REINVENTING THE WAY OF CONSTRUCTION: THE DEVELOPMENT OF A NEW DESIGN LANGUAGE

ROSSI RESIDENCIAL LTDA[1]

[1] Rossi Residencial is one of the largest Brazilian real estate developers, providing apartments to the medium social class, and as it is usual in Brazil, Rossi is the constructor of its owner buildings. Today Rossi is operating in 14 important Brazilian cities and is building about 180 buildings.
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INTRODUCTION

Since the industrial revolution, the companies come looking for to rationalize the production activities, in an effort to reduce the costs of production. It is a process of constant increase of the productivity, in that it tries to reduce the resources, efforts and time demanded for each activity.

The conceptions on the ideal model of industry went by great transformations in the last decades, especially after the expressive development of the Japanese economy, happened starting from the seventies and obtained, largely, in function of the adoption of procedures productive considered revolutionaries for the western patterns.

In the classic model of administration of production, the ideal worker was seen as a type of extension of the machine, with repetitive movements and without opportunity to use his creativity or intellectual ability–should limit to those tasks for which he had specialized, in a rigorous work division.

Today, to the opposite, is more and more frequent the production cells, where versatile workers redirect its attentions for the tasks demanded to every moment.

Another myth that dropped was the one that stocks of safety were important to avoid the interruption of the production. Today we look for the elimination of stocks, in all practically all the sections of the economy. The rationalization of the production and its adjustment to the demand–in the whole productive chain, became the production objective, with the adoption of techniques as just-in-time or kanban. The lay out of the factory also went by important transformations, seeking optimize the matters cousins' transport, materials in production and the workers' movement.

Another myth that became questioned it was what quality can only be obtained with increase of the production costs. To the opposite, which it comes verifying it is simultaneously the production of goods of better quality to the reduction of its costs.

One of the premises for that is that the use of matters quality cousins reduces or it eliminates the loss of materials during the production, lowering the number of defective items.

Another important subject is the elimination of the rework. The production of items out of the specifications it interrupts the productive routine. When a product goes out with defect of the assembly line, responsible teams for the quality control should define its destination–it discards total or return to the factory. In any of the two cases, wastes are had, of materials and of labor. Thus, to create conditions so that all the production is made inside of the specifications, if, in a first moment, it can imply in increase of costs, it results in joined economy, when considered the whole productive chain. Several companies adopted as philosophy the total quality they have for slogan: “to do certain of the first time.”

The concern with the rationalization of the production–as form of reduction of costs–it won larger dimension with the process of growing globalization of the economy. The growing increase of the competition does with that the offer of products better every day, for more accessible prices, be a survival subject. The search for the increase of the productivity became a continuous process, where it cannot conform with the reached landing, independently of the improvements already introduced.

The concern with increase of the productivity was developed in different rhythms in the several sections of the economy. In general, in those more subjects to the competition,

the process began earlier and it assumed more intense rhythm. In other, to the opposite, the attention to the rationalization need had more recent origin.

All over the world, the civil construction tends to be one of the industries that more lately woke up for the new reality. It can be affirmed that the search for more effective productive processes is still quite incipient in the section. The several sub-systems that compose the conventional process of construction of a building involves a series of uses and habits that produce distortions, that oppress the costs without, however, to join value to the very acquired by the buyer.

PROBLEM

Rossi is a company specialized in offering apartments destined to the middle class, with high quality pattern and competitive prices. The company opted for acting with reduced unitary margins, obtaining profitable through won of scale.

If, in any company, the reduction of the production costs is always a goal to be reached, in a company that adopts a strategy as the one of Rossi, this subject assumes a critical importance. Each small detail that can be improved can contribute to the success of the company. That, in the day-to-day of the company, its engineers and technicians are always looking for improve the productive activities–through, for example, of the development of new materials and tools or researches of alternative materials–with the purpose of reducing the construction costs.

The rationalization of the activity can mean an enormous potential for reduction of costs. The elimination of wastes represent not only the increase of the profitable but an important stimulator of the activity. Being reflected in smaller final price to the customer, the best use of the resources would result, ultimately, in the access of new contingents of customers to the market.

In fact, Rossi's engineers came observing that, in spite of the improvements and innovations introduced in its works, there were still expressive waste of materials and labor force.

