Warehouse layout selection using PROMETHEE II method

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ABSTRACT

This paper deals with the warehouse layout optimization problem with respect to the distance reduction and the travel time minimization. We also searched for a flexible tool in order to optimize layout functionally to the fluctuations in demand and inventory level. ALDEP (Automated layout design program) algorithm has been developed and a system for the effective optimization of each department in the warehouse is presented. The ware house locations are selected and they are ranked according to the priority using AHP(Analytical Hierarchy process) and PROMETHEE method. Using AHP method certain results have been sorted out, and PROMETHEE method brings out the best results than AHP.

INTRODUCTION

WAREHOUSE MANAGEMENT SYSTEM (WMS)

Warehouse Management System (WMS) have been available since the earliest computer systems were introduced and it allowed simple storage location functionality. From then on, it kept on improving until what it is today. Today WMS systems can be either standalone or as a part of an Enterprise Resource Planning (ERP) system. WMS can be coupled together with other complex technologies such as Radio Frequency Identification (RFID) and voice recognition. However, the basic principle of the WMS has remained the same, to provide information which allows efficient control of the materials movement within the warehouse.

Implementation of WMS is often complicated. Project planning is critical to the success of WMS implementation. It requires warehouse resources to collect data on the physical warehouse, materials, inventories as well as defining the strategies required to operate the warehouse. Adding to the challenge is to implementing the system while the warehouse is still in operation.

The complexity of WMS implementation varies with different businesses. Data on the physical dimensions and characteristics of each item in the warehouse are required to be collected and entered into the WMS system. The physical size and weight of the items are to be calculated, can the items be stored separately, can it be stacked, all this information are to be fed into the WMS system correctly. Hazardous material information needs to be collected so that the item is not stored in certain areas. This information is only part of the requirements of the WMS implementation.

WMS system requires decisions or configuration to be made on how items are to be placed or removed from the system, in what order, for what types of materials and what methods of placement and removal should be used. The implementation requires significant input from the resources that operate the warehouse on a day to day basis and this can be a strain on warehouse operations. A successful project will recognize this fact and ensure that the key personnel required for the implementation are

given adequate back up so that warehouse operations do not suffer.

After the successful launch of the WMS system, many businesses will find that the resources required to operate the system is greater than prior to the implementation. This is primarily due to the data intensive nature of the software and the fact that warehouses are in a state of flux; racks are moved, placement and removal strategies changed, new items added, new processes developed. Warehouse accuracy is paramount for the software to operate and to do this data will need to be entered accurately and in a timely fashion. Although most WMS implementations will reduce labor costs in the placement and removal of materials, there is often an added warehouse management function required just to operate the software.

LITERATURE REVIEW

Ashayeri and Gelders (1985) addressed aggregate design issues using the entry-order-quantity rule and proposed an optimal model for warehouse design. Rosenwein (1994)applied cluster analysis, based on the measure of similarity, to locate items within a warehouse. His result showed the potential benefits of the approach. Dichtl and Beeskow (1980) applied multidimensional scaling method for allocating commodities in a warehouse. The practical approach to storage systems design problems mainly considers the criteria of where stock items are to be located and how they should be arranged in the distribution Centre. Wilson (1977) suggested the use of order quantity and product popularity criteria for determining the location of stock items within a distribution Centre. Ballou (1999) pointed out that the design of stock location can be based on complimentarily, compatibility, popularity, and size criteria. Heskeett (1963)combined popularity and size criteria into a cubic-per-order index and applied for warehouse design. KallinaandLynn(1976) showed that the cubic-per-order index rule can help better stock location. Malmborg and Krishna Kumar (1988) modified the cubic-per-order index for designing conventional warehouse with dual command controls. Joseph, Roll and Rosenblatt (1980) applied facility layout technique as well as some stock location policies for internal layout design of a warehouse. Davies et al. (1983) compared four stock location strategies, including alphanumeric placement, fast and often placement, frequency placement, and selection density factor placement. Their results showed that selection density factor placement produced the lowest average distance and

