Implementation of Lean Logistics System in Material Handling Process of Break Water Construction

R. Midhun Chakravarthi1, K. M. Sharath Kumar2, N. Bhupesh Chowdary3
1 – MBA (Engg. Operations) Student, 2 - Senior Lecturer, Department of Management Studies, M.S. Ramaiah School of Advanced Studies, Bangalore 560 054
3 - General Manager, JSWIL, Mumbai

Abstract

A port is a facility for receiving ships and transferring cargo. They are the major source of movement for large quantities of material. Breakwaters are essential construction in coastal engineering for the protection of coast, infrastructure and a key component in port design. Construction of breakwater involves wide range of activities that need transportation of resources from wide range of sources. Often these projects run into costly time and budget overruns. However they can be reined through proper logistics management and coordination of various activities.

In the current project work, most of the materials required for construction of break water have been carried by ships and barges, making it necessary to plan activities in a way that would minimise the total cycle time required for the barge through lean logistics. Analysis of the entire operation has been carried out by constructing activity based timing chart. Many delays in the offshore dumping process have been observed due to lack of integration among the suppliers in the operation. Due to less rate of loading by using excavator, loading large capacity barge became impossible. Resource allocation model and Short Message Service (SMS) mode of communication has been formulated and implemented respectively to reduce the delays with better information sharing among the trading partners. Just in Time (JIT) principle has also been implemented to reduce the operating time of the excavator along with lean logistics through an end on loading jetty to increase the rate of loading of the barges.

Results showed decrease in waiting time of the barge and elimination of the stock on the pontoon. By implementing lean logistics the loading rate has been increased from 250 MT/hour to 750 MT/hour optimising the utilisation of resources. Through this enhanced material flow rate has been achieved which further reduces the time and cost. Based on the results obtained through pilot run, suggestions towards improving the performance of the process have been made.

Key Words: Overruns, Short Message Service, Just in Time, Offshore Dumping

Nomenclature:

T  Tonnes
M  Meters
MTPH  Metric T per Hour

Abbreviations:

CD  Chatted Datum
DGPS  Digital Global Positioning System
FTB  Flat Top Barge
JSWJPL  Jindal South West Jaigarh Port Limited
SHB  Split Hopper Barge

1. INTRODUCTION

A breakwater is a structure protecting a harbor from waves as shown in Fig. 1. It creates calm water and gives protection for safe mooring, operating and handling of ships. Construction of breakwater involves wide range of activities that need transportation of resources from wide range of sources. Since most of the materials required for construction have to be carried to the site of construction by ships and barges, it is not economical to transport materials as and when required in inland constructions. So it is necessary to plan activities in a way that would minimise the number of cycles required for barges, which further are limited by their carrying capacity and availability [1]. At the same time the duration required for project completion increases if the number of barges used are reduced, which further may increase overhead costs and liquidation damages, if applicable. Also there are many other technical and construction issues which influence the cost of construction. In the study, a perspective to optimise the time and cost of the total project has been made through implementing lean logistics so that it finally benefits the profitability and efficiency of the project [2].

Fig. 1 Break water protecting port

Logistics is the management of the flow of goods, information and other resources including energy and people between the point of origin and the point of consumption in order to meet the requirements of consumers. Logistics involves the integration of information, transportation, inventory, material-handling and packaging. Logistics management is that part of the supply chain which plans, implements and controls the efficient, effective forward, reverse flow, storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements. Lean logistics strategy is to do every operation by...
optimising the use of each resource - people, space, stock, equipment, time etc., it organises the efficient flow of materials to eliminate waste, gives the shortest lead time, minimum stocks and minimum total cost. By combining the lean and integrating logistics principles, the better efficient flow of material is achieved [3]. Just-in-time (JIT) system received considerable attention since the early 1980s. Some of the main benefits of JIT such as inventory reduction, quality improvement and quick delivery are well documented [4] [5] [6].

The break water construction has been carried out by two methods of dumping the basalt stones of various sizes which are end on dumping process and offshore dumping process. In the end on dumping process the material is dumped directly in to the sea with the dumpers and then dozing with a dozer as shown in Fig. 2.

