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OPTIMUM SELECTION OF CONCRETE BATCH PLANT (CBP) LOCATION MODEL USING ANALYTIC HIERARCHY PROCESS

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ABSTRACT

The selection of the Concrete Batch Plant (CBP) location is the most essential element for success of a project and recently most of the companies using the ready mix concrete in many projects especially that is need a high requirements and specifications because the RMC is more useful and that raise the importance of concrete batch plant (CBP). For that the companies need to take right decision about best site selection for construct a CBP or to choose best location of batch plants to deliver RMC.

This paper presents the most important factors affecting on the decision of site location selection by identifying this factor through interviews with experts engineers who works in RMC industry and high qualified workers in CBP by sending the questionnaire to them. To construct an analytic hierarchy process (AHP) to help the companies in taking the right decision to choose the best alternative of CBP location.

This module is very helpful in decision making process to select the best method from the available alternatives.

Keywords: Site Selection, Concrete Batch Plant, Optimization, Analytical Hierarchy Process, AHP Model, Delphi Technique, Super Decision Software.

Nomenclature

RMC
CBP
AHP
MCDM
Ready mix concrete
Concrete Batch Plant
Analytical Hierarchy Process
Multi Criteria Decision Making

1. 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

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Table 1: The Weakness and Strength Points of CBP

WEAKNESS POINTS		
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.
STRENGTH 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

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.

AHP is one of the multiple criteria decision-making method that was originally developed by Prof. Thomas L. Saaty (1977),provides measures of judgment consistency derives priorities among criteria and alternatives and simplifies preference ratings among decision criteria using pair wise comparisons. (1)

The analytic hierarchy process AHP tool help to show the priorities of each criterion and sub criteria to evaluate and present the priorities of each alternative by the questionnaire and making pair wise comparisons matrix.

The main aim of this paper is developing a mathematical model to select the optimum positions for concrete batch plants. And form a questionnaire to investigating the main factors which effect on the selection of batch plants location.

Decision making is process to choose among alternatives based on multiple criteria. In each of these decisions, deep in our mind we have several factors or **criteria** on what to consider and we also have several **alternatives** choices that we should decide. On group decision making these criteria and alternatives are more obvious and must be determined first before we give some judgment score or evaluation values on them. (2)

In our complex world system, we are forced to cope with more problems than we have the resources to handle. What we need is not a more complicated way of thinking but a framework that will enable us to think of complex problems in a simple way.

The AHP provides such a framework that enables us to make effective decisions on complex issues by simplifying and expediting our natural decision-making processes. (3)

2. CONCRETE BATCH PLANTS AND THEIR IMPORTANCE

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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.

3. IDENTIFYING THE FACTORS AFFECTING THE LOCATION OF CBP

The choice of the geographical location of the projects requires careful consideration of the technical and economic feasibility of studying all the factors that influencing the choice of the best location through an alternative of the alternatives, because the choice of an inappropriate place here leads to heavy losses in the economy. Therefore, selecting the appropriate location for the project should depend on many factors such as environmental, economic and social factors that help to develop and grow the relationship between the fields of industry and construction because they are pioneering and vital activities.

Division of factors and questionnaire structure

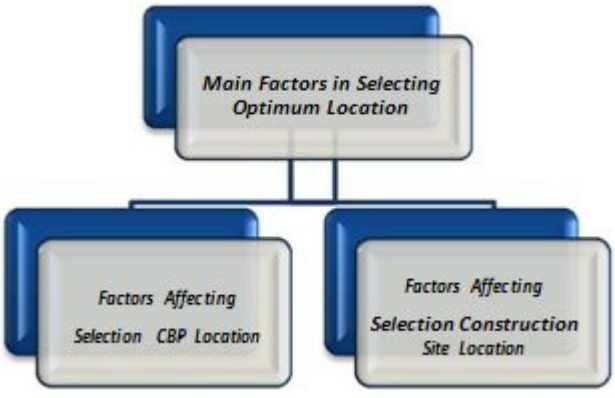

Figure 1: The two points of views of the factors affecting on site selection

After the each of the previous categories had been divided to many factors and formed in questionnaire form, after compilation a group of experts, engineers and research scientists with extensive experience more than 15 years in the field and they have a direct dealing with the problems that emerged as a result of the poor selection of concrete mixing plant location, especially contractors and projects execution companies who are facing such

