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Optimum Selection of concrete Batch Plant (CBP) Location Model Using Analytic Network Process

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ABSTRACT: *The selection of optimum location for concrete batch plant (CBP) became very important problem that needs a right decision to avoid many difficulties and problems may results due to select wrong location. For that we can use the analytic network process (ANP) in decision making process. The ANP is more generalized than the analytic hierarchy process (AHP).*
This paper shows a form of questionnaire to identifying the factors affecting CBP location to deal with it or to construct a new batch plant after sending it to expert engineers and workers.
The ANP model presents the framework criteria and available alternatives ad feedback which can help to choose the best alternative.
KEYWORDS: Site Selection, Concrete Batch Plant, Optimization, AHP, ANP, Feedback Structure, Super Decision Software.

NOMENCLATURE

RMC	Ready Mix Concrete
CBP	Concrete Batch Plant
AHP	Analytical Hierarchy Process
DFSS	Design-for-six-sigma
ANP	Analytic Network Process

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I. INTRODUCTION

The concrete batch plant is very important and became an element help the companies to success in its project which it provide high quality of RMC and the mixing process under fully controlled through computerized environment. There are table present examples of strength and weaknesses points in batch plants the affecting on the concrete. As shown in **table 1**

Table 1: The Weakness and Strength Points of CBP

STRENGTH POINTS			WEAKNESS POINTS:		
Reduce the rate of errors in the mixing ratios of the concrete components and the method of mixing them in the site, thus providing the stations with more precise mixtures.	A team of specialized engineers supervises the mixing of concrete from the receipt of raw materials to the delivery of the mixtures..	Concrete is followed after loading and pre-casting, and concrete samples supplied with certified inspection certificates are taken	Some stations are very far from the site and therefore the time to move from the concrete mixing plant to the site is very important and you may need to use additives for the mixtures.	The roads leading from and to the site must be paved and able to carry the heavy weights of the Arab women in addition to the load	Quantity and quality of admixture added to the concrete mix is very important. This is because the Limited time interval between mixing and curing Admixtures can be adjusted for that time period.

The "Selection" of optimum location for batch plants needs more works to optimize this location, for the importance of this process and that will need to spend more time and efforts to study all the available alternatives and identifying the all criteria and sub – criteria can be affected on the decision making process about which alternative is preferred.

The ANP also introduced by Saaty, is a generalization of the AHP (Saaty, 1996).ANP allows for complex interrelationships among decision levels and attributes. The ANP feedback approach replaces hierarchies with networks in which the relationships between levels are not easily represented as higher or lower, dominated or being dominated, directly or indirectly (Meade and Sarkis, 1999). For instance, not only does the importance of the criteria determine the importance of the alternatives as in a hierarchy, but also the importance of the alternatives may have impact on the importance of the criteria (Saaty, 1996). Therefore, a hierarchical structure with a linear top-to-bottom form is not applicable for a complex system.[(1)]

II. CONCRETE BATCH PLANTS AND THEIR IMPORTANCE:

The global trend is strongly oriented to use RMC that produced in patch plants. Because of that the choice of the factory site is one of the important and difficult decisions faced by industrial companies due to the process of selecting the right location for either the concrete mixing plant or for the construction of a CBP is one of the difficult decisions facing the owners of the industry due to the size of the large financial investments used in the newly established factories or in the old factories. This decision is based on long-term strategies affecting the future of corporate success, including marketing strategies and storage strategies .

Companies at various times have to re-evaluate the locations of the concrete batch plants they deal with in terms of the location availability of important and essential factors for companies. Therefore, there are many important aspects for the importance of mixing plants such as producing better quality concrete, minimizing the procurement / machinery hiring of plants, avoiding materials waste .

In order for companies to avoid the problems of bad selection of the site of CBP, it is necessary to conduct preliminary studies and be flexible and easy to change or move the site at the lowest cost possible if the plans or circumstances change.

Examples of difficulties or problems that companies may encounter are the difficulty of disposal of waste, the high wages and employment of workers, the high cost of transport and the legal legislation for the protection of the environment from pollution caused by mixing stations.

Accordingly, the best location is chosen based on direct factors that help to make a decision that achieves long-term benefits and benefits, including defense and security efficiency.

III. IDENTIFYING THE FACTORS AFFECTING THE LOCATION OF CBP:

The choice of the geographical location of the project should depend on several factors that may develop, grow and deepen the relationships between different industry areas because industry is a pioneering and vital activity.The select the suitable geographical location for CBP to deal with or to construct one that's Requires a thorough and accurate study of all the factors that can influence the selection of one of the alternatives provided through all aspects such as technical factors, economic factors, environment etc.The bad choice of the site may lead to many problems in several areas such as the quality of the concrete time and economic cost. Therefore, the decision of the appropriate location is one of the difficult and important decisions faced by factories, companies and investors and the decision is linked to long-term strategies that may affect the growth, development and success of companies such as storage, marketing and raw materials strategies.

IV. DIVISION OF FACTORS AND QUESTIONNAIRE STRUCTURE

After identified all the factors "criteria" by making the extensive interviews with experts and workers in RMC industry the questionnaire can be formed. The factors were studied from two points of views the first point concerning the choice of the best location for the ready mix concrete batch plant and the second for choosing the best project location as shown in figure 1.

