GUIDELINES FOR THE ACQUISITION OF NEW CONSTRUCTION TECHNOLOGY

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The Brazilian market for construction and development has grown strongly in recent years, driven by both foreign and domestic investment, with consequently ever increasing demand for raw materials and skilled labor.
Anticipating a likely shortage of these resources, many builders and developers are opting for new construction methods, which are less reliant on limited numbers of suppliers and skilled labor.
According to Sabbatini (Sabbatini, 1989) the building construction industry has a great resistance in implementing and adapting to changes, especially because of the "philosophy" of empiricism as a tool of technical development.
This manner of incorporate new construction methods, based only on experience without any technical support, brings risks, low productivity and skilled labor dependence.
Adopting new technology involves new challenges and risks, especially when it has not been fully developed and tested.
In order to minimize the risks of purchasing new and unproven construction technology and to support the analysis of future business investment, we have sought out an innovative methodology.
The aim of this work is to present the guidelines applied by a Brazilian construction company to the acquisition of a construction system for concrete walls using aluminum formwork. The methodology was initially applied to the construction process of making concrete walls using aluminum formwork, a technique that is already known throughout the Brazilian market, but, as it is still not standard practice, therefore, represents an innovation.
This study was carried out by the company's R & D team and addressed a variety of topics, such as market analysis, benchmarking, participation in technical committees, expert support, site visits, post-work performance analysis in different bioclimatic regions, architectural and building systems efficiency, systemic study of all production cycles, evaluation of the technology suppliers, study of technological attributes that yield environmental / social and occupational safety benefits, rate of return on capital investment involving different production scenarios and cash flow exposure, considering different ways of financing the acquisition, and customer opinions following completion and delivery.
We analyzed three scenarios (optimistic, pessimistic and realistic) in the cost comparison for decision making. This comparison showed the results of the concrete wall technology, in terms of margin and rate of return, to already be very close to the structural masonry technology (currently adopted), with a tendency for them to improve with mastery of this new technology.
Keywords: Procurement Guideline, Construction technology, Benchmarking, Systems

INTRODUCTION

One of the most important in the Brazilian economy, with roughly 173,000 companies, the construction sector is enjoying a period of rapid growth (Simão, 2012).

The increased demand has also brought new challenges for the industry, which is attempting to adapt as it goes to the evolving market needs (Simão, 2012).
The main factors underlying the construction industry growth are as follows (Ribeiro, 2011):

- First of all, the easing of credit restrictions by the government, which has particularly affected the middle class. Social class C has been the major buyer of new properties, and this has led to the increased launching of real estate developments, to meet this demand.
- The federal government's implementation of the PAC (Growth Acceleration Program), which is generating an increased volume of infrastructure works.
- Infrastructure works for the two sporting mega-events that the country will host in 2014 (World Cup) and 2016 (Olympic Games).

In anticipation of a probable shortage of building materials, labor and equipment, many builders and developers have been adopting new construction methods that are less dependent on a limited number of suppliers and a specialized workforce, such as mechanized solutions and industrialized construction systems.
One technique that has been widely discussed in the Brazilian market is the use of concrete walls, since the method, based on industrialized processes, is highly productive, reduces the development execution cycle, enables simultaneous erection and sealing of the structure, does not require specialized labor, brings down the labor and indirect costs, the aluminum formwork generate no waste, requires no plastering or the plaster can be applied in a thin layer, and the overall cost is highly competitive (ABESC, 2012; Elmor, 2012; Misurelli, 2009; Loturco, 2007).
This alternative technique, capable of replacing the structural masonry building method, is currently being used by the company on work for the economy sector and is being studied in action.
The adoption of new technology always brings new challenges and risks, particularly when it has not been fully developed. In order to minimize the risk associated with acquiring a new building technology, the company has pursued an innovative methodology.
In view of the need for a careful assessment of all the factors involved in the adoption of a new technique, particularly when dealing with the erecting of the building structure and the widespread impact on the other sub-systems, the company decided, acting through its R&D department, to utilize a broad methodology for analysis of the options available in the market. The aim of this work is to present the technological selection methodology adopted and the results obtained from applying it.

