# Optimization of transport system in cement industry: A Case study in Omid Siman Darab Cement Manufacturing Company

**Mina Salehi[1], Mohammad Ali Soukhakian[1], Mohammad Reza Mozaffari[2]**

[1]Department of Management, Science and Research Branch, Islamic Azad University, Fars, Iran; [2]Department of Mathematics, Science and Research Branch, Islamic Azad University, Fars, Iran

## Abstract

The aim of this research is to study transport system in Darab Siman Omid (cement) manufacturing Company where system optimization is carried out at 3 phases: we have implemented 3 phases of this point for December 2012 through August 2013 .Therefore, 3 phases are explained in the following: At the first phase, with respect to customers' demand and by application of linear planning, quantity of the needed trucks for any route is identified in certain period of time. At the second phase, it is determined by goal programming model and the number of the existing trucks i.e., how many trucks should be allocated to any route. Moreover, at the second phase, quantity of deficiency or surplus of trucks will be obtained for each route within several periods as well and finally at the third phase, the extra trucks, which have been focused on by this method of allocation in the main base, will be allotted to the routes with respect to the shortages of these facilities obtained from the second phase of this problem. Currently, we compare the suggested system with the existing system. The acquired result from this part signifies that the given company should reduce the number of trucks from this system in order not to be compelled to incur their extra costs or it should meet more demands with this quantity of trucks at its disposal.

**Keywords**: Goal programming, Linear programming, Transportation programming, Optimization

## Introduction

The importance of transportation is so high from economic views that some consider it as economic development matrix while some others deem it as backbone for development (Matin, 2007:11). Transportation industry serves as heart of economy for any country. Today this industry possesses a position which even in developed countries anything that causes delay (demurrage) in this sector will also be followed by irrecoverable losses and often economic paralysis for the given nation (Behmardi & Shahriari, 2006). Thus, the necessity of planning for efficiency of transportation has been purposed more than ever and as one of the criteria for development that depends on the rate of effective and optimal utilization from production factors and facilities. By addressing slightly the problems of domestic roads for goods transportation, we may find that transport agencies and companies only suffice to working agency regardless of management principles i.e. planning, organizing, mobilization of sources and facilities, and guiding and control so that this has caused transport corporations, which should provide the needed facilities as transportation directors, have limited their activity only to managing of garage- keeping or agency of shipment and rather than avoidance from planning for transport affairs, they only focus on marketing for receiving cargoes from the goods loading centers (Vahdatifard, 2008, pp.52-59).

In this survey, we try to resolve the above- said problems in transportation system by means of transportation programming, linear programming, and goal programming for this purpose.

## Background of research

Optimization of transportation system in Omid Siman Darab (cement) Manufacturing Company is the main problem in this study so that optimization of this system will be done in 3 phases. We carried out these three phases for the period ranged from December 2012 through August 2013 and 3 phases are as follows:

**Corresponding author:** Mina Salehi, Department of Management, Science and Research Branch, Islamic Azad University, Fars, Iran. Email: mina_salehi333@yahoo.com

At first phase, with respect to customers' demand and by application of linear programming, quantity of the needed trucks for any route is identified in certain period of time. At the second phase, it is determined by goal programming model and with respect to number of the existing trucks that how many trucks to be allocated to any route. Moreover, in the second phase, quantity of deficiency or surplus of trucks will be obtained for each route within several periods as well and finally at third phase the extra trucks, which have been focused by this method of assignment in the main base, will be allotted to the routes with respect to the shortages of these facilities obtained from second phase of this problem.

Now, we compare the suggested system with the existing system.

## Significance of the study

Importance of research subject matter may be interpreted from several perspectives. First attitude is integration of a branch of science with a course of industry so that if we could achieve this goal then we will take a step toward making trend of industrial activities more scientific for which operational methodologies have many capabilities and potentials that are used in solving many existing problems and bottlenecks in various fields of industry that may purpose appropriate strategies in this respect (Jafari Behbahani, 2000, p.12). And finally the last one is the improvement of transportation status and particularly transportation system in OmidSimanDarab (cement) Manufacturing Company and organizing its status quo.