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a problems like that in the field. Then introduced these factors that collected in the form of A questionnaire to be published face to face or by sending it to them and sending it also to university professors with relevant Specializations such as project management and other Specializations to give a ranking of the importance of each factor from their point of view and their experience with various projects .

This assessment indicates the impact of each factor on the location of the CBP, the construction site and its workers, and its effect on the productivity and final product of the batch plant which is the RMC.

A total of 15 questionnaire forms were distributed among the collected groups in the construction industry, including consultants, contractors, engineers and experts in the RMC fields in Egypt, According to experts opinion and the previous studies and extensive interviews during the questionnaire formation some criteria added and deleted of initial set of criteria to make the final analysis of a total 50 criteria is ready to publish to the collected group.

And after receiving these results from the engineers and specialists and analyzed them to give a percentage of the importance of each factor for the first trial and to ensure the accuracy of the results so the results sent again to the same group of experts and engineers to re-evaluation the questionnaire and at the second trial found that the results are very close. Therefore, the final results adopted and this method is called Delphi technique and will be explained in detail further.

So, after the publication of the questionnaire the results of views gathering and analyze through the use of Delphi technique as Saied before to determine the minimum variance to select the optimum site location according to the priorities and importance of different factors, and the final results are used to developing the AHP modeling

The variance was very small so the weight of these factors can be adopted, and shown in table 2

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

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**

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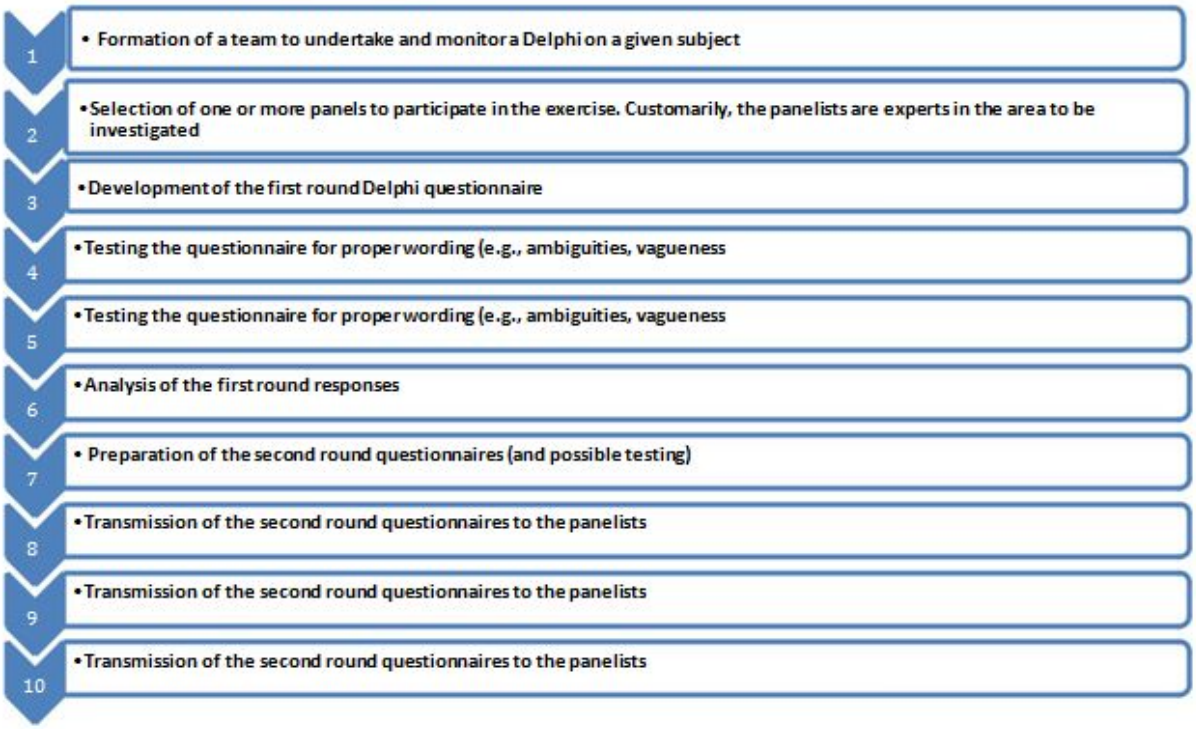
A.11	Telecommunications.	**67%**	**High**

