Scientific Journal of Impact Factor (SJIF): 4.72

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 4, Issue 4, April -2017

Cost Saving in Transportation of Various Construction Materials by Using Operational Research Method

Deep Chetanbhai Patel[1], JayrajVinodsinh Solanki[2]

[1] M. tech Student Civil(CEM), U.V. Patel College of Engineering, Kherva, Mehsana, Gujarat, India
[2] Assistant Professor, Civil Engineering Department, U.V. Patel College of Engineering, Kherva, Mehsana, Gujarat, India

Abstract *– The transportation method is an important method of the linear programming problem. In India, the construction industry is the second largest industry where various construction materials are being used. This industry wants a solution for transportation problems with inventory control, managing of fund, and resolving disputes of scheduling production over different time periods for construction materials by using the transportation model. In this paper, the research has been done on three different construction materials (Brick, Cement and Steel). There are two main objectives behind this study. (1) To reduce the cost of transportation &maximize the profit by giving low rate materials to the end users(customers) in this competitive world. (2) To make optimal transportation schedule of materials which helps to minimize transportation cost. The data of three different construction materials have been collected over a 6-month period.The data analysis has been done by Excel Solver which solves transportation model and reduce the transportation cost of these materials.After the analysis concluded that the ultimate transportation cost saving of Bricks, Cement and Steel is 4.55%, 39.6% and 20.9% respectively.*

Keywords *– Brick, Cement, Steel, Supply, Demand, Excel Solver*

I. INTRODUCTION

The name 'Operational Research' was derived directly from research activity on operational area of the armed force in a war. After war, the industries adopted operational research. In the 1990s, operational problem well-structured used to handle management problems. The methodology of operational research consists of (i)define the problem, (ii)formulate the model/framework, (iii)input the data, (iv)solution of model/framework, (v)model validation, (vi)implementation. Linear programming is a powerful operational research technique which helps to solve allocation problem.

The transportation problem in linear programming is one of the most important and effective application of quantitative analysis for solving business problems which is related to products distribution.The distribution of products which is produced in various factories or various warehouses to different markets where they are required that is problems to almost every organization. The transportation method is concerned with the transportation of products from different sources to different destinations and deal with suitable data like capacity of various sources, requirement at the destination and the cost of transportation along each route. Transportation cost must be considered as a prime factor affecting total cost of product which is approximately 10% (Dr. Jean-Paul Rodrigue, 1998). A research done by World Bank showed that the country with highest logistics cost in the world is none other than India. In a developing country, there costs are 6% to 8% of the total value of goods. The transportation cost is estimated at 10% of total cost of products in China, the cost of logistics in India is 14% of the total cost of products (PIANC Magazine, February 2007). In 1941, the solving method of transportation problem was first proposed by Hitchcock. Koopmans in 1949 and Dantzig in 1951 further developed this problem. Transportation problem deals with the difficulty of how to plan manufacture of products and transportation from manufacture plants at different locations to larger figure of consumers at different location. Transportation problem is a logistical problem for organizations which provide transport service and manufacturing products. This method is a useful tool in process of allocating problem and decision-making in organizations. This thesis work mainly concerns with optimizing the transportation cost of different products and give optimized transportation schedule program.

A transportation problem is like this. The manufacturer of AC Company has three plants A, B and C which are located at different places. The customers are located in three regions X, Y and Z where the products deliver. Also, assume that the demands of the three places equal to the capacity of different plants per unit time periods and the cost of transportation of each product for shipping from origin points to destinations is given and constant. Basically, the company deals with the problem which aims to find the best methodology to achieve the demand and supply of products and to decrease in transportation cost. In other words, they have to decide as to how many AC should be supplied from plant A to X, Y and Z, from plant B to X, Y and Z and from plant C to X, Y and Z with a minimum cost. The place where the products are manufactured that is called the source and the place where products are supplied that is called the destination.