Among the most frequent problems they were the location mistakes. Not always the foundations, structures, walls and facilities were built in the specified places. To solve the current problems of the location mistakes, it is necessary from the use of a larger mortar volume, to correct imperfections and differences among the walls, until the rework of whole the work, in the case in that foundations or structures out of pattern they can place in risk the safety of the building.

Another problem in the activity is the excessive turn-over of labor force. In spite of being considered an activity that uses non qualified labor, nevertheless a lot of specialization exists among the workers during the construction. Along the execution of the project, workers specialized in foundations and structures are used, in a first moment, others that understand of hydraulic facilities, in a more advanced stage, and so forth, until the responsible persons for the final finish. With that, at every moment new workers are joined to the work, tends to familiarize with the details of the design. Besides, several sequences activities are executed by professionals with different abilities. A lot of times , the team is stopped, hoping other workers finish their part, so that then they can give continuity to the task for the which they are responsible.

It was also observed that great part of the time of the administrative staff in the site, construction engineers and technicians, it was not destined to the planning and management of the works, but yes to guide workers in routine activities.

Rossi's technical team it started to seek, besides topical solutions for specific situations, a form of rethinking the whole constructive process, in an effort of “reinvention” of the site of works. Tends as example the factories of consumption goods– especially the automobile industry–the idea was to do with that the civil construction worked in way similar to an industry with assembly lines.

DIAGNOSIS

Coordinated by Luiz Henrique Vasconcellos, Technical Director, a team of Rossi started to research the routine of the works in full detail, looking for to identify the main causes of the wastes.

The best form of diagnosing a problem that seems inherent the one given organization–as it is the case of the wastes in the civil construction, that for many of the involved professionals, they are understood as part of the own “nature” of the activity–it is to try to notice the productive routines with an external focus. That because the people get used with the routine tasks and they don't stop to analyze the reason of the procedures; it doesn't exist a better form of doing the things. When the whole productive chain is analyzed, since the beginning to the last stage, asking every moment “why is that like this”, “what will be made later” and another of the gender, he starts to have a vision much more critic, facilitating the development of alternative simpler, practices and you ration.

Architects Lucy Mari Tsunematsu and Cláudio Miotto received the incumbency from developing forms of rationalizing Rossi's works. Looking at the whole sequence of activities involved in the execution of an enterprise, talking with everybody involved them, the technical team entrusted of the mission could notice the main focus of the problem.

The development of an project begins when the company decides which will be the characteristics of the buildings to be built in a certain land–in reason of legal restrictions, as limits to the use of the land; of the topography; of marketing decisions, as more appropriate public-objective or expectations and needs of the target approved.

Of ownership of information as number of pavements, units for walking and comfortable in each apartment, the architects develop the architecture design.

The architectural design is passed then for several teams, that determine the type and dimensions of the foundations; dimensions and location of the pillars, beams and slabs that will sustain the building; to design the hydraulic and electric facilities; and other specific designs.

Those designs–usually in leaves size bent A1 or A0–they were guided to the site of works, for its execution.

Arriving in the work, the engineers and the construction foreman transmit the information contained in each design to the workers entrusted of its execution. It is there they begin to appear the execution mistakes in the works.

When working with plants of great dimensions, the professionals face difficulties to manipulate the designs, aspect worsened by the fact of they work many times in foot, in the middle of the work. The manipulation difficulty turns slower the apprehension of the information, being also a source of mistakes.

With the designs in hands, the construction foreman start to separate the information contained in each plant, preparing drafts with the tasks that they will be accomplished in each stage, giving sequence of execution . That because the designs contain more information than the necessary ones for the execution of each stage of the work. It is

necessary to define, also, the amount of material to be used in each stage and the place in that will be stored.

The designs use symbols reasonably standardized–but that don't keep any visual relationship with that indeed represent. They exist, also, some variations among each planner. The construction foreman needs a lot of time, to interpret–according to own approaches, taking in its bill experience–what the planner determined.

The measures come expressed in millimeters, centimeters or meters, depending on the dimension of each distance. He gave way, it should be observed with attention the used pattern, in agreement with the good sense.

Thus, in the construction process, the planners code the intended final result, they send the plants for it work, where the information will have to be decoded and again coded, of this time using a "language" specific of construction. And, in the middle of the process, a lot of times the information are deformed. It was observed, like this, that two "languages" they coexisted in the works: a, formal, guided by the planners' focus and other, informal, adapted by the responsible persons by the execution to the reality of the work .