4. 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. (4)

Delphi Method Steps (4):



Delphi Method Advantages (5):

- Anonymity, anonymity for participants make contributions of ideas a safe activity.
- More accurate representation of an individual's feelings
- No group meetings are required.
- A large heterogeneous group may participate on an equal basis.
- Allows participants to be geographically scattered.

Delphi Method Limitations (5):

- Ti
me may eliminate Delphi as a possibility.
- Is not useful for individuals who have difficulties reading or writing.

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- High participant interest and commitment is assumed or the quantity and quality of responses will decrease with each round.
- By design Delphi does not allow for instant communication or intellectual stimulation

5. ANALYTIC HIERARCHY PROCESS

The organization technique that used to analyze and organize a complex problem that need to take a right decisions based on mathematics and psychology is called Analytic Hierarchy Process (AHP). AHP helps decision-makers choose the best solution from several options and selection criteria. (6) Thomas Saaty developed AHP as a decision-making method in the 1970s, (6) since then; this technique has been studied extensively and extensively. There may be some inconsistency of the verdict because human is not always accurate. Hierarchy is one of a fundamental mind tools.

To build AHP model we can use software such as:
1- Excel
2- Expert choice.
3- Super Decision.

Hierarchy Development
In AHP model, the first step is to develop a graphical representation of the problem that needs to be resolved to take the appropriate decision in terms of the general goal, criteria and the available alternatives.

The hierarchy analytic divided in to three levels, Level one is overall goal of the analysis. Level two is all criteria that affecting a problem; also it can add more levels of sub-criteria. The third level is the alternative options available that need to be decided which the best alternative is. As shown in figure 2

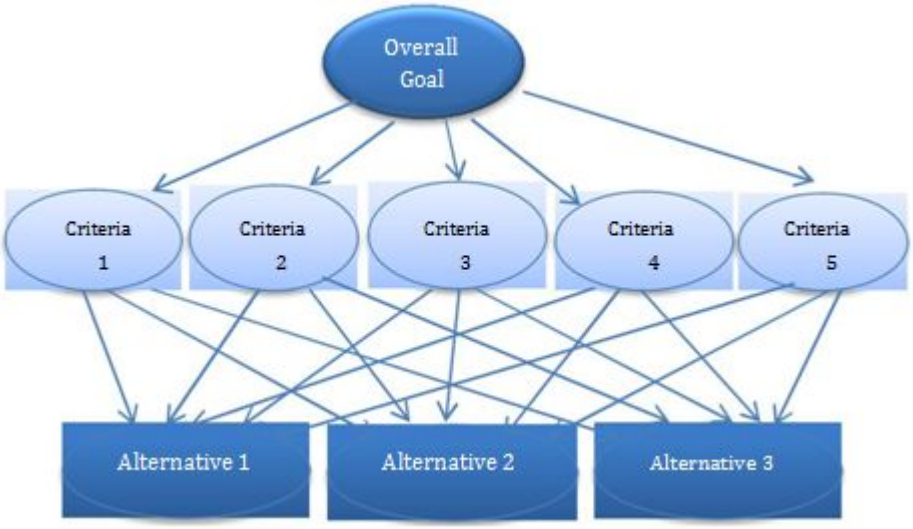

Figure 2: The Analytic Hierarchy Process Breakdown Structure

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Pairwise Comparisons

The second step in the AHP model is to make pairwise comparisons between each criteria with respect to goal and the third step is to make wise comparison between each alternative with respect to each criteria.