time per picking trip. The selection density factor is the ratio of selections per year to the required storage volume in cubic feet. Rosenblatt and Roll (1984) utilized several stock location policies for warehouse design. Harmatuck(1976) compared two approaches for the design of stock location and concluded that the stock location using at throughput-based approach performed better. Francis et al.(1992) considered four storage location policies, that is dedicated storage, randomized storage, class-based dedicated storage, and shared storage, for determining the assignment of items to storage locations. Due to the dynamic nature of customer demand in most local distribution centers, the class-based dedicated storage policy might provide better design for stock location. Goetshalckx and Ratliff (1990) proposed shared storage policy based on the duration of stay for stock location problems. The shared storage can recognized and take advantage of the inherent differences in lengths of time that individual items remain in storage. A number of mathematical models for storage layout and order picking operations problems can be found in literature. Francis et al. (1992) presented some mathematical models for determining the size of the storage system and assigning items to storage locations. Ballou (1967) formulated a linear programming model to similar problem involving reserve storage and order picking areas. Marlette and Francis (1972) applied a generalized assignment model to optimal facility layout considering the material-handling cost. Jarvis and McDowell (1991) developed a stochastic model for locating products in an order picking warehouse. Malmborg and Deutch (1988) constructed a stock location model in which the inventory level and cost were considered. Liu (1999) presented clustering model and developed a closed-form solution for improving stock location and picking operations for distribution center. Their results showed that the use of clustering techniques as well as mathematical models involving stock location and order picking problems is quite promising. However, further efforts should be concerned with the investigation of adequate mathematical programming models that can integrate factors related to the dynamic nature of customer order demand, the configuration of picking area, and the dynamic product flow. Due to the advent of information technology, the questions related to the subject of storage layout problems can be resolved by the applications of simulation technique .Dangelmaier and Bachers (1986) developed a simulation system for material flow and warehouse design using a simulation software package, SIMULAP. Liu (1999) constructed a simulation model using a visual interactive modeling system, WITNESS, for evaluating stock location policies in a distribution centre.

Although simulation technique can apply for planning storage layout and order picking in a warehouse, this method is limited to account for the dynamic nature of customer order demand and to optimize the stock location. Hence, the entry-order-quantity rule, heuristic-based optimization technique, computer simulation method, and application development tools should be integrated. The integration of the entry-order-quantity rule, heuristic-based optimization technique, computer simulation software, and application development tools might constitute a dynamic stock layout system for design planning and provides a useful tool for decision-makers.

PROBLEM IDENTIFICATION:

There are different types of warehouses. We have chosen automobile warehouse and collected its layout information. The layout is designed using the ALDEP method. (Automated Layout Design Program).Warehouse facilitates the easy availability of goods at the point of consumption. In international business, the location of warehouse is very critical. An exporter must locate his warehouse very strategically in order to meet his various objectives. AHP (Analytical Hierarchy Process) is a comprehensive structured frame work. It is used for selecting the warehouses by comparing the various departments in it. PROMETHEE is also used to select the best warehouse like AHP but it gives the best result compared to Analytical Hierarchy Process.

Methodology and Calculation

We have used three methodologies to optimize and selecting the location for warehouse. They are,

- ALDEP (AUTOMATED LAYOUT DESIGN PROCEDURE)
- AHP (ANALYTICAL HIERARCHY PROCESS)
- PROMETHEE METHOD

AUTOMATIC LAYOUT DESIGN PROCEDURE

 AUTOMATED LAYOUT DESIGN PROGRAM (ALDEP)

Now we will examine Automated Layout Design Program (ALDEP).

ALDEP is basically a construction algorithm but it can also be used to evaluate two layouts. The algorithm uses basic data on facilities and builds a layout by successively placing the layout using relationship information between the departments. The basic inputs to ALDEP are:

1. Length and width of facility.
2. Area of each department.
3. Minimum closeness preference (MCP) value.
4. Sweep width.
5. Relationship chart showing the closeness rating.
6. Location and size of any restricted area.

The procedures adopted for using ALDEP are:

Step 1: Input the following:

1. Length and width of facility.
2. Area of each department.
3. Minimum closeness preference (MCP) value.
4. Sweep width.
5. Relationship chart showing the closeness rating.
6. Location and size of restricted area.

Step 2: One department is selected randomly and placed in the layout.

Step 3: In this step, the algorithm uses minimum closeness required between departments for the selection of departments to be placed with an earlier placed department. Select the department having maximum closeness rating. If there is no department having minimum closeness preference then any department that remains to be placed is selected.