@IJAERD-2017, All rights Reserved

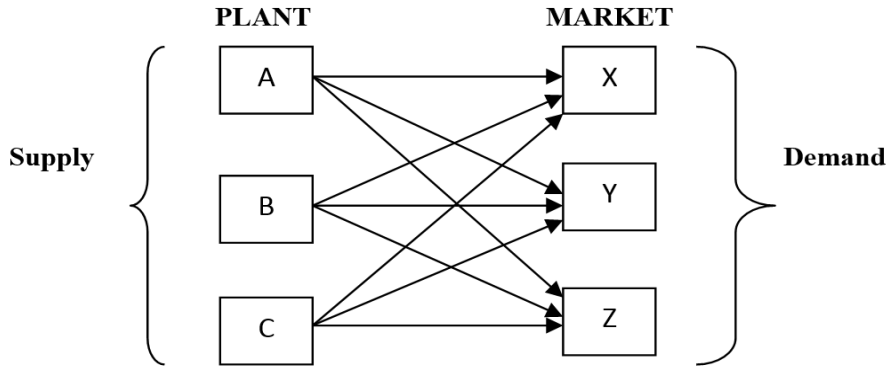


Figure 1. The model of transportation problem

- **The transportation problem can be started mathematically as follows:**

Let a_i= quantity of product available at origin point i
b_j= quantity of product necessary at destination point j
c_{ij} = the cost of delivery one unit of product from origin i to destination j
x_{ij}= the quantity of products shipped from origin i to destination j

Assume that $\sum^{m}_{i=1} a_i = \sum^{n}_{j=1} b_j$ which means that the total quantity existing at the start points is equal to the total amount needed at the destination point.

The problem can be started as a linear programming problem as:
Minimise: Total cost $Z = \sum^{m}_{i=1}\sum^{n}_{j=1} c_{ij}x_{ij}$
Subjected to $\sum^{n}_{j=1} x_{ij} = a_i$, for $i = 1, 2\ldots, m$
$\sum^{m}_{i=1} x_{ij} = b_j$, for $j = 1,2\ldots, n$
$x_{ij} \geq 0$ for $i = 1, 2\ldots, m$ and
for $j = 1,2\ldots, n$

- **The transportation model can also be managed in tabular form by means of transportation tableau**

Table 1. Transportation tableau

Origins(i)	Destination(j)							Supply,a_i
	1		2		….	n		
1	c_{11}	x_{11}	c_{12}	x_{12}	….	c_{1n}	x_{1n}	a_1
2	c_{21}	x_{21}	c_{22}	x_{22}	….	c_{2n}	x_{2n}	a_2
….	….		….		….	….		….
m	c_{m1}	x_{m1}	c_{m2}	x_{m2}	….	c_{mn}	x_{mn}	a_m
Demand, b_j	b_1		b_2		….	b_n		$\sum^{n}_{i=1} a_i = \sum^{m}_{j=1}$

- **Types of transportation model**

There are two types of transportation model

(1) Balanced transportation model: When total number of supply is equal to total number of demand, a transportation model is said to be balanced.

(2) Unbalanced transportation model: When total number of supply is not equal to total number of demand, a transportation model is said to be unbalanced.

- **Basic feasible solution:** Any solution $x_{ij} \geq 0$ is said to be a feasible solution of transportation problem if it satisfies the constraints.The feasible solution is said to be basic feasible solution when the number of positive allocations is equal to (m+n-1) while satisfying all column and row requirement.

@IJAERD-2017, All rights Reserved

- **Optimal solution:** Whena feasible solution of transportation problem minimizes the total transportation cost, it is said to be optimal.

- **The detail working of transportation method**
  The transportation method involves the following three steps:

  Step 1: **Obtaining the initial feasible solution**
  The initial feasible solution can be obtained by some methods. There are used North-West Corner (NWC) Rules, Least Cost Model (LCM) and Vogel's Approximation Method (VAM).

  Step 2: The optimality testing
  After receiving the initial basic feasible solution, the second step is to test that this solution is optimal or not. Two methods are used for testing the optimality of initial feasible solution. One of these is called Stepping Stone Method in which check optimality test is applied by calculating the opportunity cost of each empty cell. The other method is called Modified Distribution Method (MODI). It is easy to apply and more efficient than the Stepping Stone Method. Both methods can be applied only when the problem has the initial feasible solution.

  Step 3: **Improving the solution**
  After applying either of the methods, if the solution is found to be optimal, then the process finishes as the problem is solved. The problem is reconsider and improved basic feasible solution is achieved when it is non-optimal. This is done by replacing a non-basic variable for a basic variable. Re-arrangement is made by transferring units from an occupied cell to an empty cell which has the largest opportunity cost. Then adjust the units in other related cells in a way that all the requirements are satisfied.