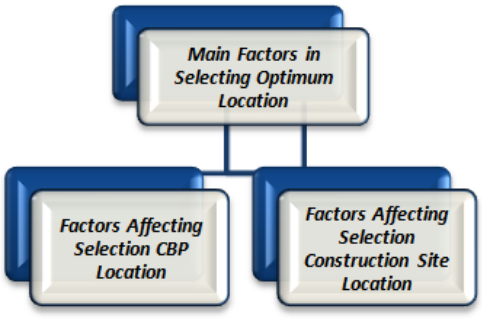

Figure 1: The two points of views of the factors affecting on site selection

estionnaire form. After the publication of the questionnaire the results of views gathering and analyze through the use of Delphi technique to determine the minimum variance to select the optimum site location according to the priorities and importance of different factors. The variance was very small so the weight of these factors can be adopted, and shown in table 2.

FACTORS		*AVERAGE*	*WEIGHT*
Factors Affecting The Choice Of Plant Location			
	A. Impact of Egyptian work condition		
A.1	Economic and cultural problems.	**92%**	**V. high**
A.2	The level of productivity in a country.	**86%**	**V. high**
A.3	Political stability.	**85%**	**V. high**
A.4	Currency exchange rates.	**85%**	**V. High**
A.5	Laws and regulations.	**84%**	**V. High**
A.6	Availability of equipment.	**81%**	**V. High**
A.7	Market locations.	**80%**	**V. High**
A.8	Impressions.	**80%**	**V. High**
A.9	Availability of manpower.	**80%**	**V. High**
A.10	Costs.	**68%**	**High**
A.11	Telecommunications.	**67%**	**High**

Table 2: Snapshot of The questionnaire results after two trials of Delphi Technique

V. DELPHI TECHNIQUE

The Delphi Method is based on a structured process for collecting and distilling knowledge from a group of experts by means of a series of questionnaires interspersed with controlled opinion feedback. Delphi represents a useful communication device among a group of experts and thus facilitates the formation of a group judgment. It comprises a series of questionnaires sent either by mail or via computerized systems, to a pre-selected group of experts. These questionnaires are designed to elicit and develop individual responses to the problems posed and to enable the experts to refine their views as the group's work progresses in accordance with the assigned task. [(2)]

5.1. Delphi Method Steps[(2)]:

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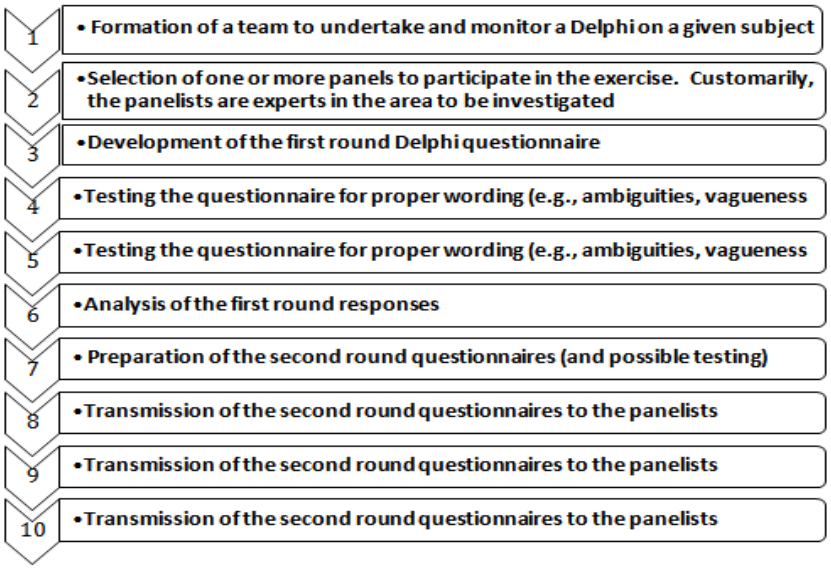


VI. ANALYTIC NETWORK PROCESS

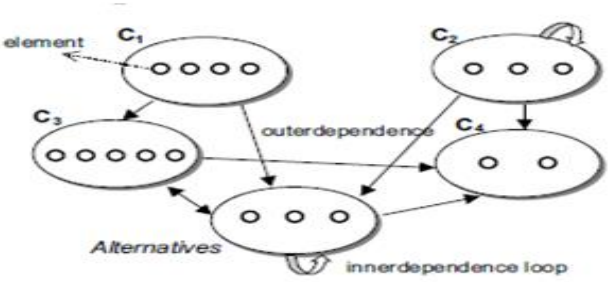


Figure 2: Feedback Network

5.2. Analytic Network Process Overview:

The process of decision-making is a necessary and very important part of human life. In order to make a correct decision, it is necessary to study all the factors affecting the decision-making from all aspects of the problem, whether the factors are political, social, environmental, cultural or psychological. When there is an interaction between higher levels and lower levels of the different elements of the problems that needs a decision, cannot be formed as hierarchical form.The diagram that called "network" can give a solution for problem that cannot be structured in hierarchical form as in AHP modelingbecause the importance of the all available alternatives themselves determines the importance of the criteria. As shown in figure 2.

The models shows in a hierarachical structure formand that means the models not necessarily to present in linear form from the top to bottom. The anp model has loops to connect between the clusters and between cluster and nodes.

The anp is one of the systems that called systems-with-feedback. The problems with feedback that need to solve by making a right decision the anp is the suitable technique to manage this process through overall methodical way.