Step 4: If all the departments are placed in the layout, go to step 5. Else, go to step 3.

Step 5: Compute the total score of the layout.

Step 6: If the total score required is the acceptable score, then go to step 7, else go to step 2.

Step 7: Print the current layout and the corresponding score.

Layout specification

1. Truck waiting area	=75m*15m
	=1125sq.m
2. Storage Area	=134.4m*110m
	=14,740sq.m

3. Dock   = 400sq.m

4. Mau shilling area   =72m*18m

     =1296sq.m

5. Workshop area   =18m*18m

     =324sq.m

6. Preliminary Treatment Area

     =240sq.m

7. Truck Path   =20m*110m

     =2,200sq.m

8. Truck loading area   =15m*134m

     =2010sq.m

9. Total A   =22335sq.m

TABLE 1: LAYOUT REQUIREMENTS

DEPARTMENT	AREA (sq.)	NO OF UNIT SQUARES
1	1125	11
2	14740	147
3	400	4
4	1296	13
5	324	3
6	240	2
7	2200	22
8	2010	20
TOTAL	22335	223

Assume one square in the layout to be equal to 100 sq. ft.

Number of unit squares for a department = dept. area in sq. ft/area per square.

Let the size of layout be 16 × 14, and the sweep width be 2 (this means that we will fill 2 columns simultaneously).

TABLE 2: RELATIONSHIP CHART

DEPARTMENT	1	2	3	4	5	6	7	8
1	-	A	O	I	I	O	U	I
2	U	-	I	A	I	U	O	E
3	U	O	-	U	I	O	U	O
4	O	A	I	-	U	U	O	I
5	X	U	O	O	-	O	X	O
6	X	U	O	O	O	-	X	O
7	I	O	A	I	I	O	-	I
8	O	O	I	I	O	O	I	-

In ALDEP the closeness rating uses the following notations with the following values:

TABLE 3: Chosen closeness rating

Absolutely necessary	A	64
Especially important	E	16
Important	1	4
Ordinary	O	1
Unimportant	U	0
Undesirable	X	−1024

Randomly select the first department in the layout. Place the first department in the upper left corner and extend it downward. Width of the extension is determined by the sweep width. The next department begins where the previous department ended and follows the serpentine sweep pattern (shown in figure below)
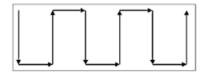
Sweep pattern

Let department to be selected. Number of unit squares in department to be 147. Now, 147 square units are filled in 16 × 14 grids as shown in figure

2	2	2	2	2	2	2	2	2	2				
2	2	2	2	2	2	2	2	2	2				
2	2	2	2	2	2	2	2	2	2				
2	2	2	2	2	2	2	2	2	2				
2	2	2	2	2	2	2	2	2	2				
2	2	2	2	2	2	2	2	2	2				
2	2	2	2	2	2	2	2	2	2				
2	2	2	2	2	2	2	2	2	2				
2	2	2	2	2	2	2	2	2	2				
2	2	2	2	2	2	2	2	2	2				
2	2	2	2	2	2	2	2	2	2	2			
2	2	2	2	2	2	2	2	2	2	2	2		
2	2	2	2	2	2	2	2	2	2	2	2		
2	2	2	2	2	2	2	2	2	2	2	2		

Since the minimum closeness between departments required for selection of departments is A =64, scan the relationship chart randomly to find the departments having closeness rating of 4 or greater with department 2. For the above case closeness rating for the pair (2-4) = 64, (2–8) = 16, (2–-5) = 4 and (2–7) = 1.

Select department 4 and place next to department 2. Place department 4 in the layout in a serpentine pattern as shown in the figure below. Placing department in the layout.

2	2	2	2	2	2	2	2	2	2				
2	2	2	2	2	2	2	2	2	2				
2	2	2	2	2	2	2	2	2	2				
2	2	2	2	2	2	2	2	2	2				
2	2	2	2	2	2	2	2	2	2	4	4		
2	2	2	2	2	2	2	2	2	2	4	4		
2	2	2	2	2	2	2	2	2	2	4	4		
2	2	2	2	2	2	2	2	2	2	4	4		
2	2	2	2	2	2	2	2	2	2	4	4		
2	2	2	2	2	2	2	2	2	2	4	4		
2	2	2	2	2	2	2	2	2	2	2	4		
2	2	2	2	2	2	2	2	2	2	2	2		
2	2	2	2	2	2	2	2	2	2	2	2		
2	2	2	2	2	2	2	2	2	2	2	2		

the above procedure to get the final layout as shown in figure below. Final layout after the final layout is obtained, the score is calculated. The score is the sum of the closeness rating of all the neighboring departments as shown in the table below.