II. LITERATURE REVIEW

Literature review has been done by referring various textbooks, reference books, research papers, and construction journals. Form literature review, there is new proposed method to find an initial basic feasible solution of transportation problem which is known as Allocation Table Method (ATM). This method will help to achieve the objective of originations which would like to maximize their profit by minimizing the transportation cost. Zero Suffix Method and Improved Zero Suffix Method provide an optimal solution in fewer iterations for the transportation problems. TOCM-SUM Approach is very easy to understand and provides better result in comparison to the existing methods.In one paper, the optimal solution was obtainedby Zero Suffix Method forfirst problem and NWCM and NMD methods are optimum for second problem. So, they cannot be depended on one particular method as they give the best optimum method because the reliability condition may change. BCM and NMD are also given closest optimum solution for transportation problem.

III. DATA COLLECTION

The primary objective of the study is to make optimal transportation schedule of materials which helps to minimize transportation cost. To achieve this objective, data of three different construction materials (Brick, Cement and Steel) like date wise details of the quantity of materials which were supplied to a particular site, number of trips, the distance between source to destination and transportation cost have been collected. Transportation cost has been calculated by actual cost occurred and by applying transportation model. Hence the study aims to reduce the cost and maximize the profit of transportation of construction materials by using operational research method. The Data has been collected through personal interview and from record sheets of plant.

Methodology of Data Collection

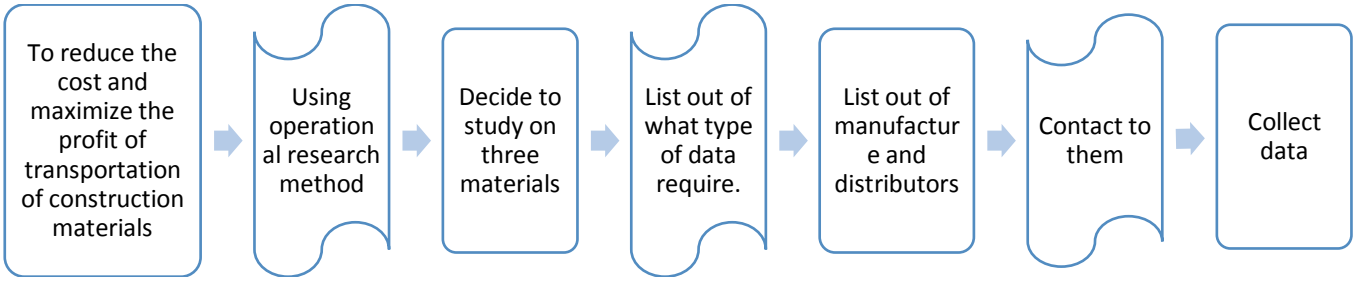


Figure 2.Data collection methodology

@IJAERD-2017, All rights Reserved

BRICK - The data of brick have been collected from 1st August, 2016 to 15th February, 2017.

Table 2.Data collection of Brick

Date	Site Name	Source	Distance (Km)	No. of trucks	Quantity of Bricks in Each Truck	No. of trucks	Quantity of Bricks in Each Truck	Total no of bricks	Transportation Cost (Rs)
01-08-16	Government Colony	P1	13	2	4000			8000	2600
	Utsav Elegance	P2	23	2	4000			8000	4600
	Maruti Amrakunj 2	P2	4.2	2	4000			8000	840
	Om Shanti Bungalows	P1	19.3	1	4000			4000	1930
….	….	….	….	….	….	….	….	….	….

CEMENT - The data of cement have been collected from 1st August, 2016 to 15th January, 2017.

Table 3. Data collection of Cement

Date	Destination	Source	No. of Bags	Weight (Tonne)	Distance (Km)	Transportation Cost (Rs)
01-08-16	VaibhavBunglows	S2	160	8	43.1	1379
	Rajvi Palace	S2	220	9	42.3	1523
	Government Colony	S1	340	17	15.8	1074
02-08-16	120-Men Barack - BSF	S2	260	13	19.7	1024
….	….	….	….	….	….	….

STEEL - The data of steel have been collected from 1st August, 2016 to 31th January, 2017.

Table 4. Data collection of Steel

Date	Destination	Source	Distance (Km)	Weight (Tonne)	Transportation Cost (Rs)
01-08-16	K.R. Square	G2	3	8.452	152
05-08-16	Shah & Mehta Company	G2	14	9.658	811
08-08-16	Shree Krupa Trader	G2	21.8	10.63	1390
10-08-16	Sai Chemical	G3	11.4	4.564	312
….	….	….	….	….	….

