Development of ERP Module for Quality Management in Construction Industry

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ABSTRACT:  
India has finally fallen into the groove as far as globalization is concerned. This has led to the domestic large and medium sized companies embrace standards and processes that measure up to global standards. It has become more the reason for IT solutions vendors to cheer up looking at the requirements of the Indian market. Statistics reveal that there has been a significant increase in the IT spends of Indian companies in the last few years. ERP was one of the first IT concepts to hit the Indian market, although with meager success. Enterprise Resource Planning (ERP) is software driven business management system, which integrates all facets of the business, including planning, manufacturing, sales, and marketing. The business environment has become increasingly complex and the marketplace has changed from local to global. Management is under constant pressure to improve competitiveness by lowering operating costs and improving logistics. Organizations therefore must be more responsive to the customer and competition. And ERP as a business solution aims to help the management by setting better business practices and equipping them with the right information to take timely decisions. Construction management is a discipline comprising systematic approaches to control time, cost and quality of a construction project based on recorded research and experience. It is found that the majority of construction firms in India have awareness about the ERP systems but very few organizations have so far implemented such systems. The major reason is that the implementation of any ERP system needs a huge investment in time, money and resources. However, when implemented to solve the right problems, these ERP systems can be a powerful tool for business improvement. The construction industry is a highly fragmented industry. The goal of ERP is to support one time entry of information at the point where it is created and to make it available to all the participants within the organization. But interestingly it is found that there is no module for Quality Control or Total Quality Management in ERP solutions in India. This paper deals with the design of ERP module for quality control & its application in building enterprise. Much of the discussion in this paper relates to the development and the implications of different quality requirements for construction as well as the issues associated with ensuring conformance with the help of ERP solution. For developing quality requirements, 5 m’s of construction viz. men, money, materials, machines and methodology are considered. And quality parameters are developed relating to these 5 M’s. For developing quality module of ERP, a resource (5 M’s) based e-Model has been developed. The reports of this module have been designed in such a manner so as to give the concise and precise knowledge of quality parameters of a construction project to its various stakeholders such as builder, developer, contractor, project manager, quality inspector and last but not least the consumer. This paper even exhibits these reports which inform the various stakeholder and help them deciding the right quality benchmarks at a right time within a right budget.

Keywords:  
Construction, quality management, Enterprise Resource Planning (ERP)

1. INTRODUCTION

Enterprise Resource Planning ERP is an integrated suit of application software modules, providing operational, managerial and strategic information for an enterprise, in order to improve productivity, quality and competitiveness. ERP enables an enterprise to balance its resources such as manpower, machines, materials, money, methods and marketing to stay competitive in a globalized economy. It is a business tool rather than a system tool. ERP is an integrated system that allows information to enter at a single point in the processes and updates (e.g. At the material receiving stage of a manufacturing process) and updates a single shared database for all functions that directly or indirectly depend on this information. Once placed into the system the information should be available in all the necessary forms through which it may be accessed, throughout the system. To enable the easy handling of the system the ERP has been divided into the Core subsystems or modules viz. Sales and Marketing, Master Scheduling, Material Requirement Planning, Capacity Requirement Planning, Bill of Materials, Purchasing, Shop floor control, Logistics, Asset Management, and Financial Accounting. It cannot be overemphasized that quality is an objective of project management that is equally important to project budget and schedule of
construction; in India still there is no specialized module of ERP which has been developed for quality control or quality management. Whatever one or two modules of ERP for quality in construction are available, they just deal with superficial elements in Quality Control.

1.1 HISTORY OF ERP
The history of ERP can be traced back to the 1960’s, when the focus of systems was mainly towards inventory control. Most of the systems software were designed to handle inventory based in traditional inventory concepts. The 1970’s witnessed a shift of focus towards MRP (Material Requirement Planning). This system helped in translating the master production schedule into requirements for individual units like sub assemblies, components and other raw material planning and procurement. This system was involved mainly in planning the raw material requirements. Then, in 1980’s came the concept of MRP-II i.e. the Manufacturing Resource Planning which involved optimizing the entire plant production process. Though MRP-II, in the beginning was an extension of MRP to include shop floor and distribution management activities, during later years, MRP-II was further extended to include areas like Finance, Human Resource, Engineering, Project Management etc. This gave birth to ERP (Enterprise Resource Planning), which covered the cross-functional coordination and integration in support of the production process. The ERP as compared to its ancestors included the entire range of a company’s activities.

1.2 OBJECTIVES OF STUDY
When a large multinational consortium or a small contractor uses ERP, the software system offers a comprehensive, integrated set of software tools for managing construction projects, improving accuracy and increasing productivity. The integrated Project Management Software includes Estimating, Valuations, Critical Path Planning, Forecasting and Cash Flow Modeling. In addition there a variety of construction related tools such as Material Costing, Drawing Register, Sub-contract database, Allowable Cost reconciliation, Information schedules and Time-Location charts.

