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Using Sustainability Related Criteria in Construction Support Systems

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Abstract
The need for better productivity measurement and materials and equipment utilization and wastage arises from the relatively new concept of sustainable development. The potential of construction support systems as an adaptive approach to more closely link sustainability with project management is discussed. This paper outlines some key institutional barriers to achieving this potential. Indices representing the above criteria are introduced to express in quantitative terms namely the total or overall productivity, material and equipment utilization and product waste recycling. Concepts of active adaptive management utilizing these criteria are being tested in a pilot study construction project in West Macedonia Greece. The data collected at real time control basis were used for the calculation of the corresponding indices. Conclusively this methodology may be implemented in achieving better productivity and desired system performance.

Keywords
Information Systems, Construction Support Systems, productivity, wastage

1. Introduction

A Contruction support System as any Information System used in the field of Construction Management as a system that changes data of form via suitable treatment, in given other form that allows the support of operations of enterprise and the support of decision-making (Emery, 1987). According to this general definition, a informative system that is used in the construction management changes the data of planning and control of work in data that allow in the designer or in the person in charge of work to take all the required measures in all is phases of work.

Construction Support Systems CSS provide the possibility of treatment of data in the production of suitable information that is used for the support of decision-making in the management of technical work. In order to do this are required the development of timetable, the training of budget of work, the training of table of financier flows and the most optimal exploitation of resources. The contribution of informative systems in this sector is decisive for the total productivity and the productivity per factor of production because in the particular case are required complicated calculations, permanent briefing and follow-up of implementation of technical work and simultaneous analysis of cost.

The first applications of CSS in the Construction Management are marked in the beginning of 80s. In this first applications CSS are used as Data Bases in the organisation of complicated data that they enter into the Management of Technical Work. In their wide application at period 1985-1989 CSS important possibilities, such as applications to the particularities of data and conditions of each technical works. En continuity, from is beginning 1990 until today with the growth of computer systems CSS were usecd for the flexible exploitation of data in technical works. The last years Contsruction Management has profited from the growth of CSS for the treatment of information that is related with a wide circle of applications (Manoliadis 2001).

The need for better productivity measurement and materials and equipment utilization and wastage arises from the relatively new concept of sustainable development during the construction phase. Aim of this work is to introduce relative indices and to explain the possibility to calculate these in combination of CSS utilizing their technical Characteristics in order to increase productivity in the technical work while avoid wastage.

2. Sustainability Indices

According to Manoliadis (2001) and Manoliadis and Pantouvakis (2003) the sustainability of a system can be measured of the system ability to overcome abnormal conditions while obtaining its productivity. Despite the fact that the conversion p with construction operations is complex, influenced by the technology used, by many externalities rocess from CSS inputs such as labour, materials, equipment, tools, capital, and design, to CSS outputs associated such as weather, unions, economic conditions and management, and by various internal environmental components, productivity and especially labour productivity materials and equipment utilization and wastage can be measured using the following indices.

2.1 Productivity measurement

Productivity, as a ratio between input and output, can be distinguished by type of measure (Tsolas 1995):

a) Overall productivity is measured as the ratio of output produced to aggregate input used by a production system. The aggregate input refers to the available tangible resources such as labor, capital, energy and intermediary inputs and the output refers to any one or more of the tangible products yielded.

b) Total factor productivity (TFP) or multifactor productivity is measured as the ratio of output to the weighted sum of labor and capital.

c) Partial productivity is measured as the ratio of output to input, where the input refers to any one or more of the available tangible resources such as labor, capital, energy and intermediary inputs and the output refers to any one or more of the tangible products yielded.

The most usual types of productivity measurement are the partial productivity measures:
the measurement of labor productivity and the measurement of productivity of capital.

Labour productivity is measured as technical achievement, usually in units completed (e.g. tons or cubic yards of excavated materials in the case of excavations) or as advance rate (e.g. road advance rate, tunnel advance rate). Capital productivity is measured as return of invested capital, usually as income per invested capital or as annual output per invested capital.

It should be noted that labour productivity in construction operations is measured as labour input requirement (i.e., the reciprocal of the above defined labour productivity), thus the higher the labour productivity the worst the performance (Thomas and Zavrski 1999).

2.1 Project productivity measurement

Project (labour) productivity is measured under the assumption that the construction operation is a closed system with all factors held constant except for the known input (labour) and output.

