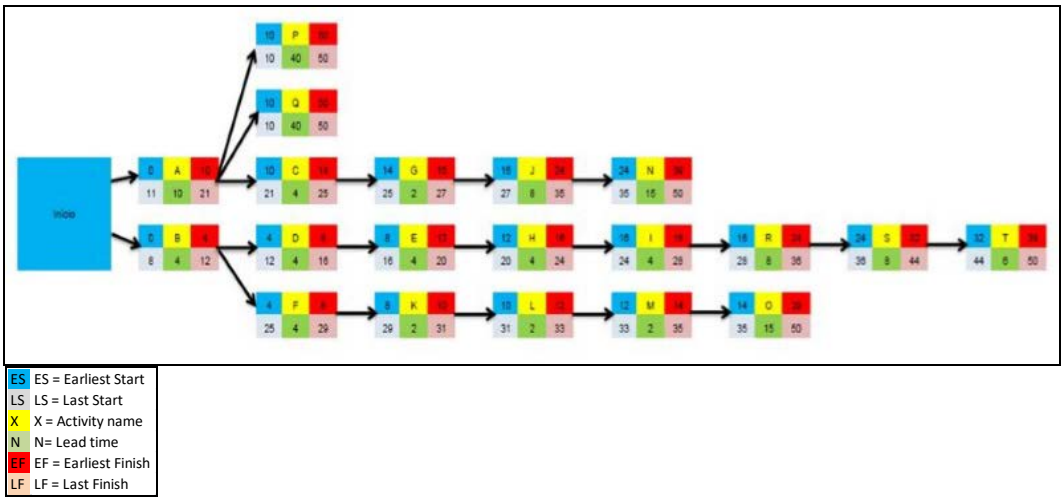

Figure 2: Gantt chart
Source: the authors, 2017

5. CONCLUSION

Gantt and PERT/CPM diagrams were analyzed with the entrepreneur. It was agreed that for the Gantt diagram there is a need to apply the PERT/CPM method, since it calculates the initial and final dates of the activities, and they depend on each other. The Gantt diagram, without the other systems, has only the function of distributing the average execution time of the tasks, so that the PERT/CPM result can be applied directly to the Gantt diagram.

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In addition to indicating the critical path, PERT/CPM allow the project to be easily visualized and allow the user to choose another path where there is more free time between the execution of the tasks, prompting the need for the exchange sequence of activities if it is necessary.

In view of this research, the PERT/CPM, as expected, met the demands of the company, where the diagram elaborated without the necessity of a great theoretical repertoire on the part of the entrepreneurs. It was immediate used; it was applied to the calendar of the company's activities, making it possible to estimate the total and partial dead line of the work and its stages, which was impossible for administrators to do without adequate methodologies.

It was proposed to the company, to encourage the establishment of dates to start the activities and to send the reminders of these dates and execution deadlines, directly to the e-mails, schedules and calendars of the coordinators of each nucleus, which are responsible for the execution of the works of each activity, leading the process of creating a sustainable educational center to the success.

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