- Studying the present scenario of ERP (Considering case of SPCL)
- Benefits of ERP implementation.
- ROI Calculation in ERP Implementation
- Limitations and Drawbacks of the system
- Recommendation for more efficient and effective implementation in Construction industry

1.3 SCOPE OF DESIGN OF ERP
- Problems faced due to conventional / legacy methods of resource management.
- Optimum resource management
- ERP as a solution to Resource Management.
- Costing of ERP to company.
- Study of implementation of ERP in construction industry

1.4 NEED FOR ERP
- ERP allows for simultaneous access to planning and control
- India’s projected ERP growth will be at a CAGR of 25.2% over the next five years.
- ERP solutions provide competitive advantage to the organization.
- ERP marries management issues to information technology.
- ERP is becoming total solutions for construction management.

2. RESOURCE MANAGEMENT IN BUILDING AND CONSTRUCTION INDUSTRY
In any construction project resource management is one of the most important concerns. Its availability and procurement at proper time is the key for successful completion of any project. Resources include work force (Men), materials, equipment (Machines), standard costs and budget,(Money). These resources are also called as four M’s of construction industry.

2.1 WORKFORCE (MEN)
The manpower planning primarily focuses on determining the size of the project work force, its structuring into functional groups and workers’ teams, and scheduling the manpower recruitment / induction to match the task requirements. This process chiefly involves identifying the trades or the skills required, establishing productivity standards to determine the number of workers needed to perform a given job in the specified time. For Quality control & Quality Assurance purpose it is important to rate the performance of contractors, subcontractors & their crews. (See report no. 1)
2.2 MATERIALS
Efficient materials management in project environments calls for an integrated approach covering numerous functions such as materials planning and programming, materials purchasing, inventory control, store-keeping and warehousing, materials transportation and handling at site, materials codification and standardization, and the disposal of surpluses.

2.3 EQUIPMENTS (MACHINES)
Construction equipment is indispensable in the execution of modern high-cost, time-bound, massive construction projects. It produces output with an accelerated speed in a limited time. It saves manpower, which is becoming ever more costly and demanding. It improves productivity, quality, and safety and also adds a sense of urgency. Acquisition of equipment mass involves initial heavy investment but, on the whole, it adds to the profitability by reducing the overall cost, provided it is properly planned, economically procured and effectively managed. Equipment planning for a project aims at identifying the construction tasks to be undertaken by mechanical equipment, accessing the equipment required, exploring the equipment procurement option and, finally, participating in the decision making for selecting the equipment. For Quality Control & Quality Assurance purpose the choice of right equipment & its proper calibration for the specific task is important.

2.4 CONSTRUCTION STANDARD COST (MONEY)
The construction cost planning has as its aim the integration of planning, judgment, costing techniques and accounting discipline for developing standard cost, financial forecast, project budget and cost control measure with the ultimate goal to achieving the project profit or cost objectives. Construction cost plan uses standard cost concept for costing work-packages, work items or activities. The standard cost techniques finds wide application in estimating, forecasting, budgeting, accounting and controlling of cost.

2.4.1 CONSTRUCTION BUDGET
A project budget reflects the financial plan of operation with specified goal and the cost expected to be incurred for achieving these.

2.4.2 THE COST OF QUALITY
It is obvious that quality is proportional to costs associated with the construction process. Costs associated with quality need to be identified for management decisions. The costs of quality can be broken down as follows:

• **Failure costs:** The costs of demolishing and rebuilding, the cost of production time, delays to other gangs
• **Appraisal costs:** The cost of inspection and testing.
• **Prevention costs:** The costs of providing better designs, more training to reduce failure costs, more maintenance.

2.5 RESOURCE MANAGEMENT – A STRATEGIC PERSPECTIVE
Two of the major resources that should be optimally planned are human resources and equipment. The strategic and business planning is centered on an enterprise's resources. Looking at human resources management, the functionality provided should include the employee database, job descriptions and evaluations, applicant tracking, requisition management, performance review, cost benefits, career and succession planning, creating alternate organization structures, apart from taking care of the training needs of employees on a continuous basis. Equipment is another critical resource. Online records need to be kept of equipment location and status. Proper accounting methods need to be followed in respect of equipment location to track unit, status, operation and maintenance costs.

Time accounting and billing must be integrated when the equipment is directly charged to a job. Time and attendance reports need to be integrated into the resource control system. Usually handled through the data collection applications, it needs to provide interfaces to time clocks through bar coding or key entry applications and should eventually be linked to payroll, job evaluation and performance appraisal.

