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# Optimization of Material Cost through MRP in Road Construction

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**Abstract**— In a construction project, materials account for more than 40% of the total project cost. A small saving in material cost through efficient management of materials can result to a large saving in the total project cost. One of the root causes of improper material management is that materials are ordered based on the information from project schedule. Hence the study is conducted to optimize the cost through material requirement planning for District road construction based on site scenario. The study involves mainly three stages, namely factors identification, data collection and its analysis. Data collection on factors which are based on time, cost, quality, quantity and location of various activities were acquired. These were analyzed and optimisation of cost is done through MRP. These results are validated using actual case studies. Efficient planning of materials can result in substantial savings in project costs.

**Index Terms**— Material Management, Road Construction, Material Requirement Planning, EOQ, DOQ.

## 1 Introduction

The The construction of road gives the better transportation facility around the country. For better development of the country in the construction assertive, the project management is necessary. Time and cost are the two basic parameters to control work in the execution of the road construction. Optimization is a systematic effort made to improve profit margins and obtain the best results under given circumstances. Flow of cost and its usage is very important aspect for beneficial point of view. It is necessary to develop the planning in terms of material to easy the works and risks arise in the projects. For the material cost analysis of the road works, MRP technique is used to overcome the problems raised during execution.

Material Requirements Planning (MRP) is a time phased priority planning technique that calculates material requirements and schedules supply to meet demand across all products and parts in one or more plants. It focuses on optimizing inventory. This project demonstrates the functioning of MRP using Discrete Order Quantity (DOQ) and Economic Order Quantity (EOQ) lot sizing techniques. While DOQ orders just as much material as required, EOQ determines the ideal order quantity, so as to minimize the total cost of inventory management and only ordering material in that quantity, whenever required. Each of these methods is suitable for specific demand scenarios.

In conventional methods, the project budgeted total cost is determined by the difference, between the actual cost, and planned cost. That means the project manager's focus was on only for planned cost and expenditure cost as actual cost. In modern days many schedule properties and cost parameters only for planned cost and expenditure cost as actual cost. In modern days many schedule properties and cost parameters are considered. Because it is very important in every construction project, losses are due to inadequate construction management and cost performances done by the contracts in the road construction projects. So it is necessary to develop the planning technique to easy the works and risks arises in the projects.

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## 2 Statement of Problem

Companies need to control the types and quantities of materials they purchase, plan which products are to be produced and in what quantities and ensure that they are able to meet current and future customer demand, all at the lowest possible cost. Making a bad decision in any of these areas will make the company lose money. A few examples are, if company purchases insufficient quantities of an item used in manufacturing (or the wrong item) it may be unable to meet contract obligations to supply products on time, if company purchases excessive quantities of an item, money are wasted - the excess quantity ties up cash while it remains as stock that might never be used at all and beginning production of an order at the wrong time can cause customer deadlines to be missed. Material Requirements Planning (MRP) is a time phased priority planning technique that calculates material requirements and schedules supply to meet demand across all products and parts in one or more plants.

## 3 Aim

The aim of the project is to optimize material cost in road construction.

## 4 Objective

The main objectives of this study are to:
- Identify factors affecting material cost.
- Evaluate or analyze material cost.

- Optimize material cost through MRP in road construction.

## 5 SCOPE

Improve material management in construction site there by reducing cost.

## 6 METHODOLOGY

The methodology adopted for the present survey is illustrated in Fig.1

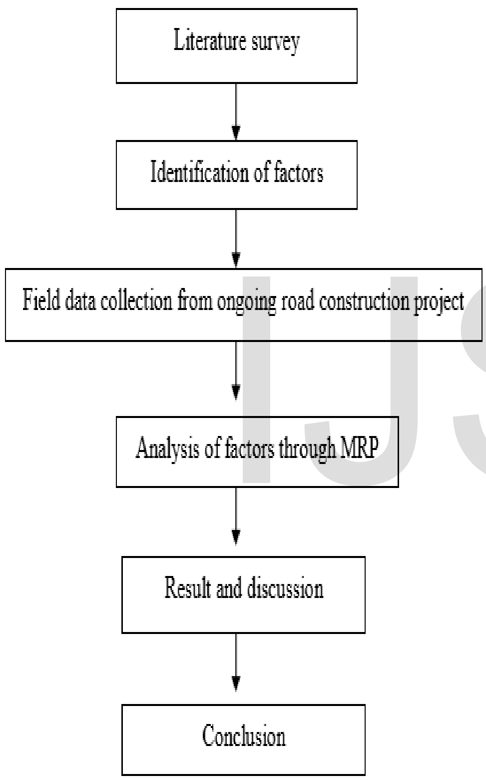


Fig. 1 Methodology of work.