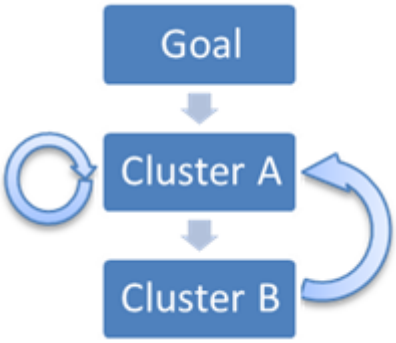


Figure 3: The ANP systems with feedback

The nodes in Analytic Network process (ANP) model are criteria, sub criteria and alternatives. Any of each node compared with any other node in the model. The preferring of alternatives not only depends on the weighting of criteria but the preferring of criteria also can depend on the weight of alternatives. Figure 4

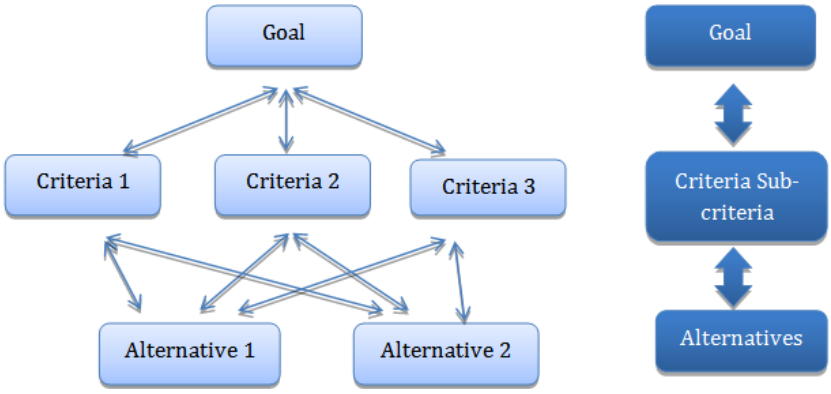
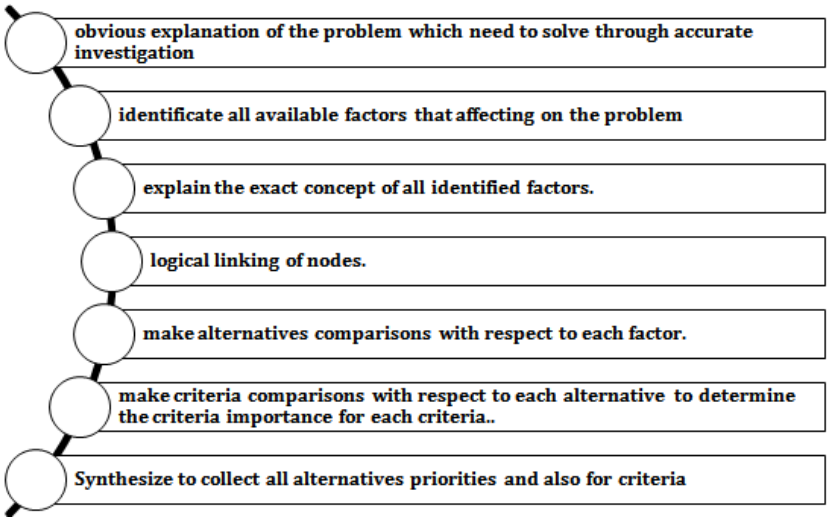


Figure 4: The Network Model

The AHP model answers the comparisons question: "how important is criteria A to criteria B with respect to the overall goal?"

The ANP model it is very important to determine the criteria priorities with respect to the alternatives, the comparing process became easier when the comparing question is dealing with actual alternatives.

1.1. ANP: Setting Up a Model



1.2. Pairwise Comparisons

The Fundamental Scale used for the judgments is given in Table 4. Judgments are first given verbally as indicated in the scale and then a corresponding number is associated with that judgment. The vector of priorities is the principal eigenvector of the matrix. This vector gives the relative priority of the criteria measured on a ratio scale. That is, these priorities are unique to within multiplication by a positive constant. However, if one ensures that they sum to one they are then unique and belong to a scale of absolute numbers.[3]

When starting the comparison process, the factor that is more important than the other factor being compared is worth a larger number. Therefore, the comparison is described with an integer value from (1 to 9) where 1 (equal value) to 9 (very different), as shown in table 3.

Verbal Judgment of Preference	*Numerical Rating*
Extremely preferred	**9**
Very strongly to extremely preferred	**8**
Very strongly preferred	**7**
Strongly to very strongly preferred	**6**
Strongly preferred	**5**
Moderately to strongly preferred	**4**
Moderately preferred	**3**
Equally to moderately preferred	**2**
Equally preferred	**1**

Table 3: The Scale Ranging For Pairwise Comparisons

All previous Research and experience have definite the nine-unit scale as a reasonable basis for discerning between the two items.

- Moderate values for the scale are called Even numbers (2, 4, 6, and 8).
- If the two objects are equally preferred it will take a value of 1.

It is recommended that should be less than or equal to 0.10. Inconsistency may be thought of as an adjustment needed to improve the consistency of the comparisons. But the adjustment should not be as large as the judgment itself, nor so small that it would have no consequence. Thus inconsistency should be just one order of magnitude smaller. On a scale from zero to one, the overall inconsistency should be around 10 %. The requirement of 10% cannot be made smaller such as 1% or .1% without trivializing the impact of inconsistency.

But inconsistency itself is important because without it, new knowledge that changes preference cannot be admitted [4].

Table 4: The Average Random Index

Order	1	2	3	4	5	6	7	8	9	10
R.I.	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

VII. THE ANP MODEL OF OPTIMUM SELECTION OF CBP LOCATION BY USING SUPER DECISION SOFTWARE:

This model introduce a descriptive for the case study project of selecting the best location for CBP, by the SUPERDECISIONS software application together with themajor factorsthat chosen from the previous formed questionnaire. Also include the results determine from implementingthe developed software application which applied on two different CBP locations(location in region) and (location outside) to determine the most preferred location to deal with 13 major factors in this type of projects. The results will be discussed to demonstrate the efficiency of the software in such cases.