TECHNOLOGICAL SELECTION METHODOLOGY

The usual procedure adopted by a construction company when acquiring new technology means following the supplies team procurement process, involving the evaluation and ratification of suppliers and a cost/benefit analysis.
In this particular case, the study began from a current market view of concrete walls and related systems and involved the acquisition of technical know-how (participation in seminars and committees), the evaluation and ratification of all the suppliers in the chain, and final selection of the best options for the technical-economic study of the technology's viability. The methodology followed the sequence shown in Figure 1.

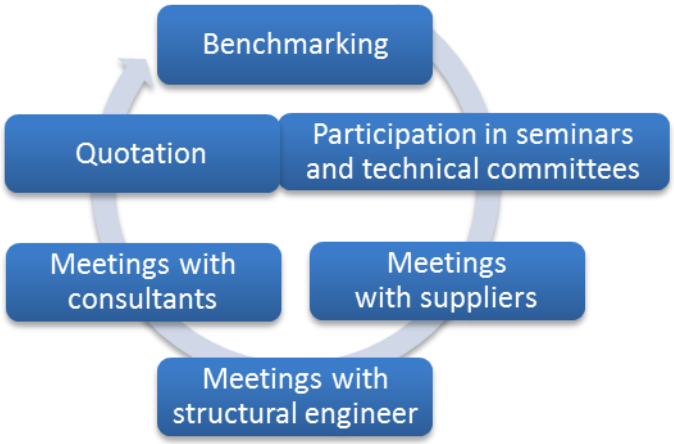

Figure 1 – Activity flow for the study of concrete walls

Each of these stages receives feedback from the others.
In addition to the R&D team, during the course of the work, other professionals from different areas of the company were invited to participate, such as financial analysts, the developments coordinator, architects, buyers, and people from the building installations, technical assistance, budgeting, planning and works departments.
In order to analyze the feasibility of a structure using concrete walls that are molded on site, a study was made of a project for an economy standard development, which had been designed to use structural masonry. To compare the cost of the two techniques, the designs were prepared for the same development using concrete walls, considering different building heights (G+5, G+12, G+19), so as to be able to analyze the behavior of the system compared to that of structural masonry.
Furthermore, 3 different work durations were considered, to analyze the impact of variations in the concreting cycle on the total cost of the works. The cycles that were considered were:

- 6 days per slab for the 10 towers; considered in this study to be a pessimistic cycle.
- 6 days per slab for the first 4 towers and 4 days per slab for the last 6 towers; considered to be the most likely cycle.
- 4 days per slab for the 10 towers; considered to be an optimistic cycle.

Benchmarking
For the purpose of better understanding the market players already using concrete walls in building construction, a mapping was carried out of the

leading construction companies using this technique, the results of which are shown in Figure 2.
The mapping includes 2 different housing/construction market sectors: MCMV is a government initiative which has been created under the PAC, providing low income/popular housing funding to facilitate the demand of the social class 'D' created by the easing of credit restrictions.
The economy sector refers to social class 'C' market, where the client/costumers are independent purchasers.