2	2	2	2	2	2	2	2	2	2	8	8	8	8		
2	2	2	2	2	2	2	2	2	2	8	8	8	8	6	6
2	2	2	2	2	2	2	2	2	2	8	8	8	8	1	1
2	2	2	2	2	2	2	2	2	2	8	8	8	8	1	1
2	2	2	2	2	2	2	2	2	2	4	4	8	8	1	1
2	2	2	2	2	2	2	2	2	2	4	4	8	8	1	1
2	2	2	2	2	2	2	2	2	2	4	4	3	3	1	1
2	2	2	2	2	2	2	2	2	2	4	4	3	3	7	1
2	2	2	2	2	2	2	2	2	2	4	4	5	5	7	7
2	2	2	2	2	2	2	2	2	2	4	4	5	7	7	7
2	2	2	2	2	2	2	2	2	2	2	4	7	7	7	7
2	2	2	2	2	2	2	2	2	2	2	2	7	7	7	7
2	2	2	2	2	2	2	2	2	2	2	2	7	7	7	7
2	2	2	2	2	2	2	2	2	2	2	2	7	7	7	7

TABLE 4: CLOSENESS RATING

DEPARTMENT PAIR	CLOSENESS RATING
(2,4)	64
(2,8)	16
(2,7)	1
(4,8)	4
(4,3)	4
(4,7)	1
(8,3)	4
(8,1)	1
(8,6)	1
(3,7)	0
(3,5)	4
(7,1)	1
(7,5)	4
(1,3)	1
(1,6)	1
TOTAL	107

From the above, the layout score is 2 × 107 = 214

Analytical Hierarchy Process(AHP)

It is another way to structure decision problem and is used to prioritize alternatives and to build an additive value function. Also it attempts to mirror human decision process, which is easy to use. AHP is the most often used method and it is more familiar. It can be used for multiple decision makers which is c=very controversial..

THE AHP IS BASED ON THREE PRINCIPLES:

-Decomposition of the decision problem

-Comparative judgment of the elements

-Synthesis of the priorities

PROCEDURE:

STEP 1

-Structure the decision problem in a hierarchy

STEP2:

-Comparison of the alternatives based on the criteria.

STEP 3:

-Synthesis the comparison to get the priorities of the alternatives with respect to each criterion and the weights of each criterion with respect to the goal.

-Local priorities are then multiplied by the weights of the respective criterion

-The results are summed up to produce the overall priority of each alternative.

CRITERIA:

-Transportation cost

-Near to market

-Nearer to dealer

-Availability of skilled labor

-Availability of Raw material.

Table 5: 1-9 scale

Intensity of Importance	Definition
1	Equal Importance
3	Moderate Importance
5	Strong Importance
7	Very Strong importance
9	Extreme importance

Table 6: CALCULATION

L1	ENNORE	9
L2	PORUR	3
L3	AMBATTUR	7
L4	THIRUPORUR	5
L5	TAMBARAM	1

PAIR WISE COMPARISON: TRANSPORT

	L1	L2	L3	L4	L5
L1	1	3	1.28	1.8	9
L2	0.33	1	0.42	0.6	3
L3	0.77	2.33	1	1.4	7
L4	0.55	1.66	0.71	1	5
L5	0.11	0.33	0.14	0.2	1

We have chosen L1,L2,L3,L4,L5 as the following and also we have ranked them accordingly,

Table 7:TRANSPORTATION

	L1	L2	L3	L4	L5	AVG
L1	0.362	0.36	0.360	0.36	0.36	0.360
L2	0.119	0.12	0.119	0.120	0.12	0.119
L3	0.278	0.28	0.28	0.28	0.28	0.279
L4	0.199	0.199	0.2	0.2	0.2	0.199
L5	0.039	0.03	0.039	0.04	0.04	0.229