Literature survey includes citing to previous works that dealt with road construction and Material Requirement Planning and MRP techniques were also acquired.
Identification of factors contains inflation factor, project schedule, quality of plans and specifications, size and type of construction project, engineering review, contingency etc.
Data collection consists of material management at a road construction site, identification of major materials used in road construction and types of pavements. Details on cost of materials, lead time and transportation cost between source and site, quantity of materials and number of labours would thus lie as secondary concerns.
Analysis of factors through MRP includes calculation of MRP by EOQ and DOQ methods.
Result and discussion contains optimization of cost through MRP techniques and its feasibility in construction works.

### 6.1 LITERATURE SURVEY

The basic objective of construction project is to create a unique facility, product or service within the specified scope, quality, time and cost. Some road construction projects face losses due to inadequate construction management and cost performances done by the contracts. It is necessary to probe in to previous studies that have focused upon supply chain management and process modeling. Though material requirement planning studies in road construction projects were not purely found, some key points like major road construction materials and sections relevant to study are referred from some papers.

### 6.2 IDENTIFICATION OF FACTORS

There are many factors which affect the optimization of cost through MRP are as following:

1) Quality of Plans & Specifications: A good quality construction plans and specifications reduce the construction time by proper execution at site without delay. Any vague wording or poorly drawn plan not only causes confusion, but places doubt in the contractor's mind which generally results in a higher construction cost. Improper planning may increases material quantity and improper specification causes variation in material cost and durability of project.

2) Project Schedule: Duration of construction project is affects the cost. Increase in project duration can increase the construction project cost due to increase in indirect costs, while reduction in construction cost also increases the project cost due to increase in direct costs. Therefore, construction project schedules also need to be considered during project cost estimation.

3) Inflation Factor: A construction project can continue for years before completion. During the construction period, the cost of materials, tools, labors, equipments etc. may vary from time to time. This variation in the prices should be considered during cost estimation process. If 5% inflation cost is arises it may lead increase in actual project cost than estimated.

4) Size and Type of Construction Project: For a large construction project, there can be high demand for workforce, materials and equipments. These may incur extra costs such projects and also for the type of construction project where specialized workforce is required. As size of work increases the quantity of material required also increases, which leads variation in the total cost.

5) Skill and Experience: Technical review of construction project is necessary to make sure that the project will serve the required purpose with optimum operational and maintenance cost. Proper guiding and review reduces the cost than improper work making excess cost.

6) Contingency: It is always advisable to add at least 10% contingency towards the total project costs for unforeseen costs and inflation.

## 6.3 Data Collection

TABLE 1
Road Details

| Site | Type based on IRC | Pavement type | District | Stretch (m) | Thickness (m), without compaction | Total cost of work |
|---|---|---|---|---|---|---|
| Site 1 | Village road | Flexible | Kozhikode | 1340 | 0.55 | 30,00,000 |
| Site 2 | Village road | Flexible | Kozhikode | 225 | 0.375-0.45 | 5,00,000 |
| Site 3 | Village road | Flexible | Kozhikode | 180 | 0.45 | 5,00,000 |
| Site 4 | Village road | Flexible | Kozhikode | 250 | 0.225 | 5,00,000 |
| Site 5 | Village road | Flexible | Kozhikode | 330 | 0.075 | 5,18,653 |
| Site 6 | Village road | Flexible | Kozhikode | 700 | | 5,50,000 |

The materials used in each sites and their details are collected. Details of materials in three sites are given below.

