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Optimization in Supply Logistics Cost of Construction Projects of a Company

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Abstract - *The contribution of construction materials may account 50-65 % of the project cost due to inefficiency of logistics strategies for congested site in urban areas, the supply logistics cost of material raises from 17-25% goes till 49% of supply logistics cost. As a solution to this, tier 1 cities implemented the strategy of just in time with a consolidation center. However, cities of tier 2 and tier 3 still raising concern of supply logistics cost of congested site in urban areas and a consolidation center cannot be the solution for the single contractor. So suggested methodology is just-in-time with the intermediate warehouse by the contractor. Thus, it is of high essence that material resources are managed properly to reduce cost, achieve timely project delivery at the budgeted cost and quality through logistics strategies. This paper proposes the optimization strategy and evaluating criteria of the attributes in the supply logistics cost of the strategy with fixed, semi fixed, variable cost. The study further takes the supply logistics cost of a 3 projects of a same company to develop the methodology and to provide recommendations.*

***Key Words*: Material management, supply logistics, optimization in logistics cost, transportation cost structure, warehousing cost structure.**

1. Introduction:

Materials management is defined as "a whole concept encompassing an organizational structure integrating into a single responsibility, the systematic supply and control of resources from demand identification through customer delivery." **The contribution of construction materials may account 50 - 65 % of the project cost. The delivery service cost will account for roughly 17%-25% of the material cost, i.e., the physical distribution expense will approximate 10%-11% of the engineering project construction cost, indicating that physical distribution activity in engineering construction projects has a significant economic influence.** (Chen Duiyong, 2014)

This idea includes material functions such as planning, scheduling, purchasing, storing, **transporting, and distributing**. Production and inventory control, buying, and physical distribution are all disciplines that are represented. (Klooster)

Through this study, optimization of supply logistics cost in of a company will be analyzed, assessed and methodology are proposed to identify the attributes of Transportation and warehousing in logistics cost structure and identification of methods to evaluate the attributes and analyses and asses the attributes in the case study to provide a structured methodology of cost optimization for intermediate warehouse.

1.1 Material Management

1.1.1 Material classification

Materials can be classified into different categories depending on their type and size we need or use technique on site.

Table 1Material classification (Adithya A.Pande, 2016)

Type of material	E.g.
Bulk material	Concrete, sand
Bagged material	cement
Pelleted materials	Doors, frames
Packaged material	Tiles, pipes, electrical fittings
Loose materials	Reinforcement bars, glass panels

1.1.2 Management of material resources

The emphasis of materials management is the management of material resources. It assesses material costs and makes efforts to reduce them. The essential cost of resources, according to classical philosophy, is the cost of getting them. However, in today's environment, materials management takes into account not only the cost of materials, but also their costs. This means that material costs and material costs should be reduced to a minimum. These material expenses are typically concealed and are not labeled as "materials." Instead, they are labeled as "overheads," "scrap," "storage," and so on. (Ashwin Patil, 2013)

The primary goal of materials management is to minimize any hidden material expenses, regardless of how they appear in the logistics cost.

Most specific materials impacted in the construction cost are Concrete, Cement, Steel, Aggregates, Brickwork and Flooring

1.2 Logistics Introduction

Contractors are typically merely single connections in logistic chains that deliver items, services, information, and financing to a project. In contrast to the industrial industries, which benefit from long-term collaboration, In comparison to suppliers and consumers, building logistics networks are far more complicated to monitor and optimize. (M. Muya1)

1.2.1 Types of Logistics strategies

- Just in Time Technique / Pull system
    - Just in time with consolidation centre / just in time by suppliers
- Just in case/ Push system (Construction Consolidation Centres, 2016)

1.2.2 Logistics cost

The logistics cost (LC) in the building construction project is calculated as the Summation of the transportation cost, ordering cost, inventory cost, and damage cost.