7.1. Illustrate ANP model

The first step to construct the ANP model is to breakdownin logical groupings of the nodes and clusters that structure the problem. The purpose of CBP site selection Model is to determine the priorities of locations achievementthe13 major factors that affecting on the site selection. The hierarchical site selection structure depicted **Figure 5**, shows a snapshot of the ANP Model which was developed with the SUPERDECISIONS software.

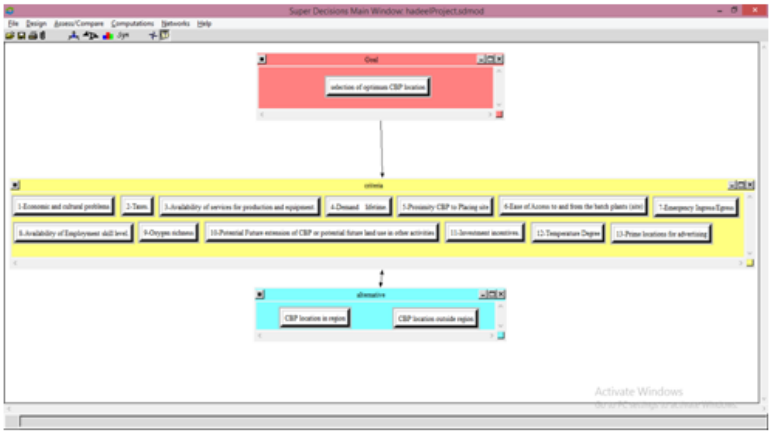


Figure 5: Snapshot of ANP Model for Best Site Selection Breakdown

The ANP model consists of a network which has all clusters and their nodes in one window. Therefore, all the comparison questions are evaluated from theviewpoint of what is more important with respect to most preferredlocation for CBP.

7.2. Pairwise Comparison of ANP Model for the Selection of CBP Location

In ANP model the alternatives are pairwise compared against to the criteria.In such a ratings model the alternatives are rated against the criteria.

The ANP model consists of clusters and they are the goal criteria and sub criteria and alternatives but in this paper there are no sub criteria. each cluster including nodes such as the criteria cluster includes the nodes of the 13 major factors that choosing from the previous questionnaire which affecting on the selection of CBP best location, such as economic and cultural problem, temperature degree, proximity of CBP to site and availability of skilled workers

Consequently, the comparisons can be completed by selecting from the drop-down menu the Assess/Compare command, after that select the required cluster and its node to serve as parent node, to starting with respect to the selected node. This process will present the comparisons screen in the questionnaire mode.

Therefore, the first pairwise comparison questionnaireisevaluating from the point of view of what is more important factors with respect to CBP best selection "Goal" which is shown in Table 5.

Table 5:Snapshot of the Questionnaire Mode for Comparisons with respect to Goal

	1-Economic and cultural problems	2-Taxes.	3-Availability of services for production and equipment.	4-Demand lifetime.	5-Proximity CBP to Placing site	6-Ease of Access to and from the batch plants (site)	7-Emergency Ingress/Egress	8-Availability of Employment skill level.	9-Oxygen richness	10-Potential Future extension of CBP or potential future land use in other activities	11-Investment incentives.	12-Temperature Degree	13-Prime locations for advertising
1-Economic and cultural problems	1.00	2.00	4.00	4.00	1.00	2.00	3.00	2.00	2.00	2.00	3.00	4.00	8.00
2-Taxes.	0.50	1.00	3.00	3.00	0.50	2.00	1.00	1.00	1.00	1.00	1.00	3.00	7.00
3-Availability of services for production and equipment.	0.25	0.33	1.00	0.50	0.14	0.20	0.20	0.25	0.25	0.33	0.25	1.00	6.00
4-Demand lifetime.	0.25	0.33	2.00	1.00	0.11	0.17	0.14	0.13	0.13	0.14	0.17	1.00	6.00
5-Proximity CBP to Placing site	1.00	2.00	7.00	9.00	1.00	4.00	5.00	6.00	5.00	5.00	4.00	8.00	9.00
6-Ease of Access to and from the batch plants (site)	0.50	0.50	5.00	6.00	0.25	1.00	0.33	0.25	0.33	0.50	0.50	3.00	8.00
7-Emergency Ingress/Egress	0.33	1.00	5.00	7.00	0.20	3.00	1.00	0.50	1.00	1.00	2.00	4.00	9.00
8-Availability of Employment skill level.	0.50	1.00	4.00	8.00	0.17	4.00	2.00	1.00	2.00	2.00	3.00	5.00	9.00
9-Oxygen richness	0.50	1.00	4.00	8.00	0.20	3.00	1.00	0.50	1.00	1.00	2.00	6.00	9.00
10-Potential Future extension of CBP or potential future land use in other activities	0.50	1.00	3.00	7.00	0.20	2.00	1.00	0.50	1.00	1.00	1.00	6.00	9.00
11-Investment incentives.	0.33	1.00	4.00	6.00	0.25	2.00	0.50	0.33	0.50	1.00	1.00	4.00	8.00
12-Temperature Degree	0.25	0.33	1.00	1.00	0.13	0.33	0.25	0.20	0.17	0.17	0.25	1.00	9.00
13-Prime locations for advertising	0.13	0.14	0.17	0.17	0.11	0.13	0.11	0.11	0.11	0.11	0.13	0.11	1.00

In figure 6 the weighting resultspresents as following, for example Economic and cultural problems 13.6% , taxes 7.35, temperature degree 2.3% and the most important criteria is proximity of CBP to placing site 24.3%.