@IJAERD-2017, All rights Reserved

IV. DATA ANALYSIS

The collected data of three different materials have been analysed. Data analysis can be analysed by different methods like North-West Corner Method, Least Cost Method, Vogel's Approximation Method, Modi Method and Stepping Stone Method. Here, the data analysis has been done by Excel Solver which solves transportation model. The Excel Solver helped to reduce the transportation cost of construction materials.

Methodology for Data Analysis

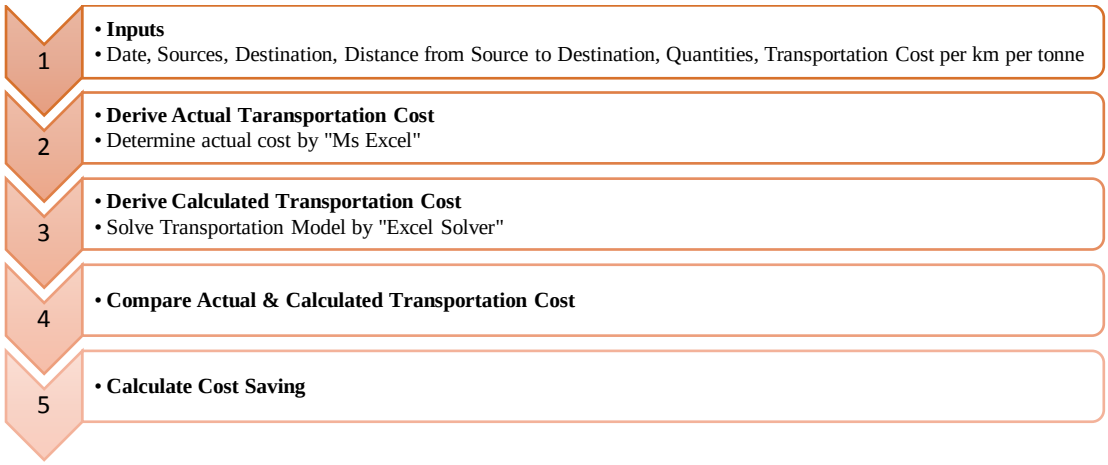


Figure 3. Data analysis methodology

Calculated Cost

The transportation cost is derived from transportation model. The calculated transportation cost has been computed in "Excel Solver" and results are listed for each day in Ms Excel. Here, one example has been taken from "Quantitative Techniques for Management by Levin, Krehbiel, Berenson, Render, Stair and Hanna – PEARSON" for better understanding.

Example - Transportation Table for XYZ Company. Find the minimum transportation cost and optimum transportation schedule by "EXCEL SOLVER"

	Warehouse at Surat	Warehouse at Kolkata	Warehouse at Lucknow	Factory Capacity
New Delhi Factory	Rs 50	Rs 40	Rs 30	100
Patna Factory	Rs 80	Rs 40	Rs 30	300
Hyderabad Factory	Rs 90	Rs 70	Rs 50	300
Warehouse Requirements	300	200	200	700