Another important resource execution application is quality control. It - provides the ability to monitor and track specifications regarding a product or process. It controls resources by identifying which equipment is required to execute the testing process, and how it is to be accomplished. Results gathered from the testing process need to be stored at the item level, allowing certificates of acceptance to be produced.

Construction cost accounting provides for the tracking and analysis of costs directly related to the production process. Movements into and out of WIP labor efficiency, material utilization, and actual-to-engineered variances all need to be backed. This application literally lives within site control, product data management and the general accounting ledgers.
A fixed asset management application should support multiple depreciation methods, disposal analysis, and responsibility reporting, financing and insurance information, in addition to property tax and license renewal information.

3. QUANTIFYING QUALITY IN BUILDING & CONSTRUCTION INDUSTRY

The quality management system monitors and analyzes quality of the constructed product and predicts quality problems and issues. Typical quality measures include:

• Quality control (QC) tests
  – Number performed
  – Frequency
  – Percentage passed/failed
• Number of non-conformance issues
• Number of change requests and root causes
• Cost of Rework
• Number of exceptions at turnover
• Cost of Quality

3.1 THE PROBLEMS WITH QUALITY OF CONSTRUCTION PROJECT

Several Quality-related problems are unique to projects. For one, it is difficult to measure. In fact, often key stakeholders cannot evaluate the true quality of the results until the benefit realization point, and then it is too late to do anything to resolve gaps. To understand this distinction better, we first need to understand the role Quality has played in the Enterprise over the last several decades. During the 1980s and early 1990s, Enterprises in the USA and other countries tried to improve global competitiveness by instituting process and project quality improvement. With process-oriented efforts it is possible to perform sampling and other quality measures. But most projects’ key results cannot be rigorously evaluated until near the project end, or later. And because projects produce something new, there are few standards against which to evaluate “good” results. This particular issue is not just at the overall project level; it often affects the individual assignment delegation process, when those doing the work cannot define the difference between “inadequate quality” and “good enough”.

3.2 QUANTIFYING QUALITY IN CONSTRUCTION

Quality is subjective. That’s why it’s important that everyone in your organization use the same guidelines for measuring it. When doing an inspection, I suggest you measure the level of avoidable problems you encounter and rate them using a rating scale of 1 to 5:

- 5 = Perfect, no problems, 100%
- 4 = Very good, 1-2 minor problems
- 3 = Good, 3-5 minor problems
- 2 = Poor, 6+ minor problems, hotspot or a major problem
- 1 = Very poor, excessive problems

Use “Inspection Forms” to record your ratings and make sure to include notes for any measurements under a 5.

3.3 RATING SCORES IN CONSTRUCTION

A unique feature this quality scoring is that one can collect performance scores from any stakeholder in the customer-supplier performance process. Using this system one can collect performance scores from:

- Field superintendents
- Other subcontractors
- Suppliers
- Quality inspectors
- Warranty service (Management)
- Third-party inspectors

Fig 1: Diagram showing hierarchy of rating scores in Construction
4. MANAGING QUALITY AT FIELDWORK

Quality is defined as ‘fitness to purpose’, i.e. providing a product (a building) which provides an appropriate quality for the purpose for which it is intended. The price to be paid for a building is a reflection of the expectations of quality - A cheaper building probably uses inferior materials and is likely to be less attractive and less durable. The quality is also related to the timing of when it is delivered. Quality control in the construction industry can be looked at as having three elements:

- To produce a building which satisfies the client
- To produce a building where quality is related to the price.
- To produce a building in which sufficient time is allowed to obtain the desired quality.

4.1 TRADE AND TASK CODES FROM DISTRICT SCHEDULE OF RATES (DSR)

Let us first consider the concept of trade & tasks. The various building works given in D.S.R. of Pune region are called as trades. While each item listed under these various building works is called tasks. The codes of these various building works i.e. the trades are maintained same as in Table 5.1

<table>
<thead>
<tr>
<th>Building Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>1     Bd-A  Excavation</td>
</tr>
<tr>
<td>2     Bd-C  Structural Steel Work</td>
</tr>
<tr>
<td>4     Bd-E  Plain Cement Concrete</td>
</tr>
<tr>
<td>5     Bd-F  Reinforcement Cement Concrete</td>
</tr>
<tr>
<td>6     Bd-G  Brick Work</td>
</tr>
<tr>
<td>7     Bd-H  Stone Masonry</td>
</tr>
<tr>
<td>8     Bd-I  Cement Concrete Block Masonry</td>
</tr>
<tr>
<td>9     Bd-J  Water Proofing</td>
</tr>
<tr>
<td>10    Bd-K  Expansions Joints</td>
</tr>
<tr>
<td>11    Bd-L  Plastering And Pointing</td>
</tr>
<tr>
<td>12    Bd-M  Paving, Flooring and Dado</td>
</tr>
<tr>
<td>13    Bd-N  Wood Finish</td>
</tr>
<tr>
<td>14    Bd-O  Oil Painting</td>
</tr>
<tr>
<td>15    Bd-P  Color/White Washing, Distempering</td>
</tr>
<tr>
<td>16    Bd-Q  Wood Work</td>
</tr>
<tr>
<td>17    Bd-R  Roofing And Ceiling</td>
</tr>
<tr>
<td>18    Bd-T  Doors And Windows</td>
</tr>
<tr>
<td>19    Bd-U  Iron Work</td>
</tr>
<tr>
<td>20    Bd-V  Water Supply And Sanitary Fittings</td>
</tr>
<tr>
<td>21    Bd-W  Miscellaneous</td>
</tr>
</tbody>
</table>