LC = CT + CO + CI + CD

In some project transportation cost is high. So to understand the cost percentage of transportation cost, ordering cost, inventory cost, damage cost is 49%-57%, 9.9%-15%, 11.5%-24.5%, 15 %. (Amornsawadwatana, Logistics Costs Evaluation in Building Construction Project)

Table 2 Types of cost associated with offsite logistics

Costs associated		Type of cost
Offsite Logistics		
Transport	Cost of inputs required for placing and maintaining the vehicle on the road (Licensing, taxes)	Semi Fixed
	Labor (Driver cost and packers cost)	Variable
	Vehicle cost – Preference type of vehicle for quantity	Semi Fixed/ Variable
	Maintenance cost of vehicles (oil charges, tire charge cleaning), Fuel cost	Variable
Transportation to storage	Loading and Unloading through equipment/labor	Semi Fixed
Warehouse – handling	Warehouse setup	Semi Fixed
	if congested site, land cost rent to store materials + Transportation from warehouse to construction site	Semi Fixed
	Labor - security	Semi Fixed
	Maintenance cost – Electricity bill	Variable

1.2.3 Attributes

To assess the suitability of attributes in implementing a logistic strategy in a particular study.

Table 3 Resource consumption during storage (Author)

Logistics process	Category	Resource
Storage at supplier yard	Labour	Worker (handling)
	Equipment	Handling truck
	Material	stocking
Storage at intermediate warehouse	Capital	Rent

Table 4 Resource consumption of transportation from supplier to construction site (Author)

Logistics process	Category	Resource
Transportation (to construction site)	Labour	Truck driver Inspector
	Equipment	Truck
	Material	
Transportation (to intermediate warehouse)	Labor	Truck driver Inspector
	Equipment	Truck
	Material	

Table 5 Resource consumption during loading, fixing and on-site storage (Author)

Logistics process	Category	Resource
Loading and fix	Labour	Worker (handling)
	Equipment	Mobile Crane
On-site storage	stocking	Truck driver Inspector
	Capital	Opportunity cost frozen in on-site stocking

2. Case study data collection and analysis

2.1 Introduction

The nachimaar engineering consultant is a construction company that deals with several projects in the southern region of Tamil Nadu. For a further understanding of optimizing cost, three case studies have been taken from the same company which are located in Thirunelveli, Thiruchirapalli, and Thanjavur. The case study sites are located in the urban areas. The company procure the materials directly and store it in the construction site without any intermediate warehouse. Due to space constraint these materials are procured every 20-25 days. Further details of case study will be brushed .

Table 6 Case study Details (Author)

Description	Case study 1		Case study 2	Case study 3
Name of the Project	Commercial Mall with Multi Level Car Parking		Conventional center (G+3)	Mall Building (G+2)
Location	Near Pallai Bus Stand, Tirunelveli, Tamil Nadu		Near Main Junction, Trichy, Tamil Nadu	Nagercoil, Kanyakumari
Total Estimated Cost	INR 39.48 Crore		INR 10 Crore	INR 20.73 Crore
Total	16,455 sq.m		4645 sq.m	9629 sq.m
Items % of total amount in civil cost	Cement	8.5 %	11.7 %	9.7 %
	Steel	22.7 %	29.2 %	24.8 %
	Aggregate	13.6 %	17.6 %	15.5 %

In the case study 1, material cost about 63.4% of total construction cost. In which half (36.6%) of the cost are bulk materials and pelleted materials. concrete takes 17.1% of material cost. The site can store only for 2-3 days .

In the case study 2, material cost about 55.4% of total construction cost. In which half (36.6%) of the cost are bulk materials. concrete takes 19.4% of material cost the site can store only for 5 days

In the case study 3, material cost about 53.7% of total construction cost. In which half (36.6%) of the cost are bulk materials, concrete takes 18.1% of material cost. The site can store only for 5 days.