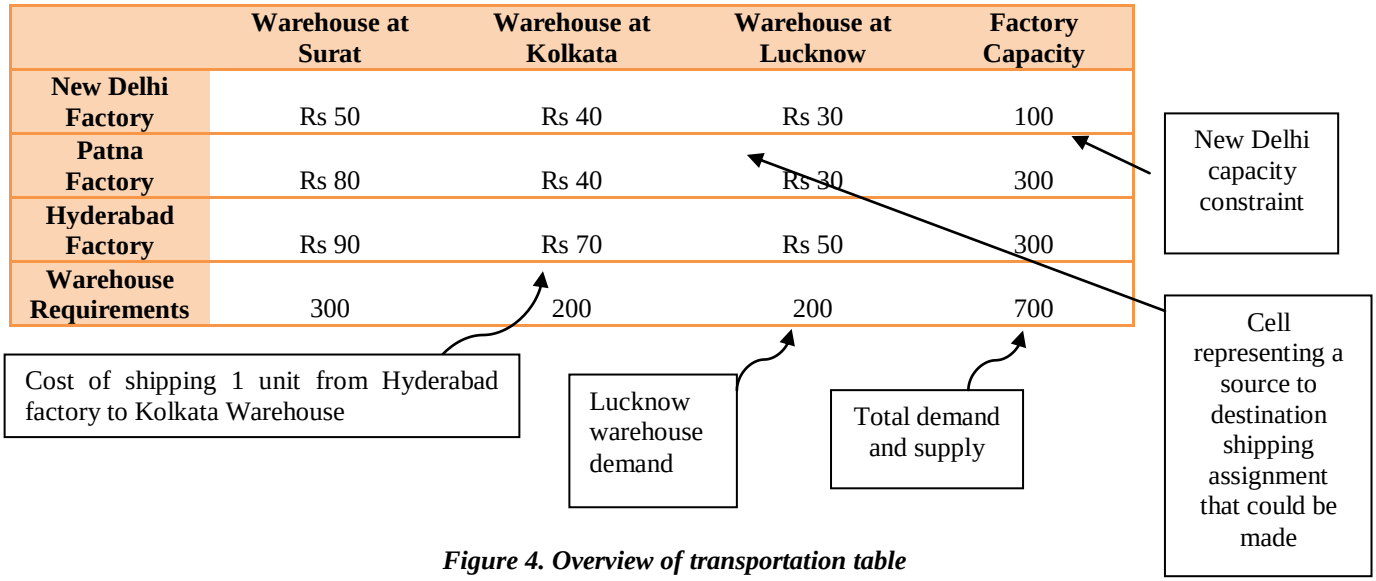


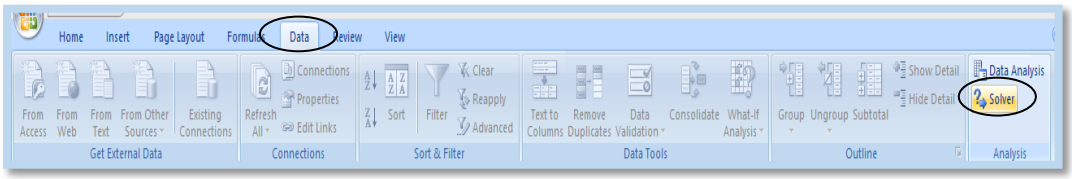
Figure 4. Overview of transportation table

@IJAERD-2017, All rights Reserved

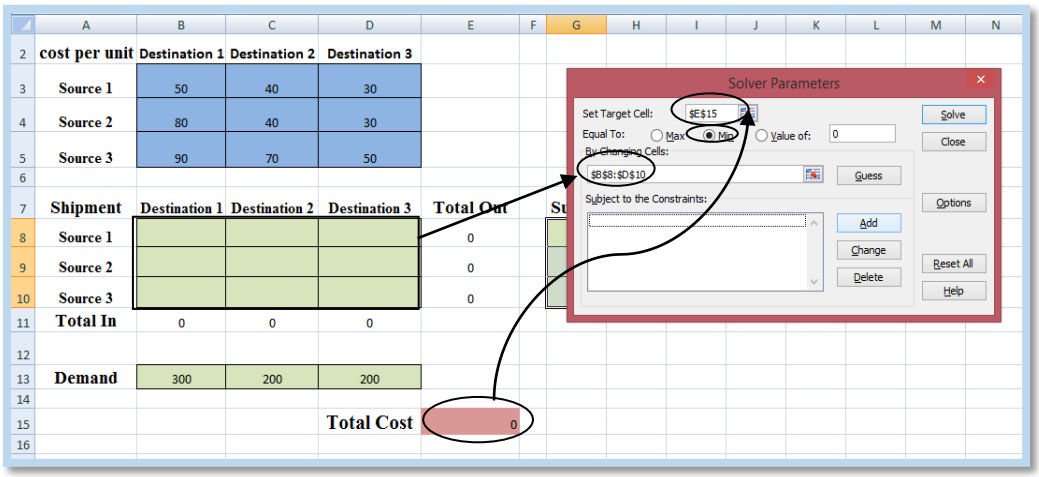
Step 1: Enter data in excel sheet

	A	B	C	D	E	F	G
2	**cost per unit**	**Destination 1**	**Destination 2**	**Destination 3**			
3	**Source 1**	50	40	30			
4	**Source 2**	80	40	30			
5	**Source 3**	90	70	50			
6							
7	**Shipment**	**Destination 1**	**Destination 2**	**Destination 3**	**Total Out**		**Supply**
8	**Source 1**				=SUM(B8:D8)		100
9	**Source 2**				=SUM(B9:D9)		300
10	**Source 3**				=SUM(B10:D10)		300
11	**Total In**	=SUM(B8:B10)	=SUM(C8:C10)	=SUM(D8:D10)			
12							
13	**Demand**	300	200	200			
14							
15				**Total Cost**	=SUMPRODUCT(B3:D5,B8:D10)		
16							