Table 1: The table showing various ‘Trades’ & their codes in District Schedule of Rates for Pune Region

4.2 INSPECTION FORMS

For each task, an inspection form is prepared as below. It checks job ready requirements, material inspection & tests, process inspection requirements, task completion requirements & test plan. In addition, the inspector can also recommend additional checks or report nonconformance. Inspection form has to be filed by seven different persons/agencies. An example is given in table 2
Fig 2: Details of Inspection form used for rating the scores for various items of construction work.

4.3 CONSTRUCTION PROCESS FLOWCHART
The flowchart below in Fig. 2 shows the various phases of construction of a house. Out of Project Inception phase, Pre-design phase, Design phase, Construction phase and Occupancy phase, this paper concentrates only on Construction phase as shown in Fig 3.
4.4 QUALITY MANAGEMENT SYSTEM
(QUALITY MODULE OF ERP)
The flowchart below in Fig 4 shows integration of Quality Control module of ERP with other modules; like

H-MS: Human Resource Management System
D-MS: Documentation Management System
O-MS: Operation Management System
M-MS: Material Management System
E-MS: Equipment Management System
C-MS: Corporate Management System
Fig 4: Flow Diagram showing details of Module for Quality Control in construction and its interrelation with other ERP modules in an ERP software.

Fig 5: Flow Diagram showing various types of output reports and their interrelation in a resource based quality control ERP module for building construction.
4.5 QUALITY MANAGEMENT SYSTEM: REPORT
GENERATION WITH REFERENCE TO FIVE
M’S OF BUILDING CONSTRUCTION:
1. Conformance Report: It includes report on Methodology including quality of work & the time required for that work. (Fig. 6)
2. Performance Report: Report on performance of Men like Contractor, sub-contractor & crew on site. This report will be generated depending upon he rating given by Quality Inspector, Builder & Customers. (Fig 7)
3. Calibration Report: This will include various Machines used for different construction processes. The calibration will explain whether the right machine with right settings is used for the right construction process.
4. Material Testing Report: This testing will be as per District Schedule of Rates (D.S.R), of Pune region. The various Materials include concrete, mortar, bricks, blocks, DPC, Timber, etc.
5. Quality Cost Report: This Money report will include Failure Cost, Appraisal Cost & Prevention Cost. (Fig 8-A,8-B,8-C,8-D)

5. INTERPRETING REPORTS OF QUALITY MANAGEMENT MODULE
These reports form part of the submittals (i.e. the paperwork/forms to be submitted to the client at certain duration of time during construction process) There will be different indicators represented in terms of colors as below:
Green Color indicates score from 4 to 5 that means the work is good.
Yellow Color indicates a score from 4 to 5 that means the work is acceptable &
Red Color indicates a score from 0 to 3 that means the work is not acceptable.

6. CONCLUSION
ERP is software based most commonly accepted business management system in construction Industry. Software like Primavera, Microsoft Project, Sap, BAAN, etc is some of the software which are popular in Construction industry. But unfortunately all these existing software systems take care of only cost constraints & time constraints. In spite, being one of the three fundamentals of Construction Project Management along with time & cost, quality constraint has been ignored in these existing e-models. Quality is the criteria of acceptance or rejection in the construction industry. But achieving quality in construction is not a one day story. Instead it is a long & continuous effort. Hence not only applying Quality Control to the various resources such as Men, Machines, and Money & Materials is important but even strict adherence of quality norms for Methodology of various processes in execution of a building construction is vital. The methodology can be checked by various experts in the construction industry. But maintaining all these documents & communicating these results to various stakeholders is something to be planned for. The Quality module of Enterprise Resource Planning ensures that this whole process of quality Control is on the right tack. Not only does it keep track of conformance to the specification but it also maintains records of material testing, machine calibrations, time deviation, cost deviation, etc. Thus Quality Module of Enterprise Resource Planning acts as a great assistance in monitoring quality of construction of a building.

Fig 6 : Diagram showing conformance report
Fig 7: The diagram showing Subcontractor Performance Summary Report
REFERENCES


Figure 8-C: Excess - Savings report of construction cost