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PROJECT CELL: THE CELLULAR ORGANIZATION OF THE BUILDING PROCESS DESIGN

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ABSTRACT

This study suggests, implements and evaluates a new paradigm for the process of building design, which is named Project Cell. Based on the transdisciplinary approach of the design process, the proposed paradigm uses evidence based practice in the industry, reorganizing them and transpose them to the production environment of the building design.

Once defined the concept, we then analyzed the implementation of a Project Cell in the University of Brasília and its operation in a real situation of project.

Finally, it was proposed a set of performance indicators for the building design process. Based on the proposed indicators of productivity, lead time reduction and rework, the performance of the cell was evaluated in contrast to the reference values found in the literature and the Brazilian market of building design.

MOTIVATION

Several researchers show the impact of the design decisions on the time and cost overruns and lack of quality in building construction industry. These studies determined that nonconformance cost in the architecture and engineering construction industry is between 10 and 30% of the total project cost. The main factors for 46% of total cost deviation and for 50% of the total errors in building construction projects are the lack of coordination in design, unclear and missing documentation (Love et al, 2004).

The Project Cell concepts proposed in this work aims to reduce these cost deviation and lack of quality by a new organization of the building design process.

PROJECT CELL

The Project Cell can be defined as an integrated group of people, equipments and methods put in the same space for executing in a simultaneous way all the activities needed by a building design process.

This concept is based on the concepts of Production Cell (Hyer and Brown, 1999), Office Cell (Suri, 1998) and Concurrent Engineering (Pennell and Winner, 1989).

From the Production Cell, the Project Cell takes the creation of a work flow where required tasks and those who perform them are closely connected in terms of time, space and information.

From the Concurrent Engineering we take the integrated and parallel development of product design and production planning.

Finally, from the Office Cell we take the focus on the wasted time reduction in the information transforming processes.

VALIDATION

Project

With the aim of validate the proposed concept, a project cell was created in the University of Brasília and put to work on the design of a reference building for child education in Brazil. By reference building, we mean a building that can be customized to fulfill diverse infrastructure frameworks, climate conditions and number of students at each location in where the building must be constructed.

This project was made upon request of the Brazilian Ministry of Education and up to now the designed building has already been implanted in 824 Brazilian cities.

Performance measurement

To evaluate the building design process, a set of performance indicators (Harbour, 2009) (Yu et al, 2007) were proposed and then applied to the project cell.

The quantitative evaluation of the project cell production rate was based on the man-hour consumption per drawing produced.

The lead time reduction value was obtained by comparing the estimated design hours allocated to the

project to the actual hours consumed for completing the design work.

Finally the rework was measured by two different indicators. The first one, equation 3, compares the number of rejected drawings to the number of drawings delivered to the client. The second one compares the man-hours allocated to correcting drawings to the total man-hours allocated to the project.

Efficiency Levels

The analysis of the project cell efficiency levels reflected the improvements achieved in production rate, lead time reduction and rework. The efficiency ratios (Marshall Júnior et al, 2008) were measured by comparing the actual measurement value to a benchmark values (Ezeldin and Abu-Ghazala, 2007) as shown in equation 1.

$$IE = \frac{(performance\ index)}{(benchmark\ value)} \quad (1)$$

An efficiency rate equal to 1 indicates that the performance was unchanged. An efficiency rate that is smaller than 1 would indicate an improvement.

Buildability

Besides the measurement of the design process performance, we looked for the impact of the project cell product on the building construction process. For that we used the concept of buildability which refers to the extent to which the design of a building facilitates ease of construction, subject to the overall requirements for the completed building (Lam and Wong, 2009).

With this aim we analyzed the construction documentation from the 16 first buildings to be completed, looking for time and cost overruns associated with design modification requests (MEC, 2010).

RESULTS

The efficiency's results for the consumption of man hours per drawing indicate an overall improvement of 36% (Efficiency rate equal 0.64).

The improvement in lead time was of 44% if compared to the bibliographic benchmark. On the other hand, when compared to the values provided by invited design companies, the improvement of lead time was up to 55% (Efficiency rate equal to 0.56 and 0.45).

The rework measured in man-hours associated with design correction activities was 94% smaller than the benchmark values (Efficiency rate equal 0.04).

Besides that, there was no construction time and cost overruns or design modification requests in the analyzed construction projects.

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