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 a integer value from (1 to 9) where 1 (equal value) to 9 (very different), as shown in table 3.

In AHP model the Pairwise comparisons are fundamental building blocks of the AHP

Table 3: The Pairwise Comparisons Scale

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**

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, 8).
- If the two objects are equally preferred it will take a value of 1.

6. THE AHP MODEL OF OPTIMUM SELECTION OF CBP LOCATION BY USING SUPER DECISION SOFTWARE:

This model presents an analysis and description of the subject of the previous study mentioned to develop how to make a decision to choose the best location of CBP through software SUPERDECISIONS software application, based on the most important key factors influencing the structured site selection questionnaire. Furthermore it is include the results acquired from implementing the developed software application "SUPER DECISION" which applied on two different CBP locations to determine the most preferred location in terms of availability of with major factors in this type of projects locations. To demonstrate the validity of the software the findings of the case studies will be discussed.

The first step in constructing the AHP model is to decide on the logical hierarchical of the nodes and clusters that structure the problem that needs to solve

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The aim of the optimum selection of CBP location Model is to estimate the priorities of locations capabilities associated with major 13 factors that affecting on the best site location selection.

In SUPER DECISION software, the model consists of a network which has all clusters and their nodes in one window.

In figure 3 the hierarchical site selection structure shows a snapshot of the AHP Model, it was used as the basis for the AHP model.