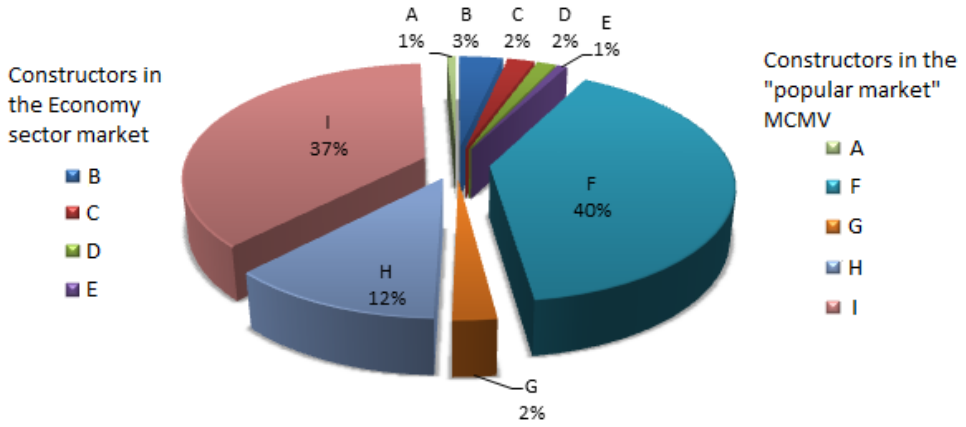

Figure 2 – Brazilian market share of housing units using concrete walls, in 2011, by construction company.

Once the leading builders had been determined, it was possible to examine the profile of the developments using this technology, analyzing the: nature, number of floors, number of buildings per development, quantity of molds purchased, number of housing units launched and under construction, differences in the plans around Brazil, and geographical location, among other data. The objective of this analysis was to ascertain whether there was any compatibility with the company's economy sector developments and identify whether any adjustments might be necessary. Another focus of the Benchmarking was to learn how the concrete walls system using aluminum molds is employed by the builders and thereby ratify the suppliers linked to the system of construction.
Visits were made to some of these construction companies' building sites, in different regions, for the purpose of studying the execution methods, with subsequent analysis of the visits, in regard to:

- Systems of aluminum formwork utilized and the respective suppliers, and the types of services added upon acquisition of this technology, such as, designs, delivery periods, technical assistance, replacement of materials, accessories, material durability, number of repeat uses, and other matters;
- Productivity of assembly and dismantling;
- Execution sequence, number of cycles per slab, number of days for completing a slab, and logistics of materials handling;
- Solutions already found for interfacing with other work activities, such as installations, door and window frames, plastering and painting;
- Other sub-systems associated with this technology, such as spacers, wire mesh, release agents, cleaning, aligners, labor, and the respective suppliers;

- Checking the final quality of the product - the apartment that is to be delivered to the customer.

Participation in technical committees and seminars

Since the use of this technology in Brazil is recent, the Concrete Wall Group has been set up, comprising developers, builders, designers and consultants, to promote the use of this system with maximum safety, savings and mastery of the processes.

This led to the first step in the regulating of the use of the technology in the sector.

The company's R&D team has participated in this group ever since it was founded.

Fundamental to this study was the opportunity to be present alongside the specialists and users of the system and gain precious insights into the matter, even without necessarily using the technology to derive such information/insights. What is more, the technical and market discernment developed over the course of the process has been beneficial for the construction sector as a whole.

The learning from participating in this group includes:

- Important guidance towards obtaining the best results from the system, from the architectural design onwards;
- Definition of the concrete's characteristics and the mechanical performance of the concrete walls;
- Recommendations on administrative and execution processes and best market practices.
- Basic text for the ABNT (Brazilian Association for Technical Standards) technical standards for the design and construction of buildings using the concrete wall system, which are presently subject to national consultation prior to their approval.

The R&D team has participated in several seminars that have discussed companies that are already using the concrete wall system and the solutions they have encountered to overcome the challenges and minimize the risks.

Meetings with suppliers

The purpose of these meetings was to get to know, analyze and ratify the companies that supply the basic items for the concrete wall system, such as: steel, concrete, aluminum formwork, supplementary materials and equipment. We contacted all the most important suppliers, as well as those that are linked with concrete structures, and a series of meetings were held, in addition to on-site visits, customer satisfaction surveys, and assessment of performance and the cost/benefit.

Particular attention was given to assessment of all the suppliers of aluminum mold systems for concrete walls that are already operating in Brazil. A comparative study was carried out of these systems, followed by analysis to identify the most suitable system for effective application of this technology.

