Continuing Education: Benchmarking Collaborative Process in Civil Construction Engineering

Alberto C. Lordsleem Jr.; Suenne A. C. Pinho
Civil Engineering Department
Polytechnic School of Pernambuco University
Recife, Brazil
acasado@poli.br

Emanuelle P. Falcão
Regional representative of ABCP PE/PB
Brazilian Portland Cement Association
Recife, Brazil
emanuelle.pontes@abcp.org.br

***Abstract*—The development of professional qualifications and construction companies is one of the most important challenges faced to the recent growth of the Brazilian civil construction industry. Continuing education is a supplement of engineers' formal education and it is responsible for the improvement of skills that contribute to confronting the present world. Within this context, this paper presents the implementation of the indicators constructive cement-based technologies program - PROGRIDE and the evaluation of benchmarking collaborative process developed in this experience. The methodology considered the establishment of standard indicators, the structuring and implementation of the program, the indicators results and the analysis of the benchmarking collaborative process. As a contribution, it stresses the dissemination of knowledge to the members of the Construction Community and other professionals that may be interested.**

Keywords—continuing education; collaborative process; civil construction engineering; benchmarking

I. INTRODUCTION

Several challenges are associated with the recent growth of the Brazilian civil construction industry; particularly, there is the need for the development of professional qualifications and construction companies [1].

Continuing education for professional qualification is responsible for the improvement of skills that contribute to confronting the present world challenges, being an important supplement of engineers' formal education to carry out activities in their companies.

Some initiatives are perceived by the productive sector of construction in the creation of collaborative processes that provide a way for organizations to acquire and share knowledge of the external environment to the adoption of improvements through benchmarking.

However, there are insufficient studies to evaluate the effects in terms of implementation of improvement and learning, and practices that are shared throughout the collaborative process are transformed into new knowledge in companies [2].

In this context, this paper presents the implementation of the indicators constructive cement-based technologies program - PROGRIDE and the evaluation of benchmarking collaborative process developed in this experience. The PROGRIDE was conducted by POLITECH, a research group in technology and building construction management of the Polytechnic School of Pernambuco University, within the activities set of the Construction Community of the Recife city in Brazil coordinated by the Brazilian Portland Cement Association - ABCP.

Collaborative benchmarking can be understood as the process through a group of companies shares knowledge about a problem situation, and the participants hope to accomplish improvements based on what we learned with the group. The goal is learning, the dominant relationship is collaboration and partnership, rather than competition, involving joint action and interaction among the group [3].

The ABCP holds an important role in continuing education in construction engineering, through its actions that promotes the knowledge dissemination on constructive technologies cement-based for construction companies and professionals in the collaborative benchmarking process developed inside the Construction Community.

II. THE BRAZILIAN CONSTRUCTION COMMUNITY OF ABCP

Brazil is the largest country in South America with a total area of 8.515.767 km^2 and has a population of approximately 201 million inhabitants [3], [4].

The ABCP was founded in 1936 to promote studies on cement applications. Already in the early ages, it has become recognized nationally and internationally as a center of reference in cement technology, expertise that supported the great works of Brazilian engineering [5].

The ABCP condition of technical leadership allowed to act directly in the development of the construction market, through the technology transfer in several ways:

- promotion of courses and training, technical seminars and events;

- partnership with universities, schools and research institutions;
- support for products based on cement industries;
- publication of books, journals and technical documents and support the generation of Brazilian technical standards within the Brazilian Association of Technical Standards – ABNT, affiliated to the International Organization for Standardization - ISO.

The ABCP is the technical department of the cement industry, seeking to interact and collaborate with links and agents that comprise the supply chain of construction.

The Construction Community is a national movement launched in 2002 by the ABCP which seeks to integrate the supply chain and increase the performance of cement-based construction systems [6].

The actions conducted by the Construction Community brings together builders, material manufacturers, designers, subcontractors, universities, organizations and consultants in a group with the same goal: to increase their market competitiveness.

The Construction Community is organized by themes of knowledge (construction cement-based systems) and locations (poles). The themes are accompanied in cycles of activities that last 12 to 24 months.

Figure 1 lists the Brazilian cities of the 21 poles from the Construction Community, namely: Belo Horizonte, Brasília, Campo Grande, Curitiba, Florianópolis, Fortaleza, Goiânia, Guarapari, Natal, Porto Alegre, Recife, Ribeirão Preto, Rio de Janeiro, Salvador, São Paulo, Sorocaba, Triângulo Mineiro, Três Rios, Vale do Paraíba, Vitória and Volta Redonda.

Fig. 1. Brazilian cities poles from Construction Community.