Using the Just in time strategy, the bulk materials are ordered and stored directly in the site warehouse by a company

2.1.1 Supply of materials of case studies for 3 months

Table 7 Supply of materials of each project for 3 months (Author)

Project site	Cement	Aggregates	Steel
Thirunelveli	929246 kg - 18585 bags	3466349 kg	310 MT
Trichy	265499 kg – 5310 bags	990385 kg	89 MT
Thanjavur	546615 kg – 10932 bags	2039029 kg	182 MT

The supply materials for first 3 months are taken. The quantities are calculated as per BOQ, schedule of the each project and first 2 projects starts in the same month and 3rd case study starts after 2 months.

2.1.2 Logistics cost from Plant to site (Author)

Material	Logistics cost of site 1	Logistics cost site 2	Logistics cost site 3
Cement, aggregate and steel	14677842	12004227	11789038

The Percentage of logistics cost from the materials cost is 27.7%, 45%, 30.79% for site 1, site 2 and site 3 respectively.

2.1.3 Details of plants of cement, aggregate and steel

The warehouse has been selected on the basis of transportation route from manufacturing/plant/quarry to site, security, rental rate, labor availability, distance from the site.

Table 8 Intermediate Warehouse Distance (Author)

Name	Distance from intermediate warehouse to site warehouse (km)		
	Site 1	Site 2	Site 3
Keezhapur near ariyalur.	355	66	43
Thuraiyur, near salem to trichy road.	337	50	94

2.1.4 Location and distance details of plants from warehouse

The company is procuring the cement from the branded cement factory and aggregates are procured from the near quarries. Even though there is availability of local brands plants in Tamil Nadu, the company prefers from JSW and Tata steels.

Table 9 Location and Distance Details of plants (Author)

Plant	Location	Distance from intermediate warehouse 1 Kms	Distance from intermediate warehouse 2 Kms
Cement	India cement Perambalur, Tamil Nadu	43	94
	Dalmia cement, Dalmiapuram, Tamil Nadu	32	66
Aggregate	Govt stone quarry	242	208
	Thiruvakkarai Rd, Tamil Nadu	162	173
Steel	Jsw Lal Bagh Main Rd, Bengaluru, Karnataka	354	305
	Tata Race Course, Gopalapuram, Coimbatore, Tamil Nadu 641018	271	203

2.1.5 Location of site, warehouse, cement, aggregate and steel

The construction sites are located in the center of the city which prohibits the travel of HGV vehicles in the particular time at 11 pm to 5 am. So the warehouse centers are taken in the highway road around 50 kms away which will reduce the rental rent also.

2.1.6 Type of Vehicle, dimensions and Rental rate

Table 10 Type of Vehicle, dimensions and Rental rate(Author)

Vehicle body type	Construction facilities other than construction sites at which used	Rate	weight
Tipper Truck – HGV	Quarries, mines	90,000-1,10,000	9.8*2.4*2.8 65cu.m Capacity :16- 28 ton
Tipper truck - LGV	Intermediate warehouse to site	86,000	3.8*2.4*3.5 Capacity : 10 - 12 ton
Flatbed - HGV	Products from processing facilities and to/from builders' merchants and storage facilities	83,000	26 ton – L 12m 12 ton – L 8m

2.1.7 Vehicle Type and Labour Charges

The labor charges for a driver are given in 2 ways one is lump sum and other way is km per way. Lump sum rate per trip by truck driver is 10,000 – 30,000 depends upon distance travel, location and type of HGV vehicle they driving.

Table 11 Vehicle Type and Labour Charges (Author)

Vehicle body type	Distance travel per day	Labour Rate
HGV	100-150 km/day	50/km or 7.4/hr
LGV	Upto 400 km/day	30/km or 3.2/hr

2.1.8 Rental rate

Rental rate depends on the area, land rent on the location.

Table 12 Rental cost of warehouse(Author)

Warehouse	Rent/ month	Total cost for 3 months
Warehouse 1	60,000	1,80,000
Warehouse 2	83,000	2,49,000

2.2 Total logistics cost are

Supply logistics = TC (CC (semi fixed cost) + CV (variable cost)) + WC (CC (semi fixed cost) + CV (variable cost)) + LC (CC (semi fixed cost) + CV (variable cost)). The cost increase, caused by a change in lead time of processes and order cycle time. The cost increase caused by a change in cargo turnover and stock level.