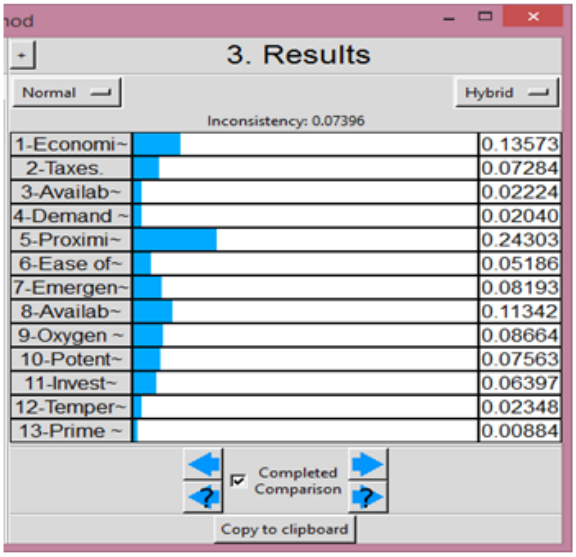


Figure 6: Snapshot of the Result of Factors

The second pairwise comparison questionnaire are evaluating from the point of view of what is more important of each criteria with respect to each actual alternative for CBP selection location "alternative", as shown in table 6

Table 6: Snapshot of the Questionnaire Mode for Comparisons With respect To Each actual alternative

	1-Economic and cultural problems	2-Taxes.	3-Availability of services for production and equipment.	4-Demand lifetime.	5-Proximity CBP to Placing site	6-Ease of Access to and from the batch plants (site)	7-Emergency Ingress/Egress	8-Availability of Employment skill level.	9-Oxygen richness	10-Potential Future extension of CBP or potential future land use in other activities	11-Investment incentives.	12-Temperature Degree	13-Prime locations for advertising
1-Economic and cultural problems	1.00	4.00	0.17	0.25	0.17	0.50	0.50	0.25	7.00	6.00	0.17	0.17	0.13
2-Taxes.	0.25	1.00	0.20	4.00	0.14	2.00	2.00	0.13	3.00	9.00	0.25	0.20	0.13
3-Availability of services for production and equipment.	6.00	5.00	1.00	5.00	1.00	4.00	3.00	1.00	5.00	5.00	1.00	1.00	1.00
4-Demand lifetime.	4.00	0.25	0.20	1.00	0.17	0.50	0.50	0.13	3.00	3.00	1.00	1.00	0.17
5-Proximity CBP to Placing site	6.00	7.00	1.00	6.00	1.00	7.00	7.00	1.00	6.00	9.00	8.00	5.00	1.00
6-Ease of Access to and from the batch plants (site)	2.00	0.50	0.25	2.00	0.14	1.00	1.00	0.14	6.00	9.00	2.00	6.00	1.00
7-Emergency Ingress/Egress	2.00	0.50	0.33	2.00	0.14	1.00	1.00	0.17	3.00	7.00	0.25	1.00	0.17
8-Availability of Employment skill level.	4.00	8.00	1.00	8.00	1.00	7.00	6.00	1.00	9.00	9.00	8.00	9.00	8.00
9-Oxygen richness	0.14	0.33	0.20	0.33	0.17	0.17	0.33	0.11	1.00	0.25	0.20	0.33	0.13
10-Potential Future extension of CBP or potential future land use in other activities	0.17	0.11	0.20	0.33	0.11	0.11	0.14	0.11	4.00	1.00	0.17	0.33	0.14
11-Investment incentives.	6.00	4.00	1.00	1.00	0.13	0.50	4.00	0.13	5.00	6.00	1.00	3.00	0.33
12-Temperature Degree	6.00	5.00	1.00	1.00	0.20	0.17	1.00	0.11	3.00	3.00	0.33	1.00	0.11
13-Prime locations for advertising	8.00	8.00	1.00	6.00	1.00	1.00	6.00	0.13	8.00	7.00	3.00	9.00	1.00

7.3. The Supermatrix

During the construct ANP model in the SUPERDECISION there are different computations included the super-matrix.To show the various super-matrices, the computations command should be selected from the menu in software. Each network associated with three super-matrices: the weighted, un-weighted and limit super-matrix.The un-weighted super-matrix includes the local priorities derived from the pairwise comparisons through the network.

Consequently, the results of all pairwise comparisons are extracting in the un-weighted super-matrix. Figure 7 shows part of the unweightedsupermatrix of the optimum selection of CBP location. Has defined a component in a supermatrix, it is the block defined by a cluster name at the left and a cluster name at the top of the supermatrix. The weighted supermatrix is derived by multiplying all the elements in a component of the unweightedsupermatrix by the corresponding cluster weight. Segment of the weighted supermatrix for the optimum selection of CBP location is shown in Figure 8[(5)]