In each cycle, the pole follows a methodological programs offered by developing technical and management improvement activities related to the chosen construction cement-based systems. Costs are shared by the participating organizations in each cycle.

These activities involve: technical studies; participation in courses, lectures and seminars; technical exchanges; monitoring of works and consultancies.

III. BENCHMARKING COLLABORATIVE PROCESS OF BRAZILIAN CONSTRUCTION COMMUNITY OF ABCP

According to [7], benchmarking is a continuous process by which a company in order to improve performance, compare their practices with best practices of other companies. It seeks to stimulate and facilitate organizational changes and performance improvements through learning from others.

The practice of benchmarking has been widely disseminated in several industrial sectors and the construction industry have been mobilized efforts for the development of initiatives in some countries, such as [7], [8], [9], [10]: United Kingdom, United States, Chile, Netherlands, Denmark, Portugal and Brazil.

It is also worth mentioning that most of these initiatives have motivated the collaborative process, since that enable the management of knowledge and the implementation of improvements in the participating organization, from the comparison of experiences and knowledge of those involved [11].

In Brazil, some benchmarking initiatives have been developed in order to measure performance in the construction supply chain through data collection and dissemination of information, details of which can be obtained in [7], [10].

Particularly, the Construction Community of ABCP promotes actions that adopt benchmarking as a learning principle, a collaborative process that encourages the information sharing for use in members companies group.

The Construction Community activities are structured on some pillars that support the development of companies and continuing education of construction engineering professionals:

- training: consists of the preparation of the technical means and the manpower to master the tools needed to improve the potential for constructive use of cement-based systems, involving the provision of courses and seminars;
- good practice and literature reports: it consists in generating products and technical and management tools based on good engineering practice and the collaborative process of effective exchange of experiences;
- presence in the sites: it consists in performing actions benchmarking by monitoring indicators within buildings constructions;
- innovation: consists of making technical trips exchange in a collaborative process, research , testing and generation of guidelines and recommendations.

Currently, were already trained over 30,000 professionals, generated more than 180 literature reports, with the participation of 69 universities, 350 construction companies and 37.500 participants in the actions of all poles of the Construction Community in Brazil [6].

The website of the Construction Community contains a detailed description of the activities carried out by poles and the literature reports developed since its creation, and can be accessed through the address: www.comunidadedaconstrucao.com.br.

Figure 2 shows the main page of the Construction Community website.

The following recent initiatives of the Construction Community poles in benchmarking collaborative process can be cited:

- Belo Horizonte city: labor productivity research of the mortar façades coating;
- Salvador city: loss and labor productivity research of the concrete structure and labor productivity research of the masonry elevation and the mortar façade coating;
- Recife city: loss and labor productivity research of the concrete structure and the masonry elevation and labor productivity research of the mortar façade coating.

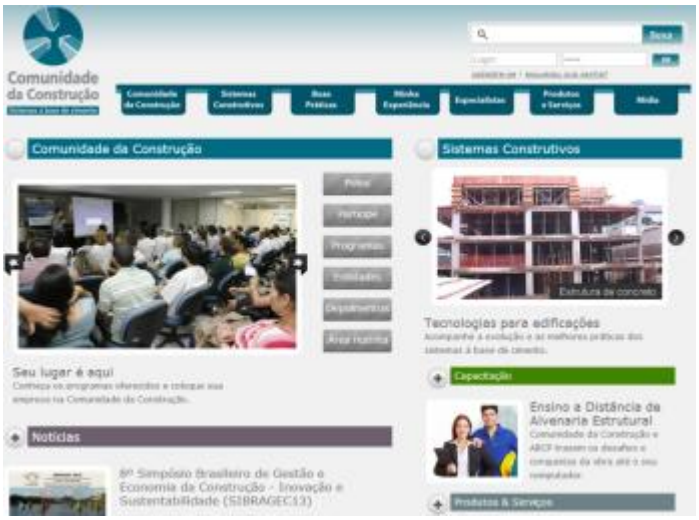

Fig. 2. Construction Community website.

These 3 recent initiatives combined constituted the indicators constructive cement-based technologies program - PROGRIDE which is based on a proposal made by the coordinator of the Construction Community of Recife pole city, first author of this paper.

Following, the benchmarking collaborative process of the PROGRIDE experience will be described in the pole of Recife city.

IV. RESEARCH METHODOLOGY

The methodology included four main stages, which were: A) the establishment of standard indicators; B) the structuring and implementation of the PROGRIDE; C) collecting data and benchmarking identification and D) evaluating collaborative process.