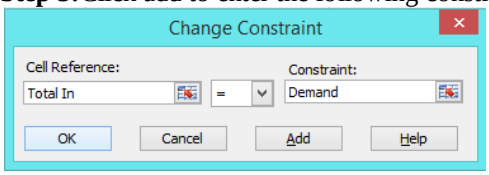
Step 2: On the Data tab, click Solver

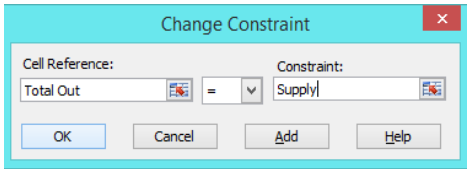


Note – Cannot find the solver button? Open word option and click here to load the solver add-in.



Step 3: Click add to enter the following constraint

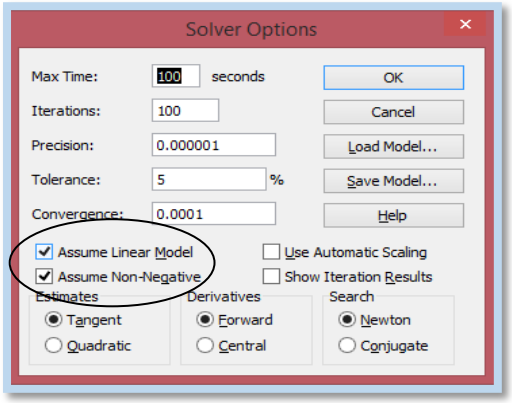




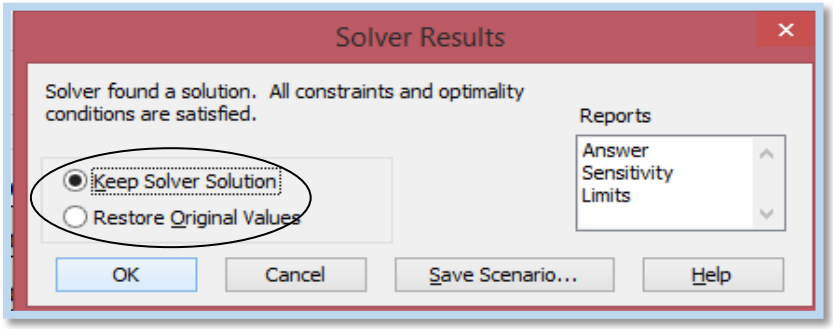
Note – If Demand > Supply, Total In ≤ Demand
If Supply > Demand, Total Out ≤ Supply

@IJAERD-2017, All rights Reserved

Step 4: Go to option and select linear model &non-negative



Step 5: Click solve



Result –

cost per unit	Destination 1	Destination 2	Destination 3		
Source 1	50	40	30		
Source 2	80	40	30		
Source 3	90	70	50		
Shipment	**Destination 1**	**Destination 2**	**Destination 3**	**Total Out**	**Supply**
Source 1	100	0	0	100	100
Source 2	0	200	100	300	300
Source 3	200	0	100	300	300
Total In	300	200	200		
Demand	300	200	200		
			Total Cost	39000	

Conclusion - It is optimal to ship 100 units from Delhi to Surat, 200 units from Hyderabad to Surat, 200 units from Patna to Kolkata, 100 units from Patna to Lucknow and 100 units from Hyderabad to Lucknow. This solution gives the minimum cost of 39000. All constraints are satisfied.

There are cost savings in transportation of bricks, cement and steel. There are some details such as date, actual cost, and calculated cost and cost savingin the table. The Calculated cost is derived by Excel solver.

@IJAERD-2017, All rights Reserved

COST SAVING IN TRANSPORTATION OF BRICKS

BRICK

cost per unit	Government Colony	Utsav Elegance	S.G Business Hub	Maruti Amrakunj 2	Upvan Villa	Om Shanti Bungalows	Sambhavnath Upvan	Malabar County 2
P1	325	375	392.5	790	435	482.5	597.5	532.5
P2	620	575	480	105	867.5	912.5	387.5	357.5

Shipment	Government Colony	Utsav Elegance	S.G Business Hub	Maruti Amrakunj 2	Upvan Villa	Om Shanti Bungalows	Sambhavnath Upvan	Malabar County 2	TOTAL OUT	SUPPLY
P1	16	4	0	0	0	0	0	0	20	35
P2	0	0	0	8	0	0	8	4.00E+00	20	30
Total In	16	4	0	8	0	0	8	4		
DEMAND	16	4	0	8	0	0	8	4		
TOTAL COST	12070									

Figure 5. Excel Solver screenshot for Brick

Table 5. Data analysis of Brick

Sr. No	Date	Actual Cost(Rs)	Calculated Cost(Rs)	Cost Saving (Rs)
….	….	….	….	….
15	16-08-16	12050	10450	1600
16	17-08-16	8640	8640	0
17	18-08-16	11810	9947.5	1862.5
….	….	….	….	….