Table 8: PAIRWISE COMPARISON: RAW MATERIAL

L1	ENNORE	9
L2	PORUR	5
L3	AMBATTUR	7
L4	THIRUPORUR	3
L5	TAMBARAM	1

We have chosen L1,L2,L3,L4,L5 as the following and also we have ranked them accordingly,

Table 9

	L1	L2	L3	L4	L5
L1	1	1.8	1.28	3	9
L2	0.55	1	0.71	1.66	5
L3	O.77	1.4	1	2.33	7
L4	0.33	0.6	0.42	1	3
L5	0.11	0.2	0.14	0.33	1

Table 10: RAW MATERIAL

	L1	**L2**	**L3**	**L4**	**L5**	**AVG**
L1	O.362	O.36	O.3	0.36	0.36	0.360
L2	0.199	0.2	0.2	0.199	0.2	0.199
L3	0.278	0.28	0.281	0.28	0.28	0.279
L4	0.119	0.12	0.118	0.120	0.12	0.119
L5	0.039	1	0.039	0.03	0.04	0.229

L1	ENNORE	1
L2	PORUR	3
L3	AMBATTUR	9
L4	THIRUPORUR	7
L5	TAMBARAM	5

L1	ENNORE	9
L2	PORUR	5
L3	AMBATTUR	7
L4	THIRUPORUR	3
L5	TAMBARAM	1
5		

Table 11:PAIR WISE COMPARISON : NEAREST TO DEALER

We have chosen L1,L2,L3,L4,L5 as the following and also we have ranked them accordingly,

Table 12:

	L1	L2	L3	L4	L5
L1	1	3	1.28	1.8	9
L2	0.33	1	0.42	0.6	3
L3	0.77	2.33	1	1.4	7
L4	0.55	1.66	0.714	1	5
L5	0.11	0.33	0.14	0.2	1

Table 13: NEAREST TO DEALER

	L1	L2	L3	L4	L5	AVG
L1	O.362	O.36	O.3	0.36	0.36	0.360
L2	0.119	0.12	0.118	0.120	0.12	0.119
L3	0.278	0.28	0.281	0.28	0.28	0.279
L4	0.199	0.2	0.2	0.199	0.2	0.199
L5	0.039	1	0.039	0.03	0.04	0.229

Table 14:PAIRWISE COMPARISON : SKILLED LABOUR

We have chosen L1,L2,L3,L4,L5 as the following and also we have ranked them accordingly,

Table 15:

	L1	L2	L3	L4	L5
L1	1	0.11	0.33	0.2	0.14
L2	9	1	3	1.8	1.28
L3	3	0.33	1	0.6	0.42
L4	5	0.55	1.66	1	0.71
L5	7	0.77	2.33	1.4	1

Table 16: SKILLED LABOUR

	L1	L2	L3	L4	L5	AVG
L1	0.039	1	0.039	0.03	0.04	0.229
L2	0.119	0.12	0.118	0.120	0.12	0.119
L3	O.362	O.36	O.3	0.36	0.36	0.360
L4	0.278	0.28	0.281	0.28	0.28	0.279
L5	0.199	0.2	0.2	0.199	0.2	0.199

Table 17: PAIR WISE COMPARISON: NEARER TO MARKET

We have chosen TC, RM, ND, SL, NM as the following and also we have ranked them accordingly,

L1	ENNORE	1
L2	PORUR	9
L3	AMBATTUR	3
L4	THIRUPORUR	5
L5	TAMBARAM	7

Table 21:

TC	TRANSPORTATION COST	1
RM	RAW MATERIAL	5
ND	NEAREST TO DEALER	7
SL	SKILLED LABOUR	3
NM	NEAREST TO MATERIAL	9

We have chosen L1,L2,L3,L4,L5 as the following and also we have ranked them accordingly,

Table 18 :

	L1	L2	L3	L4	L5
L1	1	0.11	0.33	0.2	0.14
L2	9	1	3	1.8	1.28
L3	3	0.33	1	0.6	0.42
L4	5	0.55	1.66	1	0.71
L5	7	0.77	2.33	1.4	1

Table 19: NEAREST TO MARKET:

	L1	L2	L3	L4	L5	AVG
L1	0.039	1	0.039	0.03	0.04	0.229
L2	O.362	O.36	O.3	0.36	0.36	0.360
L3	0.119	0.12	0.118	0.120	0.12	0.119
L4	0.199	0.2	0.2	0.199	0.2	0.199
L5	0.278	0.28	0.281	0.28	0.28	0.279

Table 22: PAIR WISE COMPARISON FOR EACH CRITERIA:

	TC	RM	ND	SL	NM	AVG
TC	0.04	0.04	0.039	0.039	0.039	0.039
RM	0.2	0.2	0.2	0.199	0.199	0.199
ND	0.28	0.28	0.281	0.278	0.280	0.279
SL	0.36	0.36	0.360	0.362	0.360	0.360
NM	0.12	0.12	0.11	0.119	0.120	O.117

Table 20: WEIGHTAGE OF EACH CRITERIA

	TC	RM	ND	SL	NM
TC	1	0.2	0.14	0.11	0.33
RM	5	1	0.71	0.55	1.66
ND	7	1.4	1	0.77	2.33
SL	9	1.8	1.28	1	3
NM	3	0.6	0.42	0.33	1

RATING, WEIGHTAGEAND RANKING OF THE PROJECT USING AHP METHOD:

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0.360	0.360	0.360	0.229	0.229
0.119	0.119	0.119	0.119	0.119
0.279	0.279	0.279	0.360	0.119
0.119	0.119	0.119	0.279	0.119
0.229	0.229	0.229	0.119	0.279

0.039
0.119
0.279
0.360
0.117

=

0.293
0.135
0.284
0.199
0.146

LOCATION RANKING

1) ENNORE
2) AMBATTUR
3) THIRUPORUR
4) TAMBARAM
5) PORUR

PROMETHEE METHOD

PROMETHEE methodology, a Multi Criteria Decision Making (MCDM) technique, was first developed in 1982 by J.P. Brans (Brans and Mareschal, 2005). This methodology includes various types such as PROMETHEE I (partial ranking), PROMETHEE II (complete ranking) and PROMETHEE III (ranking based on intervals) applied in different conditions for different purposes. According to Brans and Marshal (2005), a large number of fields such as Banking, Manpower planning, Industrial Location, Investments, Water resources, Medicine, Chemistry, Health care, Tourism, Ethics in OR and Dynamic management have successfully applied the PROMETHEE methodology.

They have emphasized that mathematical properties and friendliness of use are the reasons of success of the methodology. The PROMETHEE II, which ranks alternatives completely, requires very clear information for both the analysts and the decision-makers. These information include decision making matrix that contains decision maker's trade-offs data between alternatives in any criterion, weights (relative importance) of the criteria and preference functions. The PROMETHEE methodology prefers and prioritizes alternatives based on pair wise

comparisons. In other words, the deviation between the evaluations of two alternatives on a particular criterion is specified. Preference functions convert this deviation to a number between 0 and 1 and present the preference of decision maker between alternatives in each criterion .The larger the number, the higher the preference. Brans and Mareschal (2005) have proposed six types of preference functions. Decision maker can employ either these preference functions or his own arbitrary preference function CALCULATION

The objective and subjective information regarding different location selection criteria are given in table 1. The objective values for these criteria are assigned from an 11 point scale. The five selection criteria as considered here to affect the location selection decision are Transportation cost (TC), Availability of raw materials (RM) ,Nearest to dealer (ND) , Availability of skilled labor (SL) and Nearest to market (NM).

TABLE 23: INFORMATION FOR FACILITY LOCATION ALTERNATIVES:

	TC	RM	ND	SL	NM
L1	Exp.L	EH	Exp.H	EL	Exp.L
L2	L	A	L	L	EH
L3	VL	H	H	Exp.H	L
L4	AA	L	A	VH	AA
L5	Exp.H	Exp.H	Exp.L	A	VH

Rij = [Xij – min (Xij)] / [max (Xij)-min (Xij)]

Rij =   [0.045 - 0.045]/ [0.955 – 0.045] =0

TABLE 24: POINT FUZZY SCALE

LINGUISTIC TERM	CRISP SCORE
EXCEPTIONALLY LOW	0.045
EXTREMELY LOW	0.135
VERY LOW	0.255
LOW	0.335
BELOW AVERAGE	0.410
AVERAGE	0.500
ABOVE AVERAGE	0.590
HIGH	0.665
VERY HIGH	0.745
EXTREMELY HIGH	0.865
EXCEPTIONALLY HIGH	0.955