Based on the results of a questionnaire, a pre-assessment was made of 4 suppliers of aluminum formwork. The main items assessed were:

- Brazilian market share;
- Domestic manufacture or imported products;
- Technical limitations of the system;
- Productivity;

- Performance indices;
- Type of marketing;
- Services included with the supplying of the system;
- Type of labor used to operate the system and the training;
- Time scale for studies and supplies;
- Economic risks;
- System inputs associated with the molds;
- Interface with other work activities.

At the end of the assessment, one of the 4 companies was excluded, leaving the study to focus on the other 3. To choose the best company with the best system of aluminum molds, a decision matrix was drawn up, as follows:

Table 1 – Decision matrix showing technical analysis

Technical analysis		Supplier 1	Supplier 2	Supplier 3
	Multiplier	**Rating**	**Rating**	**Rating**
Productivity	0.3	10	10	9
Logistic	0.1	10	10	10
System characteristics*	0.2	8	10	9
Interface with other sub-systems	0.2	10	10	10
Safety against fall	0.1	7	10	9
Decision making risk	0.1	7	10	9
		9.0	**10.0**	**9.3**

*****Aluminum quality, formwork structural reinforcements, tools included, number of pieces, availability of spare parts, among others.

Table 2 – Decision matrix showing economic analysis

Economic analysis		Supplier 1	Supplier 2	Supplier 3
	Multiplier	**Rating**	**Rating**	**Rating**
Customer care	0.2	9	10	10
Marketing	0.3	8	10	9
Training	0.3	10	10	10
Decision making risk	0.2	8	10	9
		8.8	**10.0**	**9.5**

Through the decision matrix, supplier No.2 was chosen for the in-depth studies.
Analysis and ratification was also carried out with suppliers of inputs related to molds for the concrete wall system, as follows:

- Concrete (3 suppliers) ;
- Steel (1 exclusive supplier);
- Electricity junction boxes (2 suppliers);
- Spacers (2 suppliers);
- Aligners (2 suppliers);
- Release agents (3 suppliers);
- Companies providing labor (1 supplier plus own workforce);

The criteria used in the assessment were the meeting of the technical and quality specifications.
Moreover, analysis was also done of companies that interface with this system, such as the suppliers of door and window frames, plastering and building installations. Emphasis was given to existing solutions adapted to the specific peculiarities of the concrete wall construction system of molding on-site.
The result of these analyses was the selection of the combination of inputs offering the best performance, the budget for which was then submitted for viability analysis.

Meeting the specialists
The studies with specialists included:

- Quantity surveyors: provide project guidelines.
- Planning engineers: develop the plan of execution for all the activities and the chronograms, using the project guidelines and productivity rates for the concrete wall system using aluminum formwork furnished by the company providing the labor. The guidelines for organizing the production flow during the stages after the superstructure work were also defined.
- Concrete specialists: define the technical characteristics of the concrete (slump, consumption of cement and additives);
- Steel: fine adjustment of the wire mesh to facilitate the assembly and reduce waste.
- Painting: specification of the appropriate materials, bearing in mind the interference of the release agent applied to the formworks.

Following these consultations, it was possible to define the technical characteristics on which the feasibility study was based.

Budgeting
The final phase of the study was the full budgeting for a tower built using concrete wall technology. A development was chosen for which the detailed plans were already available and whose structure had been planned with structural masonry in mind. The reason for this choice was to be able to make a realistic comparison of the costs of the two construction techniques.
All materials that met the technical and quality specifications were included in this budget, which means they were not necessarily the cheapest.
In order to assess the conditions under which the technology was applied, 3 possible scenarios were analyzed: Optimistic, Pessimistic and Most

Likely, and the differences considered in each case are shown in the table below:

Table 3 – Characteristics of the scenarios assessed for concrete walls.