![Fig. 2 End on dumping process](image)

**Fig. 2 End on dumping process**

In offshore dumping the barge goes to the breakwater sight and dumps the rocks into the sea as shown in Fig. 3. The selection of a particular type of breakwater also depends on factors such as the availability of materials, plant and labour. A vertical wall breakwater has been placing different demands on these factors than a trapezoidal rock armouring. The trapezoidal breakwater requires more material because of its shape. Thus in an area which has an ample supply of rock strata capable of providing large primary rock armouring, this type of rock armouring is preferred.

The core of a rubble mound breakwater is commonly constructed by end-tipping progressively from the shore but careful checks are needed against segregation of the rocks which may occur during loading and tipping. A large crane can then travel along the top of the core mount to place the upper core rock to finish the profile and then to place the outer armour layers of rock and/or artificial armour. A floating crane is used in areas where shallow sea conditions are rare. Similarly, the lower part of the core is placed in position from barges [7].

It has been suggested to construct a rubble moulded overtopping break water of length 550 m at Jaigarh head. Materials suitable for the construction of break water are transported from Dabhol through barges. Rocks used for break water are naturally occurring and are of best quality. The rubble mounted break water consists of round head which is constructed with graded rock and concrete acropodes to specified line and level.

![Fig. 3 Offshore dumping process by barge](image)

**Fig. 3 Offshore dumping process by barge**

Before starting the work, a survey (Bathymetry) of the area has been carried out. It is carried out 5 m along the length of breakwater and 5 m apart over the width of breakwater plus 15 m on either side by using DGPS which is connected with the boat travelling in the pre defined path. As per the bathymetry, it has been found that average level at a distance 200 m from the take off point of breakwater was approximately 1m. Therefore it is almost impossible to dump the material (stone) from SHB even in high tide. Laying/dumping of filter require very high degree of accuracy and technique. All tool equipment and marine crafts for carrying out the work has been provided by contractors.

Rocks of various grades transported by the floating crafts (split hopper barges) has been in compliance with the regulation of port and dumped in the pre defined location. After few number of dumping of rocks through barges, an interim survey (bathymetry) is taken. Bathymetry taken after dumping is compared with the before dumping stage. Difference between these two has been reflected in an excel sheet with co-ordinates. If any major deviation is identified, same is rectified by dumping required material till it attains the required level. If in case, the level after dumping the rocks is above the required level, quantity of material meant for transportation is reduced in the subsequent barges till it is ascertained to get required thickness with certain quantity of materials. Actual progress is monitored by taking survey.

It has been suggested that if any small local area requires to be filled to attain the required level, same may be left unattended and later the same may be filled with the core or toe protection. Centre line of break water is marked by placing illuminating buoys for navigational aid. It is preferred to dump bedding material (filter) by split bottom opening barge. After completion of filter layer, dumping core material has been carried out up to +4.00 CD by the split bottom opening barge considering due allowance of draft in offloading condition. Sectioning above -4.00 to -2.00 CD has been carried out by dumping by flat bottom barge during high tide by skip and crane mounted flat bottom barge during low tide. Core above -2.00 to +5.00 CD has been placed by end on method as mentioned earlier. Placing of Armour for toe protection, toe beam has been carried out by crane.

As per the bore log data and visual inspection during low tide, the strata of sea bed from take off up to 200 m along the length of breakwaters is quite rocky. It has been decided to eliminate filter layer for that
particular chainage, i.e. 0 m to 200 m. Apart from carrying out the marine operation of dumping filter material and core materials it has been decided to carry out sectioning from land by end-on method. For sectioning by end on dumping, material of specified grade has been procured from Dabhol. Therefore it is necessary to create an unloading platform at the breakwater. It has been decided that the unloading platform is constructed at chainage 70 to 80 m considering loaded draft of around 3.5 to 4.00 m. Therefore the requirement is approximately 1 lakh T of stones from Dabhol per month. After completing the dumping of core, sectioning of core has been carried out to the line and level by excavators of sufficient capacity mounted over the breakwater.

After completing the sectioning of core, toe protection and toe beam has been carried out by long stick excavator or by SHB or by FTB or by crane and skip bucket, grapple mounted FTB to suit requirement. Placing/profileing of Armour has been commenced only from land by excavator of suitable boom length to the required line and level. Armour stone required for profiling is supplied by crane and skip bucket, grapple mounted FTB and also from land. Placing of accropodes with various grades has been found to be satisfactory.