The presence of efficient and appropriate transportation network is one of the paramount infrastructural factors for development in any country in order to meet its transportation requirements. Overall, transportation is implemented for removing various economic, social, military, strategic, accessibility needs etc. if there is no appropriate network proportionally to meet these requirements, these activities will be disrupted and stopped and this leads to spending a lot of costs (Mohammadzadeh, 1999: 126).

## Literature review

In this part, we refer to some of studies that have been conducted regarding transportation and optimization of transportation system.

In an article, Moghiseh et al (2009) studied dynamic optimization of transport of sunflower oil seed cargoes in Iran. This investigation has been carried out by aiming at presentation of a mathematical model of dynamic transport to determine optimal plan for transportation of sunflower oil seeds from production regions and entry points (as supply centers) to oil extraction factories (as consumption centers). The given study was done based on monthly statistics and information and via LINGO software pack and it was the results of execution of the suggested plan that has led to economic saving in cost of sunflower oil seeds transport in the country.

Afandizadeh Zargari et al (2011) presented as essay under title of "Design of transportation network under variable demand condition" in 6th National Congress on Civil Engineering. In this article subject of the quality of effectiveness of demand variations on subject of designing discrete transportation network was explored. For this purpose, the impact of variable demand has been considered as various demand scenarios with certain probability of occurrence and subject of design has been modeled under variable demand conditions in the form of a bi- level (optimization) problem by means of stable optimization which its uncertainty level in this problem is put at disposal of designer and planner of network. The technique of assignment, which has been used, was Frank- Wolfe traffic assignment and genetic algorithm has been adapted to solve the problem of bi- level optimization. By conducting a case study, it was characterized that answer of this problem will strongly depend on uncertainty level that considered in design.

In 4th National Congress on Civil Engineering, Sajadi et al (2011) purposed a model for increasing the efficiency and lowering cost of transportation system. In this study, the main objective was considered as increasing efficiency of organizational manpower along with minimization of costs by means of timetable schedule for workforce in the field of transportation system. Operational methodology was adapted to prepare model in this problem and the given model has been solved by the aid of goal programming.

In an investigation under title of "Linear programming for supply chain design: A case on Novel Protein Foods, Product Design and Quality Management group", Apaiah et al (2003) examined the optimization of pea cargoes shipment in four major producer countries of pea crop and novel protein foods. The results indicated that under optimal condition, it is recommended to transport the produced pea crop in some counties like Netherlands, France, Ukraine, and Canada to conduct the next stages of producing protein foods and through road transport to Ukraine and then to be transferred to Netherlands for processing of novel protein foods after implementation of needed stages via route transport.

Shih LH (1997) in a study reviewed cement transportation by means of linear programming in order to lower cement distribution cost at western part of Taiwan. The results showed that the given transport cost was reduced to 74.1million USD by execution of cement transport plan.

In another study that was done by Milan et al (2003) under title of "Sugarcane transportation in Cuba", they examined the way of lowering cost of sugarcane shipment from production areas to factories by the aid of linear programming. Results of this study indicated that in the case of executing the suggested scenario, shipment cost would be deduced 41893USD per a day.

## Methodology

Given that in the current study, a mathematical techniques have been used for optimization transport costs ,therefore it has quantitative aspect to some extent. The used data have been collected from OmidSimanDarab (cement) Manufacturing Company; as a result, this research is of applied type.

Since the main purpose of this study is transport system optimization and with respect to this fact that in the current survey it is tried to investigate into optimization of transport costs within a certain industry ,therefore this also considered as a field study.

The present study lasted from end of April 2012 to early August 2013 and the related documents, proofs, and report for several months of December in 2012 and also January, February, March, April, and May in 2013 have been utilized as input data.

Omid Siman Darab (cement) Manufacturing Company (OSD Cement Company) was site of this study, which this company is currently active in the field of cement transportation in Southern area of Iran.

## Design of the study

Linear programming, transportation programming, and goal programming may be utilized to optimize transportation system.