V. IMPLEMENTATION STAGES OF THE PROGRIDE AND EVALUATING COLLABORATIVE PROCESS

A. *Establishment of standard indicators*

The standard indicators (Table 1) were defined through literature research, which contemplated the evaluation of methodologies for data collection and benchmarks.

TABLE I. STANDARD INDICATORS OF THE PROGRIDE

Technology	Service	Material	Standard indicator
Concrete structure	Concreting	Concrete	Loss/ Consumption Productivity
Masonry	Elevation	Mortar, block	
Façade	Plaster	Mortar	

It is noteworthy that one of the criteria for the choice of indicators was the ease of application of the method, data collection and calculation.

A detailed description of the calculation of the indicators can be found in [10].

The working group at this stage consisted of the following members: 4 consultants from the national Construction Community, 4 representatives from the ABCP headquarters and 2 coordinators of the Construction Community.

As a general result of stage 1, the indicators manual was developed which aimed to provide information on the methodology of data collection, characterize the construction company, the project and the services under study, as well as facilitate the processing and analysis of data.

B. *Structuring and implementation of the PROGRIDE*

The structuring program stage initiated with a workshop with 15 construction companies from the Community Construction. This meeting presented the focus, objectives and goals of the program to the company representatives.

The working group at this stage consisted of the following members: consultant from the Recife city Construction Community, representative from the Recife city ABCP, coordinator of the Recife city Construction Community and the construction company representatives.

The implementation of the program included 3 sub-stages:

- working meetings;
- pilot implementation;
- technical visits.

The working meetings (Figure 3) were held with representatives of construction companies in order to disseminate the objectives and methodology of data collection of the program indicators.

Fig. 3. Working meeting in the colaborative process.

The pilot implementation aimed evaluating the methodology for data collection and verification of the need for adjustments. It is worth mentioning that the pilot implementation was distributed in 3 different sites.

Figures 4, 5 and 6 show technical visits in 3 different sites where professionals companies representatives have observed the data collection procedure in the pilot implementation stage program.

There were 3 technical visits in the sites, so that the first dealt with the indicators of concrete structure, the second addressed the masonry and the third façade coating.

Fig. 4. Technical visit 1 in the concrete structure site construction to present data collection procedure.

Fig. 5. Technical visit 2 in the masonry site construction to present data collection procedure.

Fig. 6. Technical visit 3 in the mortar façade coating site construction to present data collection procedure.

During these technical visits, were exposed critical points encountered during data worksheet collection.

C. Collecting data and benchmarkings identification

It was conducted by the construction companies representatives. It contemplated 3 collection cycles which 156 results were obtained referring to the samples collected in 15 sites of 10 building companies.

It should be noted that the responsibility for internal training, fell to representatives from construction companies participating in the PROGRIDE program, whose experience was obtained through the participation in the working meetings and technical visits.

The analysis results stage was conducted by the consultant. At the end of each cycle, the consultants have generated the individual (for each company) and general reports (for the total of companies participating in the program).

Table 2 shows the benchmarking results of the PROGRIDE.

TABLE II. BENCHMARKING RESULTS OF THE PROGRIDE

Indicator			**Benchmarking**
Conc	Pillar	Loss of concrete (%)	5.18
		P global (Mh/m³)	2.26
	Beam + slab	Loss of concrete (%)	2.00
		P global (Mh/m³)	1.02
Masonry		Loss of blocks (%)	0.83
		Loss of mortar (%)	12.34
		C mortar (kg/m²)	19.42
		P w (Mh/m²)	0.85
Façade		P global (Mh/m²)	1.42

Conc: Concreting: P: Productivity; C: Consumption; w: worker.

From the results shown in Table 2, it was noted that the values of benchmarking for losses of concrete in the production of beam + slab, are below the loss indicator adopted for the composition of budgets by TCPO [12] equivalent to 5% and close to the minimum (1%).

The TCPO - Table of Composition of Prices for Budgets - corresponds to the largest credible database in the Brazilian Civil Construction Industry. Its functionality consists in

guiding and referencing the elaboration of budgets of construction and civil works.

The losses of concrete values demonstrates that, despite the great potential for improvement that this indicator presents, the control during the execution of the service can be a determining factor for the reduction of loss.

Regarding the productivity of concreting, it is also verified that there is a pronounced variability between the results obtained, pointing to the need for process management. It is worth reporting the considerable difference between the values obtained from benchmarking of trucks and global productivities. This indicates that possibly the production difficulties are in the intervals between trucks, as well as in preparing and finalizing the service.

In the service of the elevation of masonry, it was found that the value of benchmarking for losses of block/brick is achieved by a site that uses a block (9x19x39cm) which has a quality higher than that of the ceramic brick, which was used on the worksite where the maximum value was obtained for losses.