The project (labour) productivity measures include: daily productivity, period productivity, cumulative productivity, baseline productivity and project performance parameters such as disruption index, performance ratio and project management index.

2.1.1 Daily Productivity

The daily productivity is defined as:

Daily Productivity = Daily Work Hours/Daily Quantity

2.1.2 Cumulative Productivity

The cumulative productivity is defined as:

Cumulative Productivity = Total Work Hours Charged to a Task/Total Quantities Installed

Cumulative Productivity can be used in order predict the final productivity rate upon completion of the activity.

2.1.3 The Baseline Productivity

The best or maximum productivity during a particular project is called the *baseline productivity* which represents the best productivity that a contractor can achieve on that particular project because there are few or no disruptions.
The baseline productivity is based on the 10% of workdays that have the highest output.

2.1.4 Project Performance Parameters

2.1.4.1 Disruption Index

The disruption index is defined as:

Disruption Index (DI) = Number of Abnormal (Disrupted) Work Days/Total Number of Work Days

2.1.4.2 Performance Ratio

The performance ratio is defined as:

Performance Ratio (PR) = Actual Cumulative Productivity/Budgeted Productivity

2.1.4.3 The Project Management Index

The project management index is a normalized index which is measured as:

Project management index (PMI) = (cumulative productivity – baseline productivity)/baseline productivity

2.2 Wastage

Wastage (WS) =(Quantity of material ordered - Total Quantities Installed)/ Quantity of material ordered

3. Data

In general terms the required data can be obtained by combining data from multiple databases of the construction support system for the purposes of the analysis. In this research the construction support system ERGOLHPTHS is used to gather Daily Work Hours, Daily Quantity, Work Hours Charged During the Period, Quantities Installed During the Period, Total Work Hours Charged to a Task, Total Quantities Installed, quantity of material ordered.

The project area is a typical building construction project in the area of Western Macedonia of a total area of 1021 square meters to be utilized for campuses purposes. The study is concerned for the concrete enterprise operation and is indicative for the calculation of these indices.

The above mentioned data are presented in the following Table.

Table 1. Data from a typical building construction project

Daily Work Hours	8 (hrs)
Work Hours Estimated During the Period	989 (hrs)
Work Hours Charged During the Period	1360(hrs)
Quantities Installed During the Period	1089 (m3)
Total Work Hours Charged to a Task	854(hrs)
Quantity of material ordered	1280 (m3)
Number of Abnormal (Disrupted) Work Days)	32 (days)
Total Number of Work Days	180 (days)

4. Results

The following table depicts the project sustainability measures.

Table 2. Project sustainability measures

Actual Cumulative Productivity	1,25 (=1360 hrs/1089hrs)
Disruption Index	0,18 (=32days/180days)
Baseline productivity	1,09 (=148x8hrs/1089hrs)
Budgeted productivity	0,91 (=989hrs/1089hrs)
Performance ratio	1,37 (=1,25/0,91)
Project management index	0,15 (=(1,25-1,09)/1,09)
Wastage	0,14 (=(1280 m3-1089 m3)/1280 m3)

From the project sustainability measures it is evident that:

The project performance as a whole is low, because the actual cumulative productivity achieved was 37% worst than the budgeted productivity.

The management of that particular project had a low influence on labour project productivity. The low management influence during the project construction as expressed by the difference of cumulative productivity minus baseline productivity is attributed mainly to the adverse weather conditions during the construction period.

The number of abnormal (disrupted) work days as expressed by the disruption index had an adverse effect on the project management index, i.e. the ratio of management influence (cumulative productivity – baseline productivity) to design influence (baseline productivity). According to the results 15% more resources were needed to complete the project.

Moreover, the quantity of materials used was 14% higher than the quantity of materials installed.

5. Conclusions

The folowing conclusions are derived from this study. First the proposed indicators of productivity and wastage it is possible to be derived from CSS. Therefore CSS can contribute decisively in the production of required data on the measurement of productivity of technical works providing the possibility of permanent briefing and follow-up of implementation of this with simultaneous analysis and as a result can be used for the improvement that befalls with the utilisation of this from historical elements of work with and without the use. Conclusively CSS and the proposed reliabiilty indices can contribute to improve project management index: management influence (filling the gap between cumulative and baseline productivity) and design influence (baseline productivity).
In this study a commercial program was used but also many others of the commercial CSS have the possibility of providing the data necessary to obtain these indices that can be used in order to increase productivity materials and equipment utilization and avoid wastage.

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