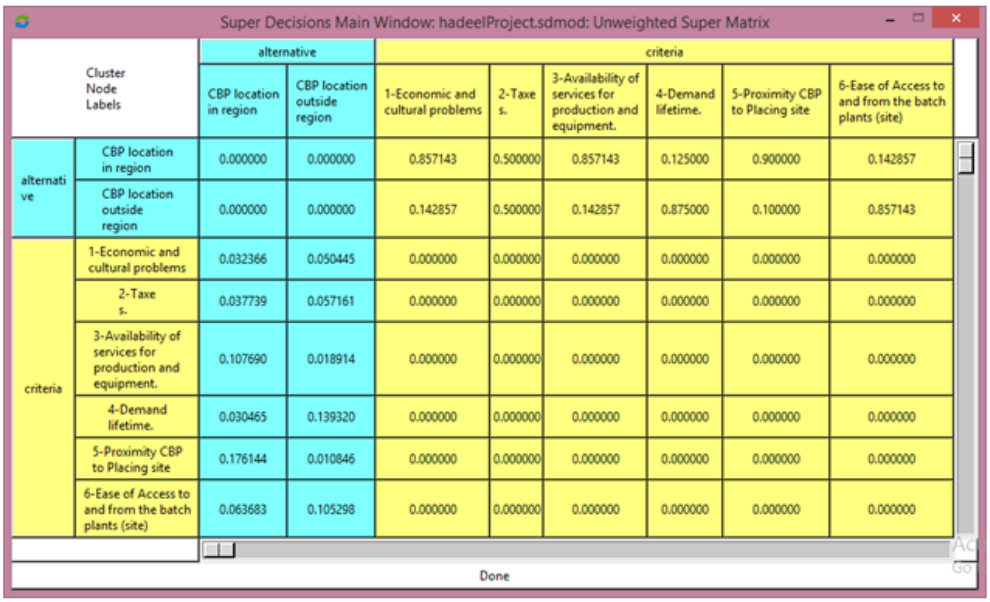
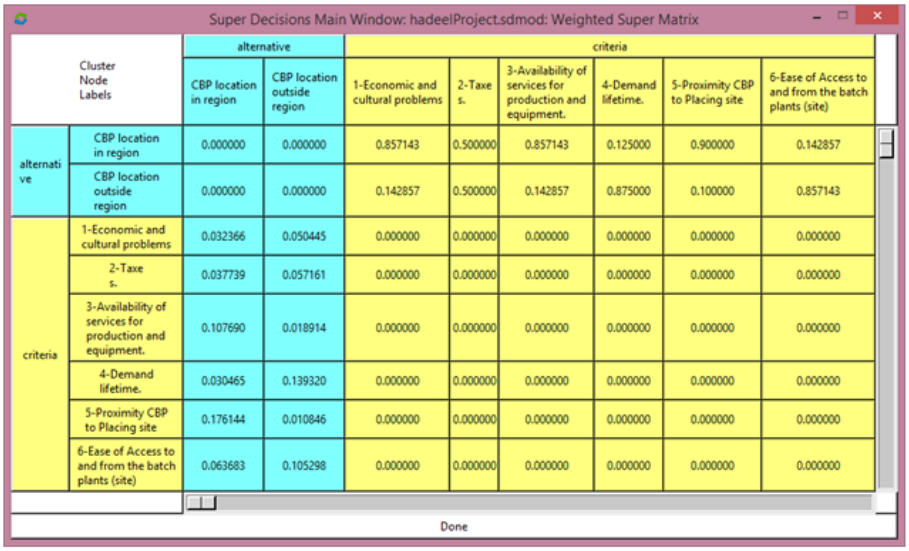


Figure 7: Snapshot of a Part of the UnweightedSupermatrix for theoptimum selection of CBP location


Super Decisions Main Window: hadeelProject.sdmod: Weighted Super Matrix

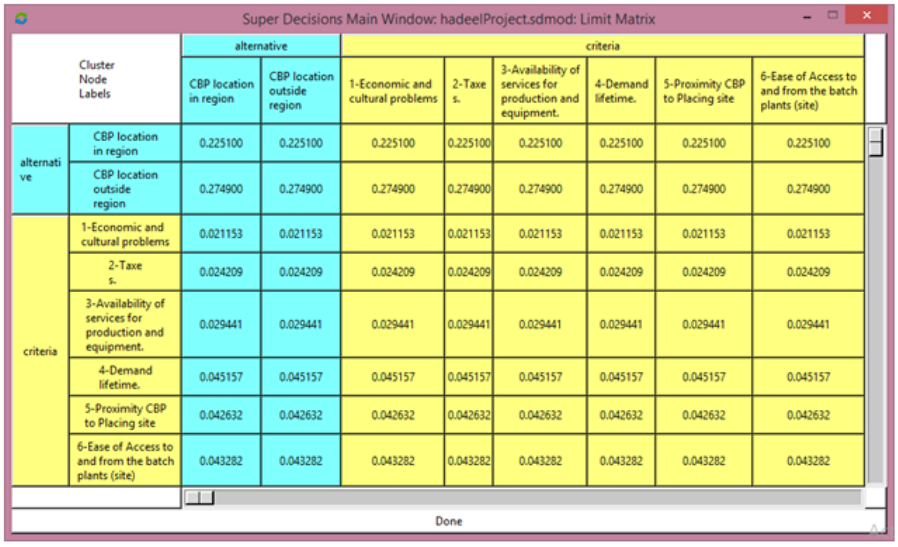
Cluster Node Labels		alternative		criteria					
		CBP location in region	CBP location outside region	1-Economic and cultural problems	2-Taxes.	3-Availability of services for production and equipment.	4-Demand lifetime.	5-Proximity CBP to Placing site	6-Ease of Access to and from the batch plants (site)
alternative	CBP location in region	0.000000	0.000000	0.857143	0.500000	0.857143	0.125000	0.900000	0.142857
	CBP location outside region	0.000000	0.000000	0.142857	0.500000	0.142857	0.875000	0.100000	0.857143
criteria	1-Economic and cultural problems	0.032366	0.050445	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	2-Taxes.	0.037739	0.057161	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	3-Availability of services for production and equipment.	0.107690	0.018914	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	4-Demand lifetime.	0.030465	0.139320	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	5-Proximity CBP to Placing site	0.176144	0.010846	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	6-Ease of Access to and from the batch plants (site)	0.063683	0.105298	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Done

Figure 8: Snapshot of a Part of the Weighted Supermatrix for the optimum selection of CBP location

Limit super-matrix is derived by raising the weighted super-matrix to powers by multiplying it times itself. If columns of numbers become typical the limit matrix has been reached.