TABLE 2
Material Detils

| Name | Material used | Quantity (cu ft) | Unit cost | Amount |
|---|---|---|---|---|
| Site 1: | 6mm aggregate | 1899.38 | 27.63 | 52479.87 |
| | 10mm aggregate | 492.52 | 27.21 | 13401.47 |
| | 12mm aggregate | 11396 | 27.21 | 310085 |
| | Dust | 759.752 | 18.49 | 14047.81 |
| | 20mm aggregate | 1278.455 | 27.6 | 35285.36 |
| | 40mm aggregate | 3979.149 | 35.24 | 140225.21 |
| | WMM | 7198 | 38.10 | 274243.80 |
| | GSB | 5505.84 | 33.34 | 183564.71 |
| | Cement | 741.292 Bags | 320 | 237213.44 |
| | Coarse sand | 2201.997 | 42.06 | 92615.99 |
| | Bitumen S-65 | 63.528 barrel | 4630 | 294134.64 |
| | Emulsion SS1 | 4.876 barrel | 7243 | 35316.87 |
| | Emulsion RS1 | 6.020 barrel | 6807 | 42203.4 |
| Site 2: | 6mm aggregate | 214.54 | 36.368 | 780.39 |
| | 12mm aggregate | 643.62 | 35.527 | 22865.88 |
| | Earth | 92.625 | 4.5 | 416.813 |
| | WMM | 3346.35 | 46.71 | 156308.009 |
| | GSB | 1048.88 | 43.65 | 45783.612 |
| | Bitumen S-65 | 9.13 barrel | 4630 | 42271.9 |
| | Emulsion SS1 | 3.15 barrel | 7243 | 22815.45 |
| | Emulsion RS1 | 1.02 barrel | 6807 | 6943.14 |
| Site 3: | 6mm aggregate | 171.631 | 35.84 | 6151.25 |
| | 10mm aggregate | 51.49 | 35.033 | 1803.849 |
| | 12mm aggregate | 514.89 | 35.033 | 18038.141 |
| | 20mm aggregate | 102.98 | 35.84 | 3690.8 |
| | 40mm aggregate | 230.11 | 43.073 | 9911.528 |
| | Earth | 3672.76 | 4.5 | 16527.42 |
| | WMM | 2113.60 | 45.923 | 97062.853 |
| | GSB | 1446.5024 | 42.58 | 61592.07 |
| | Cement | 53.46 bags | 320 | 171107.2 |
| | Coarse sand | 128.72 | 49.883 | 6420.94 |
| | Bitumen S-65 | 7.82 barrel | 4630 | 36206.6 |
| | Emulsion SS1 | 1.40 barrel | 7243 | 10140.2 |
| | Emulsion RS1 | 0.75 barrel | 6807 | 5105.25 |

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## 6.4 ANALYSIS

### 6.4.1 DISCRETE ORDER QUANTITY (DOQ)

It is the most common lot sizing technique. This technique entails ordering only the exact amount of required material. DOQ minimize inventory, but it results in increase in the number of orders placed. This might reduce the holding cost, but it maximizes the ordering cost.

- Item: In MRP, an item is the name or code number used for the material in scheduling.
- Lot Size: This is the quantity of units ordered during manufacturing
- Lead Time (LT): This is the time needed to assemble or manufacture an item from beginning to end.
- Gross Requirements (GR): This is the total demand for an item during a specific time period.
- Net Requirements (NR): This is the actual, required quantity to be produced in a particular time period.

**NR= (GR – inventory on hand) + safety stock**

TABLE 3
DOQ CALCULATION AT SITE 1

| Item: | Time In Days | | | | | |
|---|---|---|---|---|---|---|
| 40mm aggregate | (26/03/18)1 | 2 | 3 | 4 | 5 | 6 |
| GR | | 900 | 700 | 900 | 700 | 700 |
| Stock available | 0 | 0 | 0 | 0 | 0 | |
| NR | | 900 | 700 | 900 | 700 | 700 |
| planned order release | 900 | 700 | 900 | 700 | 700 | |
| cost (POR x unit cost) | 105.72 | 70.48 | 105.72 | 70.48 | 70.48 | |

The same procedure is repeated for each materials in each site for calculating total cost of materials by DOQ method.