COST SAVING IN TRANSPORTATION OF CEMENT

CEMENT

cost per unit	Vaibhav Bunglows	Rajvi	120-Men Barack - BSF	Happy Height	Shiv Infra	Shubh Vastu	Gov. Colony
S1	139.6	127.2	188	96.4	512	42.8	63.2
S2	172.4	169.2	78.8	334.8	287.2	281.2	301.6
S3	852	872	972	860	1296	916	876

Shipment	Vaibhav	rajvi	120	happy height	shiv infra	shubh vastu	gov. colony	TOTAL OUT	SUPPLY
S1	0	0	0	11	0	0	6	17	17
S2	0	0	0	0	0	0	7	7	17
S3	0	0	0	0	0	0	0	0	17
Total In	0	0	0	11	0	0	13		
DEMAND	0	0	0	11	0	0	13		
TOTAL COST	3550.8								

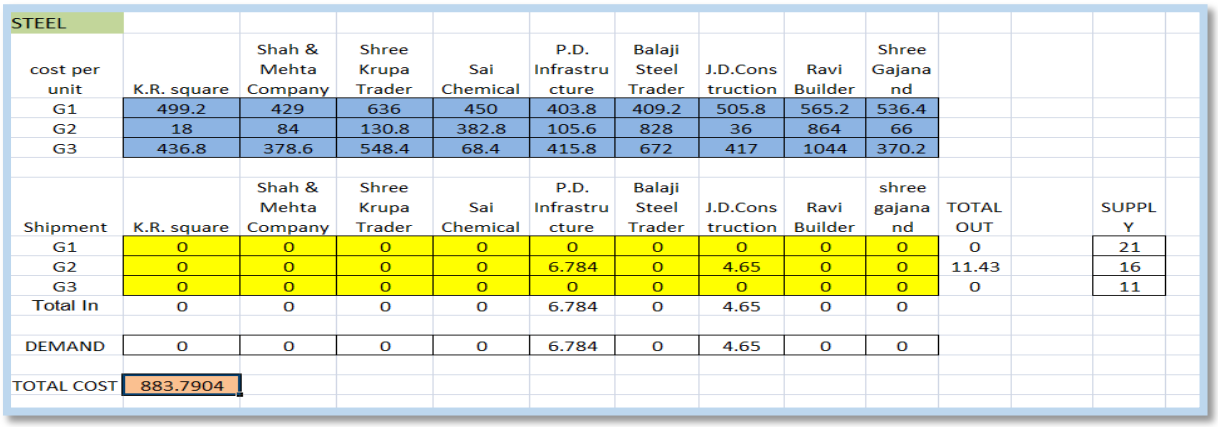
Figure 6. Excel Solver screenshot for Cement

Table 6. Data analysis of Cement

Sr. No	Date	Actual Cost(Rs)	Calculated Cost(Rs)	Cost Saving (Rs)
….	….	….	….	….
24	29-08-16	4981	3551	1430
25	30-08-16	1436	1436	0
26	02-09-16	9460	1060	8400
…	….	….	….	….

@IJAERD-2017, All rights Reserved

COST SAVING IN TRANSPORTATION OF STEEL



STEEL

cost per unit	K.R. square	Shah & Mehta Company	Shree Krupa Trader	Sai Chemical	P.D. Infrastructure	Balaji Steel Trader	J.D.Construction	Ravi Builder	Shree Gajanand
G1	499.2	429	636	450	403.8	409.2	505.8	565.2	536.4
G2	18	84	130.8	382.8	105.6	828	36	864	66
G3	436.8	378.6	548.4	68.4	415.8	672	417	1044	370.2

Shipment	K.R. square	Shah & Mehta Company	Shree Krupa Trader	Sai Chemical	P.D. Infrastructure	Balaji Steel Trader	J.D.Construction	Ravi Builder	shree gajanand	TOTAL OUT	SUPPLY
G1	0	0	0	0	0	0	0	0	0	0	21
G2	0	0	0	0	6.784	0	4.65	0	0	11.43	16
G3	0	0	0	0	0	0	0	0	0	0	11
Total In	0	0	0	0	6.784	0	4.65	0	0		
DEMAND	0	0	0	0	6.784	0	4.65	0	0		

TOTAL COST 883.7904

Figure 7. Excel Solver screenshot for Steel

Table 7. Data analysis of Brick

Sr. No	Date	Actual Cost(Rs)	Calculated Cost(Rs)	Cost Saving (Rs)
….	….	….	….	….
6	15-08-16	6048	5048	1000
7	16-08-16	3877	860	3017
8	19-08-16	243	243	0
….	….	….	….	….