Thus, the matrix multiplication process is stopped. As shown in figure 9 that present a screenshot of limit super-matrix for the optimum selection of CBP location.


Super Decisions Main Window: hadeelProject.sdmod: Limit Matrix

Cluster Node Labels		alternative		criteria					
		CBP location in region	CBP location outside region	1-Economic and cultural problems	2-Taxes.	3-Availability of services for production and equipment.	4-Demand lifetime.	5-Proximity CBP to Placing site	6-Ease of Access to and from the batch plants (site)
alternative	CBP location in region	0.225100	0.225100	0.225100	0.225100	0.225100	0.225100	0.225100	0.225100
	CBP location outside region	0.274900	0.274900	0.274900	0.274900	0.274900	0.274900	0.274900	0.274900
criteria	1-Economic and cultural problems	0.021153	0.021153	0.021153	0.021153	0.021153	0.021153	0.021153	0.021153
	2-Taxes.	0.024209	0.024209	0.024209	0.024209	0.024209	0.024209	0.024209	0.024209
	3-Availability of services for production and equipment.	0.029441	0.029441	0.029441	0.029441	0.029441	0.029441	0.029441	0.029441
	4-Demand lifetime.	0.045157	0.045157	0.045157	0.045157	0.045157	0.045157	0.045157	0.045157
	5-Proximity CBP to Placing site	0.042632	0.042632	0.042632	0.042632	0.042632	0.042632	0.042632	0.042632
	6-Ease of Access to and from the batch plants (site)	0.043282	0.043282	0.043282	0.043282	0.043282	0.043282	0.043282	0.043282

Done

Figure 9: Snapshot of a Part of the Limit Supermatrix for the optimum selection of CBP location

The main point of the importance of limit super-matrixis provides the priorities for the different criteria that affecting the problem that need to solve.

Because the columns of limit super-matrix are typical the priorities of all criteria and alternatives can be read directly from any column. Furthermore, the computation priorities command on displays menu the priorities in two different ways, they present in limit super-matrix. As shown in figure 10 present the priorities as result from limit super-matrix.

When alternatives are included in the model, the SUPERDECISION software can synthesize them to give the optimum choice from the available locations alternatives depend on the provided judgments.

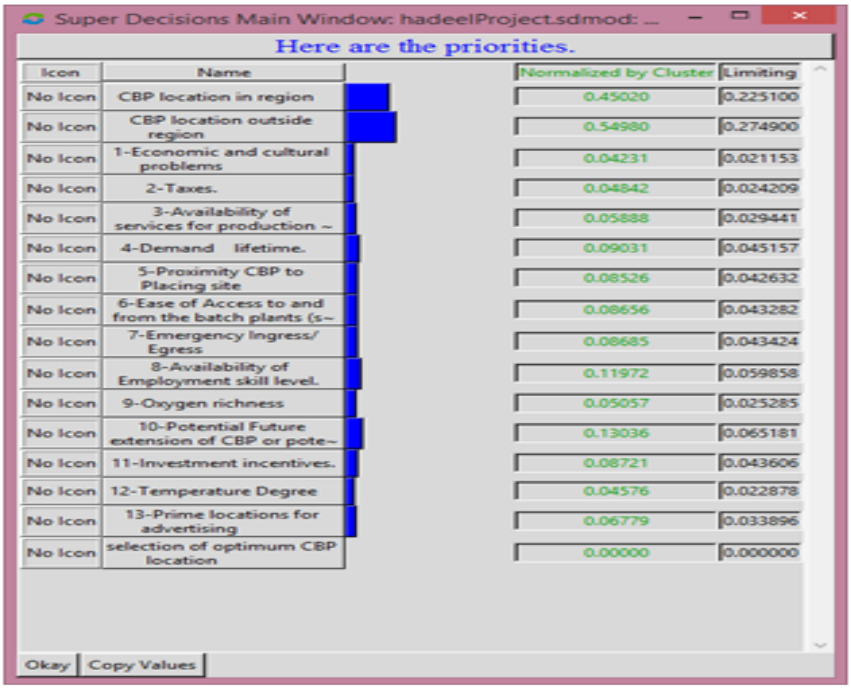
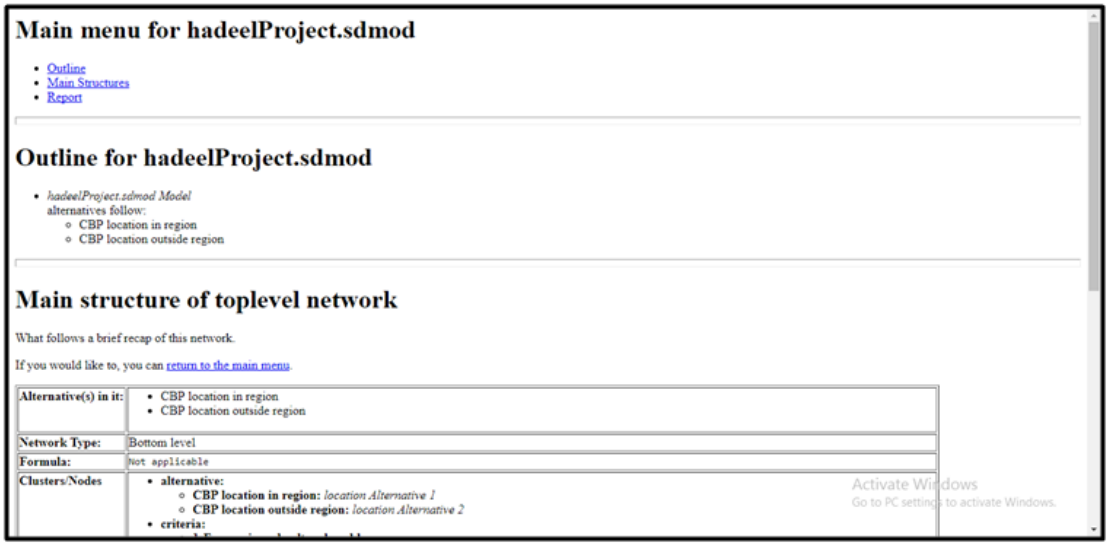