### 6.4.2 ECONOMIC ORDER QUANTITY (EOQ)

Economic Order Quantity (EOQ) is used to calculate the optimal quantity of material that can be procured to minimize both the holding cost and ordering cost associated with the material.

$$EOQ = [(2 \times A \times O)/ C]^{1/2}$$

Where,
A = Annual Demand in units
O = Cost incurred for placing a single order
C = Holding Cost per unit per year

N, Number of orders per year = A/EOQ
AA, Average annual ordering cost = (Number of orders per year) x O
AI, Average Inventory = EOQ/2
AH, Annual holding cost = (Average Inventory) x C
TC, Total Annual Cost = Annual average ordering cost + Annual holding cost

TABLE 4
EOQ CALCULATION AT SITE 1

| ITEM | A | O | C | EOQ | N | AA | AI | AH | TC |
|---|---|---|---|---|---|---|---|---|---|
| 6mm aggregate | 1899.38 | 27.63 | 2.763 | 194.9 | 9.745 | 269.26 | 97.452 | 269.26 | 538.53 |
| 10 aggregate | 492.52 | 27.21 | 2.721 | 99.249 | 4.962 | 135.02 | 49.625 | 135.02 | 270 |
| 12mm aggregate | 11396 | 27.21 | 2.721 | 787.51 | 14.47 | 393.75 | 393.75 | 1071.4 | 1465.1 |
| Dust | 759.752 | 18.49 | 1.849 | 123.27 | 6.163 | 113.95 | 61.635 | 113.95 | 227.9 |
| 20mm aggregate | 1278.45 | 27.6 | 2.76 | 159.9 | 7.995 | 220.66 | 79.95 | 220.66 | 441.3 |
| 40mm aggregate | 3979.15 | 35.24 | 3.524 | 282.15 | 14.1 | 497.07 | 141.07 | 497.07 | 994.14 |
| WMM | 7198 | 38.1 | 3.81 | 379.42 | 18.97 | 722.79 | 189.71 | 722.79 | 1445.6 |
| GSB | 5505.84 | 33.34 | 3.334 | 331.84 | 16.59 | 553.18 | 165.92 | 553.18 | 1106.3 |
| bitumen s 65 | 63.528 | 4630 | 463 | 35.645 | 1.782 | 8251.8 | 17.823 | 8251.8 | 16504 |
| emulsion ss1 | 4.876 | 7243 | 724.3 | 9.875 | 0.494 | 3576.3 | 4.938 | 3576.3 | 7152.6 |
| emulsion rs1 | 6.02 | 6807 | 680.7 | 10.973 | 0.549 | 3734.5 | 5.487 | 3734.5 | 7469 |

The same procedure is repeated for each materials in each site for calculating total cost of materials by EOQ method. 10% of material cost is assumed to be as holding cost.

### 6.4.3 CONVENTIONAL METHOD

In conventional method, total annual cost is determined by adding annual average ordering cost and average holding cost. The annual average cost is the product of unit cost of material and number of orders placed. Holding cost includes material cost and additional 10% of material cost as holding cost.

## 6.5 RESULT

From the below table of results including total materials cost in each site, it is observed that the material cost can be reduced by using EOQ and DOQ methods. DOQ orders just as much material as required, EOQ determines the ideal order quantity. In case of EOQ method about 4% reduction is observed as compared to the conventional method. DOQ requires no holding cost and it is observed that this method show about 46% reductions compared to conventional method.

TABLE 5
MATERIAL COST OPTIMIZATION

| Site name | DOQ | EOQ | Conventional method with holding cost |
|---|---|---|---|
| Site 1 | 21145.52 | 37605.47 | 38788.339 |
| Site 2 | 19335.702 | 17551.58 | 18438.59 |
| Site 3 | 18909.64 | 14966.33 | 15704.309 |
| Site 4 | 19322.806 | 18038.43 | 18955.306 |
| Site 5 | 14050 | 20962.18 | 22014.413 |
| Site 6 | 11534.688 | 18911.143 | 19851.436 |

## 7 CONCLUSION

- Factors affecting material cost in road construction site were identified.
- Material cost used in construction site has been analyzed.
- In case of EOQ method about 4% reduction is observed as compared to the conventional method.
- DOQ requires no holding cost and it is observed that this method show about 46% reductions compared to conventional method.
- ReferencesDOQ lot sizing technique is suitable for the site where the demand was considered to be variable.
- EOQ lot sizing technique is suitable for site, where the demand was considered to be uniform.

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