Table 27:PREFERENCE FUNCTIONS FOR ALL THE PAIRS OF ALTERNATIVES

	TC	RM	ND	NM	AL
P1,P2	0	0	0.267	0	0
P1,P3	0	0	0	0	0
P1,P4	0	0	0.066	0	0
P1,P5	0	0	0.82	1	0
P2,P1	0.414	0.266	0	0.292	1
P2,P3	0.184	0	0	0	0.647
P2,P4	0.414	0.266	0	0	0.455
P2,P5	0.44	0	0.355	0	0.147
P3,P1	0.230	0.552	0.123	1	0.353
P3,P2	0	0.286	0.39	0.707	0
P3,P4	0.230	0.552	0.189	0.257	0
P3,P5	0.230	0	0.743	0.555	0
P4,P1	0	0	0	0.743	0.545
P4,P2	0	0	0.202	0.45	0
P4,P3	0	0	0	0	0.192
P4,P5	0	0	0.554	0.298	0
P5,P1	0	1	0	0.445	0.853
P5,P2	0	0.743	0	0.152	0
P5,P3	0	0.448	0	0	0.5
P5,P4	0	1	0	0	0.308

TABLE 25: OBJECTIVE DATA FOR FACILITY LOCATION SELECTION PROBLEM

	TC	RM	ND	SL	RM
L1	0.045	0.955	0.865	0.135	0.045
L2	0.335	0.500	0.335	0.335	0.865
L3	0.255	0.665	0.665	0.955	O.335
L4	0.590	0.335	0.500	0.745	0.590
L5	0.955	0.955	0.045	0.500	0.745

Preference function is adopted here:
P j(i,i)= 0 if Rij≤Rij (3)
P j(i,i)= (Rij– Rij) if Rij>Rij
For (ex) take P1, P2:
0 – 0.316 = -0.316
(Therefore the output is 0, as negative sign has come)

Table 27:AGGREGATED PREFERENCE FUNCTIONS:

	L1	**L2**	**L3**	**L4**	**L5**
L1	-	O.O748	0	0.0185	0.532
L2	0.2927	-	0.083	0.1227	0.1327
L3	0.6237	0.422	-	0.265	O.415
L4	0.332	0.2193	0.221	-	0.154
L5	0.315	0.201	0.1478	0.898	-

TABLE 26: NORMALISED DECISION MATRIX

	TC	RM	ND	SL	NM
L1	0	1	1	0	0
L2	0.316	0.266	.353	.243	1
L3	0.230	0.532	0.756	1	0.353
L4	0.598	0	0.554	0.743	.664
L5	1	1	1	0.445	0.853

FORMULA TO FIND NORMALISED DECSION MATRIX:

Formula

π(i , i′)= [∑ Wj X Pj (i , I′)] / ∑ Wj

=0.039x0 + 0.199x0 + 0.279x0.267 + 0.360x0 + 0.117x0

=0.0748.

Table 28: LEAVING AND ENTRY FLOW OF DIFFERENT LOCATIONS:

Table 29: NET OUTRANKING FLOW VALUES OF DIFFERENT LOCATION ALTERNATIVES

LOCATION	NET WORKING FLOW	RANK
Ambattur	0.3688	1
Tambaram	0.081	2
Ennore	-0.0654	3
Porur	-0.0703	4
Thiruporur	-0.146	5

CONCLUSION:

Location selection decision has long-term implications because changing the locations of the existing facilities may be quite expensive. It is therefore important to select the most appropriate location for a given industrial warehouse which will minimize the cost over an extended time period efficiently. The cited real time industrial example demonstrates the computational process of the Analytical Hierarchy Process (AHP) and PROMETHEE method which will be applied to other strategic decision-making problems. Using these two methods, we have sorted out the best locations for setting up a warehouse.

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LOCATI-ONS	LEAVING FLOW	ENTERING FLOW	DIFFERENCE
P1	0.3246	-0.390	-0.0654
P2	0.1589	-0.2292	-0.0703
P3	0.432	0.0632	0.3688
P4	0.181	-327	-0.146
P5	0.390	-0.309	0.081

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