Accropodes in approved placing are transported by trailer. Crane of capacity 50 T and lifting belt is used for lifting and placing the accropodes over the trailer in strict compliance with all the safety regulation. Accropodes loaded on the trailer are tightly secured to the deck of the trailer and are unloaded near the temporary loading platform.

FTB loaded with accropodes is positioned along side of floating crane. Before placing the accropodes, all the personnel engaged for the operation is trained of the placing of accropodes. Accropodes are placed at the location from the land as well as sea depending on the requirement. Before placing, detailed positioning drawing has been prepared on the basis of approved drawing. Sounding between intermediate layer between the accropodes and armour is taken to ascertain the actual profile of the armour. After finalising the same and based upon that drawing, placing of accropodes is started. A dry placement before the actual placement has been carried out in order to train the placing team and check that material and methodology adopted in placing.

As far as possible, accropodes are placed from the land by the crane having sufficient capacity mounted over the breakwater but wherever it is not possible to place the accropodes from land, they are placed from sea by using floating crane. For placing accropodes from sea, crane barge is positioned at required location anchoring two anchors over the breakwater and two anchors in sea. Flat top barge loaded with accropodes is positioned along side of crane barge and secured. DGPS system with Hy-peck software has been used for placing the accropodes. The receiver of DGPS system is mounted over the top of crane boom which corresponds to the cable location.

During placing of accropodes, every body engaged for placing is vested with safety personnel protective equipments complying with all safety guidelines. The following are the break up of 6.65 lakh T of stones from Dabhol.

<table>
<thead>
<tr>
<th>Stone Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter (0 to 10 kg)</td>
<td>80000 T</td>
</tr>
<tr>
<td>Core Fill (10 to 200 kg)</td>
<td>340000 T</td>
</tr>
<tr>
<td>200 to 300 kg stones</td>
<td>37000 T</td>
</tr>
<tr>
<td>1.00 to 2.00 T</td>
<td>42000 T</td>
</tr>
<tr>
<td>1.5 to 3.00T</td>
<td>75000 T</td>
</tr>
<tr>
<td>2.00 T to 4.00 T</td>
<td>1000 T</td>
</tr>
</tbody>
</table>

The above stones i.e. filter and core fill are dumped below -2.00 CD by using SHB and the balance quantity are placed by using FTB.

2. PROBLEM DEFINITION

The recent focus on infrastructure has given birth to a wave of infrastructure projects. Often such projects run into costly time and budget overruns. These overruns can however be easily reined in through proper logistics management and coordination of various activities.

The aim of the project is to implement lean logistics system in material handling process of breakwater construction for the JSWJPL port development project through a pilot study. Hence the scope is limited to breakwater construction sites which includes optimisation of material handling methods used in breakwater construction.

2.1 Problems in JSWJPL Breakwater Development

- The daily required material rate for breakwater construction is not achieved due to the low loading rate. Only 500 MT of basalt stones has been procured against the required target of 5000 MT per day.
- Due to lack of information sharing among the suppliers and the company, delays in the off shore dumping process has been occurring.
- Stocks of stones are maintained on the platform which costs double for stacking and reclaiming the material from the platform.

3. METHODOLOGY

- Identification and analysis of bottlenecks in the material flow of breakwater construction has been carried out by:
  1. Preparing activity based cycle time chart to track the timely flow of material of basalt stones from Dabhol to Jaigarh stage by stage through time and motion study.
  2. Non value added activities in the material handling process has been analysed by cause and effect diagram to identify the idle times in the material flow process.
- Applied JIT, lean logistics and logistics integration principles in the system by:
  1. Optimising utilisation of available resources by formulating the linear programming model for effective resource utilisation among suppliers.
  2. Better level of information sharing, mutual cooperation between the suppliers and the company has been maintained to deliver the material efficiently using collaborative planning forecasting and replenishment technique.
• Pilot run has been carried out and the results obtained have been compared through cost benefit analysis to know the implication of lean before and after implementation.

• Dumping the stones when the barge approaches the predefined location

• Hydrographical surveying after dumping sufficient quantity of stones.

4. ANALYSIS AND INTERPRETATION

For the construction of breakwater at Jaigarh, quarried stones have been transported from Dabhol to Jaigarh, through sea route by using barges. These barges are either split bottom type or flat top type. The stones have been transported to barge loading area (emergency loading system / temporary loading system) at Dabhol by using the dumpers.