2.2.1 Analysis of supply logistics

2.2.1.1 Cost from supplier to intermediate warehouse

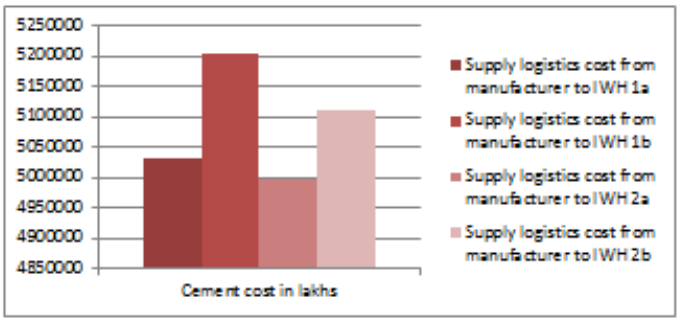

Figure 1 Cement supply logistics cost from manufacturing plants to Intermediate warehouses (Author)

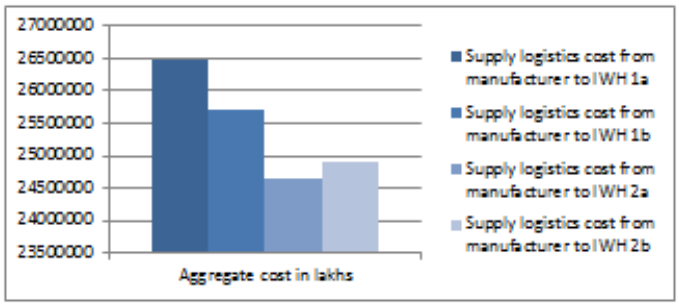

Figure 2 Aggregate supply logistics cost from manufacturing plant to Intermediate warehouse (Author)

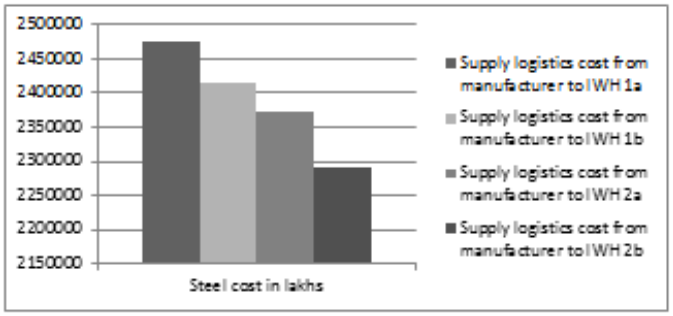

Figure 3 Steel supply logistics cost from manufacturing plant to Intermediate warehouse (Author)

2.2.1.2 Cost intermediate warehouse to site

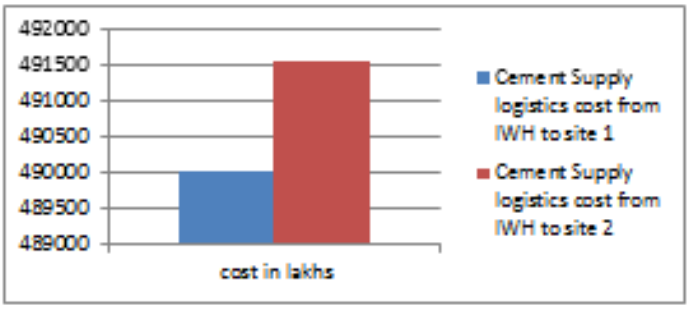

Figure 4 Cement supply logistics cost from Intermediate warehouses to site 1 (Author)