In this problem, it is tried to assign the existing trucks in OmidSimanDarab (cement) Manufacturing Company for shipment within different routes during several days of month in order to carry almost all cargoes for customers (especially exporting cargoes). For this purpose, the following steps have been taken:

**First step:** Collection of the needed statistical data and information

**Second step:** Information processing and computation of the necessary parameters

**Third step:** Formulation of problem and model presentation

Now we will explain each of these steps in details.

**First step:** *Collection of the needed statistical data and information*

The needed formation for the next phases will be gathered at this step.

This information includes:

1. *Trip demand*: It means the number of transported cargoes that were carried by trucks of OSD Cement Company. So in order to calculate rate of trip demand, one can use drivers' working schedule and our available information from OSD Cement Company.

**Table 1.Quantity of demand of j- route during time (i) separately based on trucks model**

| | Period no | Chazabeh- Fav Trucks | Chazabeh- FH truck | Chazabeh- Axor trucks | Shalamcheh- Fav trucks | Shalamcheh- FH trucks | Shalamcheh- Axor trucks | Alwaz- Fav trucks | Alwaz- FH truck | Alwaz- Axor trucks | Bandar Abbas- Fav trucks | Bandar Abbas- FH trucks | Bandar Abbas- Axor trucks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Dec 2012 | 2592 | 754 | 2160 | 984 | 156 | 1458 | 48 | 26 | 0 | 336 | 5408 | 108 |
| 2 | Jan 2013 | 1848 | 286 | 945 | 984 | 286 | 1809 | 1968 | 312 | 891 | 816 | 208 | 108 |
| 3 | Feb 2013 | 1944 | 286 | 1431 | 3024 | 390 | 2646 | 912 | 364 | 918 | 2184 | 364 | 1404 |
| 4 | Mar 2013 | 2712 | 494 | 1701 | 1008 | 234 | 1242 | 816 | 130 | 432 | 2928 | 1976 | 108 |
| 5 | Apr 2013 | 2472 | 702 | 1890 | 864 | 208 | 837 | 960 | 286 | 837 | 1272 | 78 | 864 |
| 6 | May 2013 | 4752 | 1456 | 4563 | 1584 | 390 | 1458 | 648 | 156 | 621 | 1392 | 0 | 432 |
| 7 | June 2013 | 2376 | 650 | 2403 | 1680 | 416 | 1188 | 1512 | 260 | 1188 | 2496 | 78 | 1053 |
| 8 | July 2013 | 3840 | 936 | 3051 | 2040 | 390 | 1809 | 1680 | 390 | 1593 | 2424 | 104 | 729 |
| 9 | August 2013 | 2136 | 494 | 1890 | 24 | 0 | 0 | 2088 | 416 | 1350 | 1992 | 364 | 1134 |

2. *Period of trip*: Period of trip is the time for loading the cargo plus the time that a truck is stranded for discharge of cargo (demurrage) as well as the time period needed for a truck in round trip

3. List of several heavy trailer trucks in this company and quantity of each model in the current transport system

4. Capacity of trucks separately based on their models

5. *Variable costs*: These include the costs of fuel, Bill of Lading (B/L) commission charge, and discharge and loading costs, costs of drivers' wage and salary, and charge of buying B/L. To calculate these costs, it requires conducting some computations on financial information that has been taken from OSD Cement Company.

- *Fixed costs*: The fixed costs comprise of salary and wage costs for official personnel; depletion of intangible assets; costs of the consuming tools and instruments and writing; cost of repair and maintenance of heavy weight vehicles as also trucks freight costs so these information should be prepared by financial district of this organization.

- *Income*: It means the revenue that is earned from cargoes shipment and this income may be calculated with respect to the received information from the organization and by means of the formula, which is put at our disposal by financial district. In this part, we do not compute the income that is earned by the returned cargoes and only those cargoes are considered that they have been carried by OSD Cement Company toward one of the 4 given destinations.

- *Trucks Working Schedule*: Working schedule means that how much cargo any truck has transported to destination and to where it was shipped.