Barges in regular operations are:
1. Split bottom self propelled hoper barge M.V. Dabil of capacity 400 T
2. Split bottom self propelled hoper barge M.V. Dyna of capacity 1500 T
3. Split bottom tug towed hoper barge M.V. Veemzee (SUMO) of capacity 5000 T

In addition to the above, 2 flat top barges of capacity 1000 T each have been used. However 2 tugs are used to handle these two flat top towing barges.

4.1 Material Procurement Steps

• Removal of over burden in the quarry
• Drilling/ Blasting of stones
• Sizing / Storing of stones
• Transporting for barge loading
• Barge loading

4.2 Sequence of Operation by Off Shore Dumping

• Arrival of barge from Dabhol
• Fitting the barge with DGPS apparatus
• Defining the location of dumping
• Maneuvering the barge by using tugs
• Dumping up to -2.00 CD

4.3 Sequence of Operation by End on Dumping

• Arrival of stones from quarry or barge by dumper
• Unloading of stones
• Dozing of stones by dozer
• Positioning the crane with skip bucket of 200T capacity at location is sectioned
• Feeding stones to crane by dumper (end on dumping) or by crane mounted barge (2000 MT capacity) positioning along side break water
• Providing templates for particular type of stones is profiled
• Placing stones over the underneath profiled surface in line with templates

4.4 Sequence of Operation of Sectioning

• Positioning the crane with skip bucket of 200T capacity at location is sectioned
• Feeding stones to crane by dumper (end on dumping) or by crane mounted barge (2000 MT capacity) positioning along side break water
• Providing templates for particular type of stones is profiled
• Placing stones over the underneath profiled surface in line with templates

4.5 Sequence of Operation of Accropodes Placing

• Loading accropodes over the trailer by 100 MT crane
• Shifting accropodes to unloading platform and getting the same loaded over FTB or nearer to crane mounted over the break water
• Transporting the accropodes and getting same anchored/tied near the crane barge
Fitting the DGPS apparatus with crane
• Placing the accropodes at predefined co-ordinates with good interlocking and orientation

In the process, the loading of the barge has been carried out by an excavator which gives 250 MT/hour of loading rate. But with this loading rate the required material procurement rate for the break water construction has not been achieved. Hence, increase in the loading rate to enhance the material flow for the on time completion of the break water construction has been suggested. The time required for each activity in the process has been studied with the help of statements by fact sheet and entering in to the activity based timing chart of the barges to identify the delays in the process. It has been identified that the lack of integration with trading partners is the major cause for the barge delays in offshore dumping process. The idle times’ root cause is as shown in Fig. 4. The average quantity procured per day is as shown in Fig. 5.

Average quantity achieved per day= 500 MT

4.6 Need of Lean Logistics System in Break Water Construction
• Rate of loading the barge through pontoon “Prince 1” has been very low
• Exact amount of the quantity loaded is not given and recorded; due to this, mix up of entire material on the pontoon in barge note
• Excavator of capacity 250 MT/hour has been used for loading the barge which costs about Rs 2000/hour
• As the material is heaped on the pontoon, the excavator has been working for double time, i.e. for stacking, reclamation and loading the barge
• Loading of 5000 MT to large capacity barges became highly impossible
• Hence it has been suggested to complete the under construction end on cantilever loading jetty for loading the big barges by which, with in 6 hours the loading of 5000 MT has been completed by eliminating stock on the platform
• This method saved both time and cost

4.7 Implementation of Lean Logistics Concepts

Initially the loading of the barges has been carried out from a Pontoon (Prince 1) which acted as a temporary loading platform. In order to load the barge from the pontoon, stock on the pontoon has been maintained. This made the excavator to work for more time, the excavator has to work as long as the dumpers ply on the platform i.e. for stacking the material and heaping it on the pontoon and then to load the barge when the barge arrived along side the pontoon. The working time of the excavator has been almost double. More over the quantity of the material over the pontoon gets mixed up and the exact quantity of the stones loaded to the barge are not identified and recorded, so theoretical quantity measurement has been considered which varied to the actual quantity by the difference of about 50 MT for 500 MT barge, so the exact quantity is not monitored in the process, which has become a big issue. Loading big barges from the pontoon has been highly impossible. Hence an end on loading platform has been established for loading the big barges where with in 6 hrs the loading of 5000 MT has been completed by eliminating stock on the platform.