	Pessimistic Cycle	Most Likely Cycle	Optimistic Cycle
Construction period	45 months	40 months	36 months
Construction period of the structure (10 towers, each with 20 floors)	6 months	6 months for the first 4 towers and 4 months for the last 6 towers.	4 months
Concreting cycle	6 days per slab	6 to 4 days per slab	4 days per slab

Differences in the type of steel were also considered under the pessimistic cycle (using steel rods instead of welded wire mesh), as with a period of 6 days there is time to make this change.

When it came to comparing the scenarios for the two technologies, an analysis was made for structural masonry only under the Pessimistic and Most Likely scenarios:

Table 3 – Scenarios assessed for structural masonry walls.

	Pessimistic cycle	Most Likely cycle
Construction period	45 months	40 months
Construction period of the structure (10 towers, each with 20 floors)	6 months	5 months
Concreting cycle	6 days per slab	5 days per slab

We obtained the following comparative results:

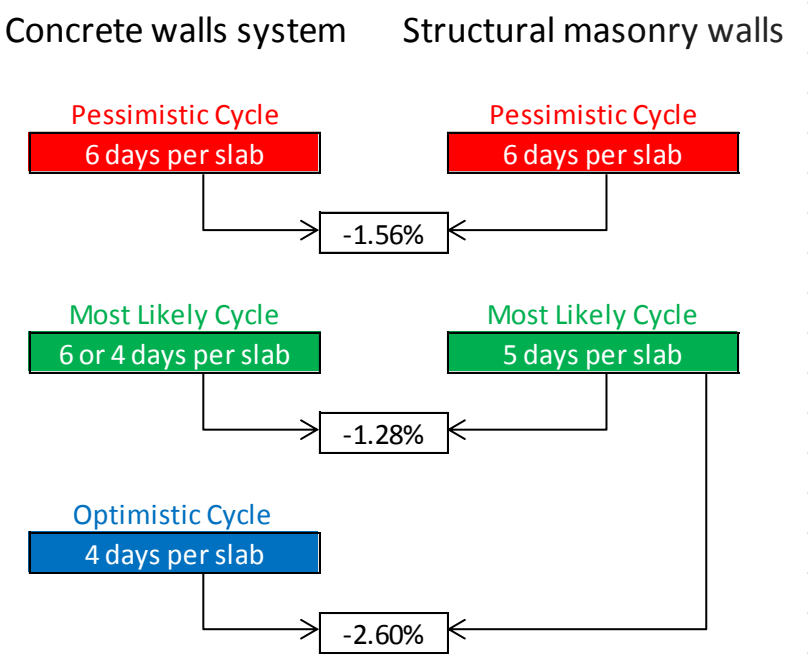

Figure 3 – Percentage comparison between unit construction costs using the concrete walls system and structural masonry walls.

Calculation was also made of the rate of return on the capital invested (ROI) for the different production scenarios and cash exposure, taking into consideration the different means of financing the purchase and the perspective of the customer when taking delivery after the project has been completed.
This comparison showed the results of the concrete wall technology, in terms of margin and rate of return, to be very close to the structural masonry technology (currently adopted), with a tendency for them to increase with evolving mastery of this new technique.
When the study was completed, a presentation was made to the Executive Board, which concluded that there is genuine potential for utilizing the new technology in economy standard developments that are to be carried out shortly, particularly in view of the confidence the company now has as a result of the study.

CONCLUSIONS

Given the complexity involved in the acquisition of new technology by a major construction company, particularly when dealing with large-scale projects, there was a need for an in-depth study such as this one. The methodology enabled us to learn in advance the challenges that would have to be overcome and the solutions to those challenges.
Only in this way was it possible to discover the difficulties that would be faced on site, really understand all the interference caused by the various simultaneous services and the building site dynamics associated with the use of the concrete wall system.
The conclusion is that the study fulfilled the objectives satisfactorily, thereby providing sufficient experience for the R&D to become the hub for disseminating the technology throughout the company.

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