V. CONCLUSION

In the highly competitive market that we are in today, usually organizations want to deliver products to the consumers in a cost-effective way and to make the product market competitive. The mentioned transportation model provides a potent structure to determine the best ways to deliver goods to the consumer to overcome this challenge. Analysis was carried out on three different construction materials (Bricks, Cement and Steel). This model helps in saving cost of transportation of Bricks, Cement and Steel by Rs93249, Rs188980 and Rs53590 respectively. The ultimate transportation cost saving is 4.55%, 39.6% and 20.9% respectively which is evident from the table below. Thus, it will help in achieving the goal to those who want to maximize their profit by minimizing the transportation cost.

Table 8. Cost saving of three materials (Brick, Cement and Steel)

Sr.No.	Material	Actual Cost (Rs)	Calculated Cost (Rs)	Cost Saving (Rs)	Cost Saving (%)
1	**BRICKS**	2049000	1955751	93249	**4.55**
2	**CEMENT**	476703	287723	188980	**39.6**
3	**STEEL**	256301	202711	53590	**20.9**

VI. FUTURE SCOPE

Other methods can be used to solve transportation problem of same construction materials. The different operational research methods can be also used in the areas of production scheduling, labour scheduling, transportation & shipping of any materials and in any other industries.

@IJAERD-2017, All rights Reserved

VII. REFERANCES

[1] Abdallah A. Hlayel, Mohammad A. Alia, "Solving Transportation Problems Using the Best Candidates Method", Computer Science & Engineering: An International Journal (CSEIJ), Vol. 2, Issue 5, pp. 23-30, October 2012.
[2] Aminur Rahman Khan, Adrian Vilcu, Nahid Sultana, Syed Sabbir Ahmed, "Determination of Initial Basic Feasible Solution of a Transportation Problem: a TOCM-SUM Approach, Research Gate, March 2015.
[3] DrS.Kumaraguru, Mr. B. Satheesh Kumar, MrsM.Revathy, "Comparative Study of Various Methods for Solving Transportation Problem", International Journal of Scientific Research (IJSR), Vol. 3, Issue 3, pp. 244-246, September 2014.
[4] Hlayel Abdallah Ahmad, "The Best Candidates Method for Solving Optimization Problems", Journal of Computer Science, Vol. 8, Issue 5, pp. 711-715, May 2012.
[5] Moh'dIshaq Abu Halawa, Abdelsalam M. Maatuk, Heba Saleh Idrees, EmanHusen Ali, "An Optimal Solution for Transportation Problem Using Computing Modelling", IEEE, 2016.
[6] Mohammad Kamrul Hasan, "Direct Methods for Finding Optimal Solution of a Transportation Problem are not Always Reliable", International Refereed Journal of Engineering and Science (IRJES), Vol. 1, Issue 2, pp. 46-52, October 2012.
[7] MollahMesbahuddin Ahmed, Aminur Rahman Khan, Md. Sharif Uddin, Faruque Ahmed" A New Approach to Solve Transportation Problems", Scientific Research Publishing, Vol.5, pp.22–30, March 2016.
[8] N. M. Deshmukh, "An Innovative Method for Solving Transportation Problem", International Journal of Physics and Mathematical Sciences, Vol. 2, Issue 3, pp.86-91, July-September 2012.
[9] Reena G Patel, P. H. Bhathwala, "The Advance Method for the Optimum Solution of a Transportation Problem", International Journal of Science and Research (IJSR), Vol. 4, Issue 10, October 2015.
[10] S.Sudha, Dr.D.Vanisri, "Finding an Optimal Solution of an Assignment Problem by Improved Zero Suffix Method", International Journal for Research in Applied Science & Engineering Technology (IJRASET),Vol.3, Issue 11, pp 502-507, November 2015.

@IJAERD-2017, All rights Reserved