4.8 Implementation of JIT

A temporary loading jetty has been inaugurated in Dabhol for loading of the barges as shown in figure 6.

It is an end on cantilever jetty so that the dumper can directly come over the jetty and dump the material over the cantilever beam which goes in to hopper of the barge.

There is no need to maintain stock of material on the platform as this has been direct dumping by the barges. This eliminated the stock carrying on the pontoon. The dumpers start plying when the barge comes along side of the jetty, until then there is no need of material on the jetty. By this method, large capacity carrying barges like Dyna, Veemzee (SUMO) has been loaded easily compared to loading from pontoon. A weigh bridge has been attached on the jetty so that the dumpers can come on the jetty, weigh the load and can directly dump the stones in to the hoppers of the barges.

Time study for the process is shown in table 1. From this, in 40 minutes 500T of material has been loaded to the barge, which gives 750 MT/hour loading rate. With this loading rate loading 5000T is possible to the big barge with in 6 to 7 hours of time. By adding all the quantities, the exact quantity of the material that has been loaded to the barge is calculated with good accuracy.
**Table 1 Material procurement timing chart**

<table>
<thead>
<tr>
<th>Process</th>
<th>Time in Minutes</th>
<th>Quantity in MT</th>
</tr>
</thead>
<tbody>
<tr>
<td>For loading one dumper to 20T</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>For transportation to jetty</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Tipping time</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Return time of one dumper</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Total time for one dumper</td>
<td>24</td>
<td>20 MT</td>
</tr>
<tr>
<td>For one set of 5 dumpers</td>
<td>20</td>
<td>20*5 = 100</td>
</tr>
<tr>
<td>For second set of 5 dumpers</td>
<td>25</td>
<td>20*5 = 100</td>
</tr>
<tr>
<td>For third set of 5 dumpers</td>
<td>30</td>
<td>20*5 = 100</td>
</tr>
<tr>
<td>For fourth set of 5 dumpers(1st set</td>
<td>35</td>
<td>20*5 = 100</td>
</tr>
<tr>
<td>second trip)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>For fifth set of 5 dumpers(2nd set</td>
<td>40</td>
<td>20*5 = 100</td>
</tr>
<tr>
<td>second trip)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>By 40 minutes 500 MT reaches jetty</td>
<td>40</td>
<td>500 MT</td>
</tr>
<tr>
<td>point @ 25 dumpers</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**5. SOLUTION AND RESULTS DISCUSSION**

Fig. 7 shows the loading rate comparison before and after lean logistics. Cost saving after lean logistics implementation is shown in Table 2.

**Table 2 Cost saving by lean logistics**

<table>
<thead>
<tr>
<th>Process</th>
<th>Before Implementation</th>
<th>After Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavators Deployed</td>
<td>1 No</td>
<td>1 No</td>
</tr>
<tr>
<td>No of working hours per day</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>Hire rate considered Rs 2000 per</td>
<td>2 hours</td>
<td>2 hours</td>
</tr>
<tr>
<td>Total Cost Per Month</td>
<td>2000<em>20</em>30 = 12 lakhs per month</td>
<td>2000<em>20</em>30 = 1.2 lakhs per month</td>
</tr>
</tbody>
</table>

Cost saving by implementing lean logistics: 12 lakhs - 1.2 lakhs = 10.8 Lakhs per month.

Time saving after lean logistics implementation is shown in Table 3.

**Table 3 Time saving by lean logistics**

<table>
<thead>
<tr>
<th>Process</th>
<th>Time required before</th>
<th>Time required after lean logistics implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loading time of barge</td>
<td>22-24 Hrs @ 250MT per Hr</td>
<td>6-7 Hrs @ 750 MT per Hr</td>
</tr>
<tr>
<td>Stock of material on pontoon</td>
<td>400 MT</td>
<td>0 for Big barges and 50 to 100 T for Dabil</td>
</tr>
<tr>
<td>Waiting time of barges for loading</td>
<td>1 Day</td>
<td>No waiting time for Loading</td>
</tr>
<tr>
<td>Waiting @ approach bridge on pontoon</td>
<td>10 Mins for each dumper</td>
<td>0 waiting time @ approach bridge as two Dumpers can Dump the material at a Time and pass out</td>
</tr>
</tbody>
</table>

**REFERENCES**