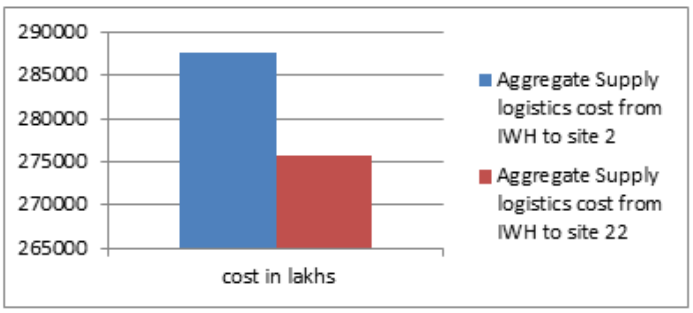

Figure 5 Aggregate supply logistics cost from Intermediate warehouses to site 2 (Author)

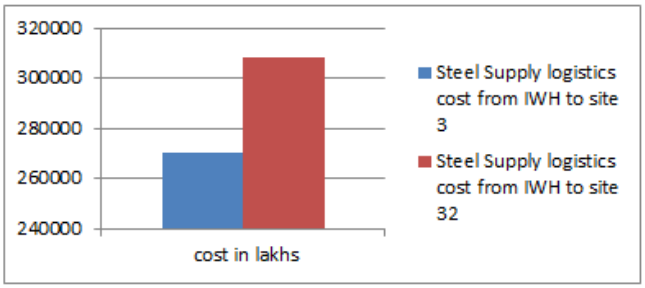

Figure 6 Steel supply logistics cost from Intermediate warehouses to site 3 (Author)

The logistics cost of the site with intermediate warehouse reduces the logistics cost by 7%-19% from this case. When compared with each scenario, the price of transportation from quarries/plants to an intermediate warehouse by road indicated a potential optimal plan. These elements can be captured by defining appropriate number of various decision variables such as distance, fastest route, time taken to reach the destination, and vehicle size. The results showed that the percentage saving in logistics cost and the feasible solution is obtained from 16 possible routes (refer above table). The least possible route is 4-5 % lesser than the other routes.

4. Recommended Methodology for Logistics cost

This paper contains the concluding remarks for the company which deals with several construction projects in congested site in a urban area. Transportation vehicle size for carrying the bulk materials of 1700 – 6000 ton use HGV of medium sized can transport comparatively in lesser cost of 3-8% than high sized of HGV due to its per day travel constraint which may increase the no of hours travel due to that maintenance and fuel charges will be high. if we take low sized HGV vehicle, speed of the vehicle increase but the no of transport increase so the transport vehicles rate takes double the times.

Intermediate warehousing can be placed at the distance of 150 km maximum for easy shipping from intermediate to site, then which will be travelled through LGVs. so it can have lesser no of trips generated.

Table 13 Percentage of logistics cost for commercial project of 5-40cr in urban areas

Distance from Intermediate Warehouse to site	Percentage of logistics cost for commercial projects of 5cr- 40cr in urban areas of material cost
Upto 100 km	7-13%
100-250 km	13-19%

Table 14Type of vehicle for supplying from materials from supplier to site via warehouse

Materials	Location	Vehicle	Distance from Intermediate warehouse to site
1700-6000 ton	Supplier to intermediate warehousing	Medium size HGV 22- 28 ton	Maximum 150 km
Upto 300 ton	Intermediate warehousing to site	Small size LGV 10 – 12 ton	

5. Conclusion

The conclusions drawn for the optimization of supply logistics cost which to answer the company with several projects in congested site in a urban area and it can be concluded using recommending a logistic strategy just in time with intermediate warehouse for a company which has several projects in the same areas. It is concluded by identifying the appropriate approaches for intermediate warehouse and the transportation by finding and evaluating the attributes in the logistics cost with fixed, semi fixed, variable cost study as a base.

The above the methodology of just in time with intermediate strategy will help to understand the variables of cost in transportation and warehousing in the logistics cost and the percentage of supply logistics cost reduced. This study has gone as far as a review of transportation cost and warehousing cost from supplier to site via intermediate warehousing of a project of same company. Thus, it can be concluded that this dissertation paper develops a valuable methodology for evaluating the logistics cost of company.

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