**Second step:** *Information processing and computation of the necessary parameters*

At this phase, the needed parameters for the next steps are calculated by computing the collected information.

*Trip demand*: To calculate trip demand, we arrange working schedule separately based on each of routes with respect to work monthly statistics for each of vehicles that have been put by OSD Cement Company at our disposal and then we calculate the quantity of demand for the given route for the aforesaid month by calculating the shipped amount of cargoes in the given route during the addressed route.

With respect to heavy size of information and statistics, we have considered only 4 routes that approximately cover 85% of working volume by the related vehicles of this system for these four routes.

*Period of trip*: To compute trip period, some of time measurement techniques may be employed but due to time- consuming nature of those methods and other constraints, this measures were not feasible. Thus, in order to calculate trip period, some information about mean period of loading and unloading of cargoes as well as period of round trip in each of routes was extracted from drivers and OSD Cement Company and a mean value has been computed for trip time period separately based on each of routes. This period may vary due to some reasons including vehicular breakdown, approaching to destination(s) in holidays by trucks (whereas if a truck arrives at the ports in a holiday when custom house is closed down so unloading and loading of cargoes will not be possible), and being stranded for taking returned cargoes (demurrage). But of course, we have not considered these variations in this study and we assumed that trucks would not have delay and they would do their mission at the predetermined period of time.

**Table 2. Number of round trips by a truck in route (j) within a week**

| LIN(J) Number of round trips by a truck in route (J) within a week | Time period of round trip | Routes | No J |
|---|---|---|---|
| 2 | 3 days | Chazabeh Bay | 1 |
| 2 | 3 days | Shalamcheh | 2 |
| 2 | 3 days | Ahwaz | 3 |
| 3 | 2 days | Bandar Abbas | 4 |

*Variable cost*: Variable costs include fuel costs, B/L commission charge, unloading and loading costs, drivers' wage and salary costs, and B/L purchase fee, so method of calculating each of them will be explained in the following.

*Fuel costs*: To compute this cost, it should be noticed that Axor trucks consume 38lit gasoil per 100km in average; and HF (Volvo) trucks consume 50lit fuel per 100km, and Fav trucks may consume 46lit gasoil per 100km. Now with respect to the route which they should pass through them and their distance, the rate of consumed fuel is obtained. As price of one liter of gasoil is Rls.1500 so by multiplying the rate of consumed fuel to this price the cost of consumed fuel after driving trucks in each of route will be acquired separately. Of course, this point should be considered that the rate of consuming fuel varies with respect to driver's speed, type of road, regulation of vehicular system etc but we have supposed fuel rate as fixed in this study.

*B/L issuance commissioning charge*: First we calculate the product of multiplying transported cargo to its freight in that route per ton and this value may show us gross income. Currently, in order to compute B/L issuance commissioning charge for exported cargoes, we multiply gross income to 7% and if the cargoes are not of exported type, gross income is multiplied to 9% .therefore, commission charge for B/L issuance is obtained.

*Drivers' wage cost*: 20% of gross income

*B/L purchase cost*: B/L purchase cost is Rls.5000. Now, if this figure is multiplied to number of demands then B/L purchase total cost will be obtained.

*Discharge and loading cost*: In average, it requires 3 persons to unload each of cargoes and their average wage for them has been Rls.100000 in 2012 and Rls.150000 in 2013. And these costs are derived by multiplying 3 (persons) to Rls.100000 or Rls.150000 to number of unloaded cargoes.

Total variable cost is acquired by addition of the above- mentioned costs.

*Working period*: Given that planning is done monthly for this company ,therefore monthly working periods have been assumed in this investigation.

**Third step:** *Formulation of problem and model presentation*

This part of problem comprises of 3 phases:

At first phase, with respect to trip demand and by means of linear programming model, needed quantity of trucks for any route is identified during several periods. At the second phase, by the aid of goal programming model and with respect to number of the existing trucks, it is determined how many trucks to be assigned to any route. Moreover, shortage and surplus number of trucks for any route will also obtained for various periods at second phase and finally at third phase extra trucks, which have been concentrated in main base due to this type of assignment, will be allocated to the routes with shortage of trucks derived from the second phase of this problem.