It is easy to understand the origin of the "language" used in the designs. Before the coming of the computer science, the designs were handmade, in transparent leaves that they were copied later on, through heliography generating the traditional plants of blue color that everybody got used to associate the architects' work and engineers. The planners worked starting from the plants of the architecture that were fundamental for the accomplishment of the structural calculations or for the determination of the light points, for example. Thus, each specific design was made directly on the architecture plant. It is they were like this correspondents for the work. When the drawing board was substituted by the computers, the planners simply started to do the designs in the same way I eat were already habituated, using keyboard and mouse in the place of the old drawing equipment.

Even an inattentive glance on the designs in its traditional form reveals, immediately, the complexity of the "language" used.

Figure 1: Old Design

As can be observed above in the electric design, the plant presents the whole apartment, with the location of walls, windows, sanitary apparels and location foreseen for the equipment of the kitchen. For the planner, this information is fundamental, in the measure in that they indicate the need of light points, it forces, telephone or television, as well as location of switches. However, when this part of the work be being executed, the workers will be working in the slab, before still of the rising of the masonry.

This information, therefore, is not necessary for the accomplishment of the work. In fact, it hinders the understanding of the design. Moreover, an only plant brings, simultaneously, information on the piping so much of illumination, that will be destined to the apartment below the slab that it be being worked, as of force, destined to take the threads that will feed the top apartment–and the wiring assembly that should go by the duct. During the work, however, those activities are executed separately.

First it is prepared the piping–one for illumination and another for force–and, only when the work is close of the conclusion, it is made the passage of the threads.

Another point that gets attention is the fact of there not being any indication about the necessary electric connections in each point, or the form as the threads will be passed. All

this needs to be determined by the engineers and the construction foreman, and instructed the workers, with the support of the drafts.

SOLUTION: CONTINUOUS IMPROVEMENT PROGRAM

Rossi's team reached the conclusion that it would be changed. The final presentation of the design would not need to be made obeying the logic with that he is created–leaving of the concluded work–but yes in agreement with the way like him will be executed. It is right that, when the planners didn't use computers, it would be very difficult to change the form as the designs they are presented. Now, even so, the resources of the computer science allow that, after they have been developed, the designs can be presented practically with a number limitless of alternatives, without that implies in expressive additional effort.

To incorporate, in a definitive way, close to all the participants of the constructions–the belonging to Rossi's functional picture and professionals and companies partners–the philosophy of fighting without truces for the conquest of new and better constructive procedures, it was created, in 1.996, the Program of Continuous Improvement. Through periodic meetings, besides the creation of more effective means of communication it interns, involved them in all the stages of the constructions they could present suggestions and to discuss the proposed alternatives.

In a first moment, the main objective of the program would be the development of a new one “language” of designs, seeking to create a system of information needs, that provided interaction among planning–design–and execution–work.

The main established goals were:

- obtaining of constructive precision
- elimination of the location mistakes
- formation of multifunction workers
- elimination of the construction foreman drafts for production

NEW DESIGN LANGUAGE

The program created a true revolution in Rossi's designs. Some measured adopted they were really simple, even so with important reflex in the works.

It was established that whole the measures should always be expressed in millimeters. That didn't just simplify the process of interpretation of the information, as it exercised an interesting effect that we can call of psychological. With the adoption of measures in centimeters, the responsible persons for the execution, instinctively, started to admit a margin of mistake of the order of a centimeter. Thus, the simple change in the pattern in that the measures are registered it results in larger precision in the construction.

The company opted also for using in all the designs, leaves A3, of compatible size with the users' visual field. In the place of the piles of traditional plants, the designs are bound, facilitating it handles. The relative designs to each sub-system–it structures, hydraulic installation, etc.–they form an only volume bound and they are identified for colors, allowing its fast recognition.

To facilitate a fast evaluation of the course of the work, the workers use colors in the same colors of the sub-systems in that are allocated.

Another initiative went easily to adoption of icons associated to that they represent, eliminating interpretation mistakes and the need of constant consultations to the legends. With that, everybody in the work started to have access easier to the information, without decoding need for the construction foreman and engineers. The use of colors was other resource used to turn the understanding of the most intuitive design.