In regard to productivity data of mortar façade coating, it can be said that the value of 1.42 Mh/m² (P global) achieved by the best practice is 12.7% greater than the median (1.26 Mh/m²), specified by [10], which indicates a large potential for an improvement of this indicator.

The results described in this paper were presented to the PROGRIDE companies group and other participants of the Construction Community.

Figure 7 illustrates the results presentation.

Fig. 7. Results presentation to Construction Community agents in the benchmarking collaborative process.

D. Evaluating benchmarking collaborative process

At the end of the third cycle data collection, a survey was conducted among the participating companies to evaluate the effects of implementing improvements and how the practices shared throughout the collaborative process are transformed into new knowledge in companies.

An evaluation questionnaire was applied to characterize the collaborative process, which was divided into:

- 10 objective questions (concerning the evaluation methodology, involvement of top management, collaborative process, continuity of indicators use, organization improvements);
- 04 open questions (concerning program difficulties and benefits, program useful tools).

Nine of fifteen construction companies participating in the program responded to the questionnaire.

Table 3 shows the benchmarking collaborative process results evaluation of the PROGRIDE.

Table 4 shows the main difficulties and benefits throughout the program implementation.

TABLE III. EVALUATION COLLABORATIVE PROCESS RESULTS – OBJECTIVE QUESTIONS

Subject	I1	I2	I3	I4	I5	I6	I7	I8	I9
1.Working meeting	G	E	G	F	E	E	G	E	G
2.Worksheets indicators manual	G	G	E	F	G	G	G	E	G
3.Technical visits	E	E	G	F	E	E	E	E	G
4.Sending results format	E	E	E	G	E	G	G	E	E
5.Reports format (general and individual)	E	G	E	G	E	E	G	E	G
6.Reaction of stakeholders to start collecting	G	G	F	G	E	G	G	F	F
7.PROGRIDE evaluation by top management	G	G	G	G	G	E	-	E	G
8.Improvement actions have been taken in function of benchmarking?	Y	Y	N	Y	Y	Y	Y	No	Y
9.Continuing indicators collect covered by PROGRIDE?	Y	Y	Y	Y	Y	Y	Y	Y	Y

I: interviewee. G: good. E: excellent. F: fair. Y: yes. N: no.

TABLE IV. EVALUATION COLLABORATIVE PROCESS RESULTS – OPEN QUESTIONS

Subject	Open questions answers
Difficulties	a) Culture paradigm. b) small resistance of the technical team by adding monitoring activities. c) Lack of structure for monitoring of new indicators. d) Difficulty in disseminating the practice of measurement between those responsible for gathering information.
Benefits	a) Greater control of processes, reducing material loss and increasing labor productivity. b) Establishment of indicators based on the results of the program. c) Comparison with results from other companies (benchmarking). d) Insertion of new indicators in the Quality Management System. e) Database creation for construction sector. f) Improving services quality of professionals skills. g) Increased profitability for the company.

The evaluation results of the collaborative process have shown:

- 100% approval of the program by top management;
- 87% improvement actions developed on the basis of benchmarking found;
- 67 % considered positive the reaction of people when they start data collection;
- 44% reported an initial resistance due to additional responsibility.

Through the information collected, it was identified that construction companies have interest in performance measurement and understand that this is an important tool for improving construction processes.

In the group of PROGRIDE participating companies four basic requirements of the collaborative group generation were observed, in different levels: focusing the discussion of real problems environment; open, equitable and reliable environment; the environment that fostered reflection, abstraction and systematic action; align individual, organizational and group interests.

Moreover, with regard to representatives professionals, four basic requirements were also observed to interact and engage in collaborative process: interact and exchange knowledge capacity in the group; abstract and reflect shared knowledge capacity; identify and observe the problems of the company and disseminate knowledge in the company.

It is noteworthy that all of the participating companies expressed interest in continuing measuring the indicators covered by the PROGRIDE in order to maintain the practice of benchmarking collaborative process.

VI. CONCLUSION

The results presented throughout this paper about the standardized methodology for data collection allowed the completion of the internal benchmarking, since some construction companies have collected data on more than one sites, and external benchmarking between construction companies.

From the program implementation analysis and the obtained results, it can be seen that the collaborative process depends mainly on the level of development of the company's management processes, integration with program goals and selection of technical representatives and individual capacities compatible with the level of exchanges being proposed in the group and the level of desired changes in the company.

In addition, the PROGRIDE provided the generation of reference values that could be compared with data from other localities covered by specialized references.

The evaluation of the collaborative process showed approval by construction companies, being of interest to continue measuring the indicators covered by the program in order to maintain the practice of benchmarking.

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