**First phase:** Determining number of the needed trucks for any route to each period

At first phase, we identify number of the needed trucks to each route for several periods with respect to demand and by application of linear programming model.

To determine quantity of the needed trucks to each route for any period, we employ a linear programming model. In this model, there is only one group of variables that are shown by symbol $X$ and based on levels of time period $i$, route of truck $j$ and truck model $k$ is expressed.

Types of the existing trucks in OSD Cement Company transport system which were derived from this company are as follows:

It should be noticed that 85% of demands are studied in this survey and for this reason number of 85% of trucks in this system are given.

**Table 3.Specifications of types of the existing trucks in transport system at OSD Cement Company**

| Quantity in system | Total capacity (tons) | Model | Model no k |
|---|---|---|---|
| 45 | 24 | Fav | 1 |
| 29 | 27 | Axor | 2 |
| 9 | 26 | FH (Volvo) | 3 |
| 83 | | | Total number (N) |

At present, the suggested Assignment Model for the needed number of trucks for any route is presented. Initially, variables of decision- making and its attributes are defined as follows:

$L$: Number of time periods

$m$: Number of the existing routes

$n$: Number of truck models

$x_{ijk}$: Number of the needed trucks for route $j$ during time period $i$ of model $k$

Now the model is defined as following:

$$Min x_0 = \sum_i \sum_j \sum_k C_{ijk} x_{ijk}$$

$$S.t. \quad Time(i) * line(j) * cap(k) * x_{ijk} \le bij \quad \begin{matrix} \forall i = 1,\dots,9 \\ \forall j = 1,\dots,4 \\ \forall k = 1,\dots,3 \end{matrix}$$

$$x_{ijk} \ge 0, \text{integer}$$

Where, the coefficients are defined as follows:

*Time (i)*: Number of the existing weeks during time period *i* (for ease of calculations, we considered number of days per week)

*Line (i)*: Number of round trip by a truck in route *j* within a week

*Cap (k)* $=C_{ijk}$: Capacity of truck model *k*

$b_{ij}$: Trip demand in period *i* within route *j*

Now, by means of LINGO software, which has special facilities and makes it possible to solve the models with great number of variables and with extremely high constraints, the given model is solved. After solving this model, $x_{ijk}$ values, or in other words, number of the needed number of trucks in all routes of system for all periods and from any model *k* will be obtained.

**Table 4.Number of Trucks in route j for period i**

| Number of Trucks in route j for period i | | | |
|---|---|---|---|
| 8 | n53 | 24 | n11 |
| 8 | n54 | 12 | n12 |
| 29 | n61 | 2 | n13 |
| 15 | n62 | 18 | n24 |
| 7 | n63 | 14 | n21 |
| 6 | n64 | 15 | n22 |
| 15 | n71 | 15 | n23 |
| 14 | n72 | 5 | n24 |
| 14 | n73 | 15 | n31 |
| 11 | n74 | 27 | n32 |
| 24 | n81 | 10 | n33 |
| 19 | n82 | 13 | n34 |
| 16 | n83 | 23 | n41 |
| 11 | n84 | 12 | n42 |
| 20 | n91 | 7 | n43 |
| 1 | n92 | 15 | n44 |
| 17 | n93 | 22 | n51 |
| 12 | n94 | 9 | n52 |

**Second phase:** Determination of quantity of fixed and extra trucks and their shortage in route lines for any period

At the second phase, by means of goal programming model and with respect to quantity of the existing trucks, it is determined how many trucks may be assigned for each route line for any period and also number of lack and surplus trucks is also obtained during several periods.