Figure 2

Simple icons and outlines of colors turn the several activities of the most intuitive construction.

To minimize the location mistakes, the use of unique reference was adopted, so that it is noticed easily starting from where each measure was computed.

Perpendicular axes–that are traced in the land and later on in the slabs of all the pavements–they are used as beginning of all the measures. The walls are only used as reference in tasks that are executed after the rising of the masonry.

Figure 3

To locate a pillar correctly, it is enough the worker to pull the tape starting from each axis, until reaching the distances specified in the design. The use of the colors facilitates the identification of each reference.

All the designs became presented taking into account the execution in loco of that was drifted. In the plants, are just contained indeed the information necessary to the execution of each task, being avoided the visual pollution and the need of elaboration of drafts by the construction foreman. The designs are presented in the order in that the tasks will be executed in the work.

Figure 4

In the plant placement of the light points and piping in the roof, it is represented just that that the workers will find in the moment in that the task will be being executed.

Figure 5

When the workers will pass the threads previously in the piping placed, the masonry will already have been lifted. On that occasion, the drawing of the walls will represent that that the workers will be selling, helping in the execution of the task.

The designs arrive to the site of works as service orders. That is to say, besides the information on as it will be the final result, they are supplied all the necessary orientations so that the task is executed. Thus, the planning of the execution is made previously, and not in the shaken atmosphere of the work.

Figure 6

Traditionally, the form as the electric wiring assembly will be gone by the piping it is defined during the work, which not always it takes the adoption of the great solution. With the system adopted by Rossi, everything is still foreseen in the office, when it is had conditions more adapted for the study of the alternative best.

Figure 7

The assembly of each space of the hydraulic installation is presented separately. The tubes are mounted in having supported–where it is made the drawing of each space–and placed inside in horizontal shafts of the masonry.

Besides the general plants of each design, specific information are supplied on each detail.

Figure 8

All the electric connections are presented in simple and objective diagrams. Same workers not very familiarized with the electric facilities they can accomplish the tasks.

The designs already bring information about the amount of material to be used, besides guiding the location and identification of the stocks, what allows larger rationalization in the manipulation of materials.

Figure 9

When the masonry blocks are taken to the slabs, for the establishment of the walls, the workers don't visualize where the walls will be lifted up. It is common that the blocks have to be moved constantly, to open space to the workers or to assist the demand of a part of the slab that has not received enough supply. In the new designs, there is previous identification of the places and of the amounts of the stocks of blocks.

Designs specifies the amount of each material to be used, with space for perform than it was executed indeed. That allows the feedback of the system, supplying subsidies for its improvement in future designs and to the “the built” of the design in subject.

Figure 10

The hydraulic design foresees the amount of pieces and amount of tubes that will be used in each space of the design. Evidently, not always planned him it corresponds to the executed. The fast refinement of the differences verified help the identification of focuses of wastes–or it allows the improvement of the designs, I marry the responsible persons for the execution they have found more economic solutions.

RESULTS

The new system was implanted in January of 1997, with expressive results.

In spite of the largest details of information, there was reduction in the handled total area of paper–without considering the elimination of the drafts. It was observed, also, that there was a change in the relative participation of each sub-system, with increase of the

foundation designs and it structures in the total of used paper, what indicates that the information on the most crucial elements of the construction was being not so available to the workers.

Differently than we can suppose, the total time of development of the design was not enlarged. To the opposite, if before that phase consumed of six to eight months, now they are just necessary two or three months until its conclusion.

In practically all the phases of the work, reduction of the time of execution was verified. The placement of the electric wiring assembly, for example, that it consumed about eight hours for each apartment, now it just requests 90 minutes.

There was still a reduction for the half of the administrative staff in the site of works, that today can be devoted indeed to the management of the work, and not more to the decoding of the designs.

The new language of designs aids enough in the formation of the labor force, due to its understanding easiness, allowing like this, the versatile employees' creation, decreasing the turn-over of the work logically, this yes, without a doubt some, is one of the great problems of the civil construction in Brazil.

Another significant gain, it is reflected on the average in the drastic reduction of the time of rework (10% in Brazil and 03% in Rossi), since great part of this rework was caused by missed interpretations of the designs, which this new design language allowed to eliminate almost completely. Without shade of doubts, she will aid plenty so that we transform the industry of the civil construction in the such dreamed assembly industry.