Figure 10: Snapshot of the Priorities the Limit Super-matrix

Also the SUPERDECISION software can generate the HTML file of reports about the model. The report gives the names and descriptions of the nodes and clusters and important priorities of alternatives. As shown in figure 10:



Main menu for hadeelProject.sdmod

- Outline
- Main Structures
- Report

Outline for hadeelProject.sdmod

- *hadeelProject.sdmod Model*
  alternatives follow:
  - CBP location in region
  - CBP location outside region

Main structure of toplevel network

What follows a brief recap of this network.

If you would like to, you can return to the main menu.

Alternative(s) in it:	• CBP location in region • CBP location outside region
Network Type:	Bottom level
Formula:	Not applicable
Clusters/Nodes	• **alternative:** ◦ **CBP location in region:** *location Alternative 1* ◦ **CBP location outside region:** *location Alternative 2* • **criteria:**

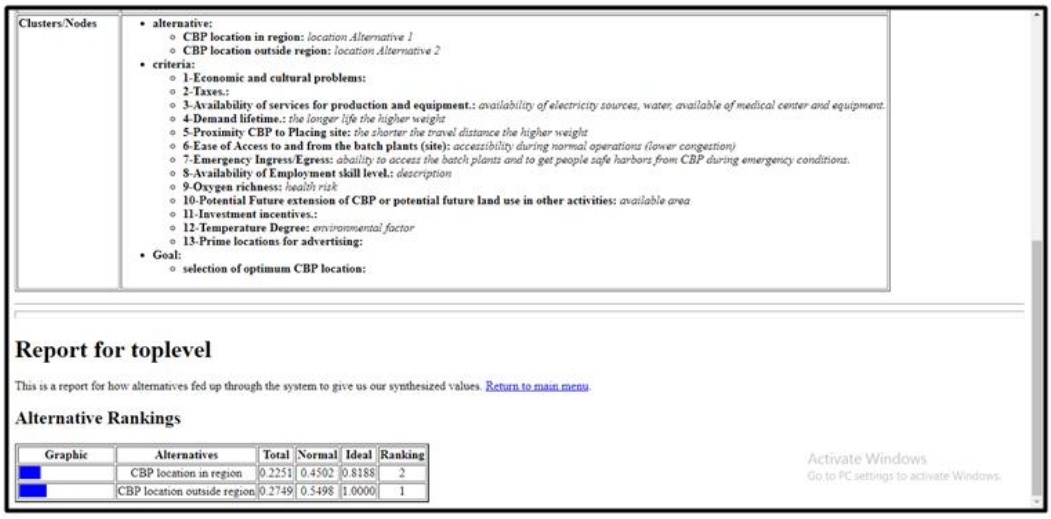


Figure 11: Snapshot of the full report

VIII. CONCLUSION

After completing all comparisons in ANP model the final results for the selection of optimum CBP location model are decided by selecting the most optimum location from the available alternatives. The result shows that: (CBP location in region) is obtained 45%, alternative (CBP location outside region) is obtained 55%. As shown in figure 12.

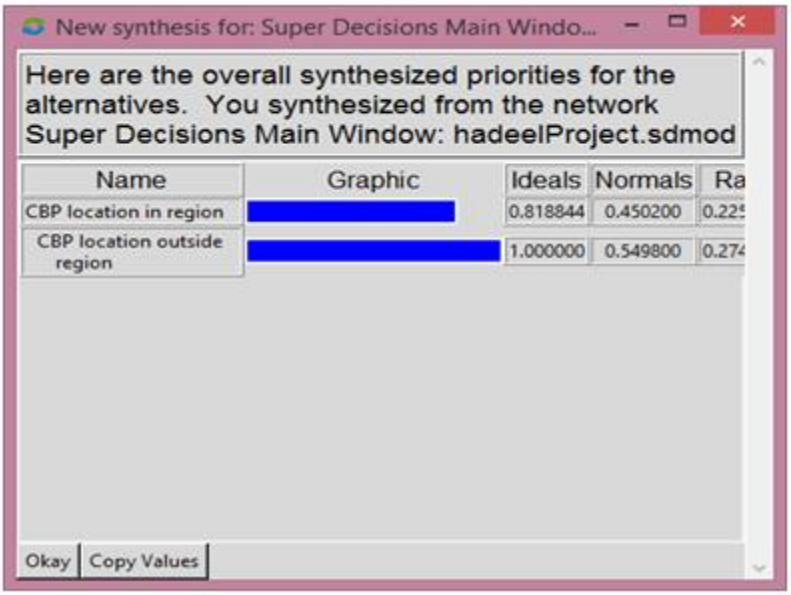


Figure 12: the result for the best CBP location in ANP

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