Type of trucks is also derived at first step but only number of the needed trucks is necessary for each period at second step. Thus, it is assumed that:

$$n_{pq}=\sum_k x_{ijk}$$

As it implied before, to purpose this problem, 2-D goal programming method is used. We define biased variables as follows:

$d^+_{ij}$: Over- achievement of goal from target limit for assignment of the needed number of trucks to route *j* in period *i*

(Namely, number of assigned trucks to route *j* in period *i* that exceeds from the needed quantity of trucks)

$d^-_{ij}$ : Under achievement of goal from target limit for assignment of the needed number of trucks to route *j* in period *i*

(Namely, number of assigned trucks to route *j* in period *i* are less than the needed quantity of trucks)

And finally, it is variable of problem decision making:

$x_j$ Number of assigned trucks to route j (fixed trucks in route j)

The presented model is as follows:

$$\min\ x_0=\sum_i\sum_j(d^+_{ij}+d^-_{ij})$$

$$S.t.$$

$$x_j-(d^+_{ij}-d^-_{ij})=n_{ij} \qquad \forall i=1,\ldots,9 \quad \forall j=1,\ldots,4$$

$$d^+_{ij}-d^-_{ij}\le 0$$

$$\sum_{i=1}^{m} n_j\le N$$

Total number of the active exiting trucks in the system

$$d^+_{ij}\ge d^-_{ij}o\ge x_j 0\ge 0$$

After solving this goal programming model by means of LINGO software, quantity of fixed trucks and also shortage and surplus of trucks are identified to any route for each period.

**Third Phase:** Way of supporting from extra buses

With respect to the current demand of organization, it does not require implementation of third phase.

1. All trucks have been assigned to the work and there is no extra truck

2. Rate of shortage was only seen in 3 cases, therefore it may be ignored.

## Comparison among the suggested system and the current system

With respect to first phase, number of the needed trucks which are derived for each period, is given in the following table.

Table 5.Number of the needed vehicles

| Number of needed vehicles | Time period |
|---|---|
| 56 | 1 |
| 49 | 2 |
| 67 | 3 |
| 55 | 4 |
| 49 | 5 |
| 76 | 6 |
| 64 | 7 |
| 79 | 8 |
| 50 | 9 |

The maximum number of needed vehicles is 79 while currently 83 trucks are active in this system. To lower costs and increase profit, we should estimate rate of further demands or to decrease number of vehicles to 79. We have reviewed table of current profit- and- loss and table of profit-and-loss in the event when number of vehicles is reduced to 79 and we concluded that this company has not acquire profit in the current stage ,therefore by implementation of the suggested system, we could reduce corporative loss up to Rls.1’654’200’000.

## Conclusions

As it inferred from title of the conducted study, the main purpose of the current investigation is to carry out research on optimization of transport system in cement manufacturing industry.

By solving the model, we conclude that one of the reasons for increasing cost in this system is that with respect to the current rate of demand, number of existing trucks in this system is more than the needed quantity of trucks for this system and this has caused increasing costs of truck freight, repair, and maintenance etc further. The company should exit some of trucks from transportation system so that not to be compelled to incur costs for extra trucks in this system or it may meet the further demands by employing this quantity of trucks, which are put at its disposal.

The other finding derived from this study suggests that if it is decided to reduce number of trucks, it is better to reduce number of fixed trucks from the route that has the maximum extra trucks instead of reducing quantity of truck of other routes. And at the same time, if it is stipulated to add to the number of trucks, therefore it is recommended to add this number of trucks to the route, which suffers from maximum shortage of trucks.

Over the time it is possible to exert some changes in this schedule (reducing or increasing of demands). The presented algorithm may be followed up only by data variation in this planning at any time and new results to be interpreted and explored. Thus, this algorithm has made it possible to update information and data.

## Suggestions

1) With respect to the given results and given that of 4 studied routes, 3 belonged to cities situated at Iranian border where there are several imported cargoes that should be transported to other parts of the country from these boundary towns; thus, it is better for trucks in this system to receive returned cargoes in order to cover and compensate some part of vehicles’ costs with respect to returning route at the time of returning so that the acquired income could cover some of these costs.

2) It should be requested from Darab Cement Company to deliver more cargoes to OSD Cement Company since number of trucks, which are currently active in this system is more than what needed for this company and or this measure is not feasible, it is better to return extra trucks to the respected company.

3) Research model may be employed for other transport agencies by a little change.

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