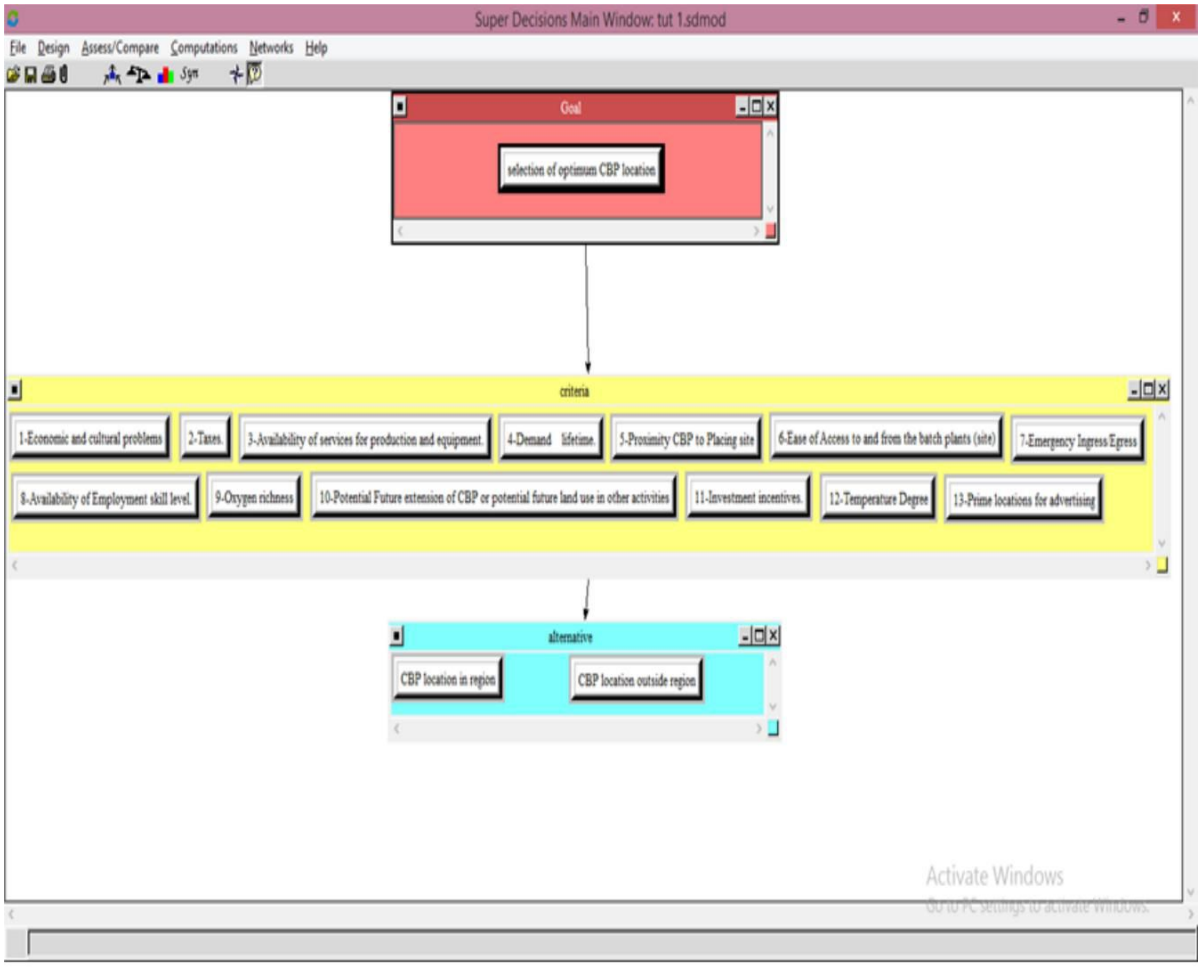

Figure 3: Hierarchical Best Site Selection Breakdown Structure for CBP Site Location

In a proportional model the alternatives are pairwise compared against the criteria. In a ranking model the alternatives are rated against standards for the criteria. So, the general control criterion according to which the clusters are compared is major factors affecting on the site selection. The clusters that build the model are goal, criteria and alternative and the nodes build each of the clusters such as the criteria with nodes were included the highest 13 factors of site selection which they were chosen from the previous questionnaire such as economic and cultural problem, temperature degree, proximity of CBP to site and availability of skilled workers. The comparison can be carried out by selecting the Assess/Compare command, then selecting cluster and the node to serve as the parent node. To start comparisons with respect to a selected node, first the Node Comparisons command from the drop-down menu should be selected, then the cluster which has the nodes required to be compared with respect to the selected node is selected

ISSN: 2394-7659
IMPACT FACTOR- 3.775

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Table 4: Snapshot of the Questionnaire Mode for Comparisons with respect to Goal

WITH RESPECT TO GOAL	[illegible]	Taxes.	[illegible]	Demand lifetime.	[illegible]	[illegible]	[illegible]	[illegible]	Oxygen richness	[illegible]	[illegible]	Temperature Degree	[illegible]
1-Economic and cultural problems	1.000	2.000	4.000	4.000	1.000	2.000	3.000	2.000	2.000	2.000	3.000	4.000	8.000
2-Taxes.	0.500	1.000	3.000	3.000	0.500	2.000	1.000	1.000	1.000	1.000	1.000	3.000	7.000
3-Availability of services for production and equipment.	0.250	0.333	1.000	0.500	0.143	0.200	0.200	0.250	0.250	0.333	0.250	1.000	6.000
4-Demand lifetime.	0.250	0.333	2.000	1.000	0.111	0.167	0.143	0.125	0.125	0.143	0.167	1.000	6.000
5-Proximity CBP to Placing site	1.000	2.000	7.000	9.000	1.000	4.000	5.000	6.000	5.000	5.000	4.000	8.000	9.000
6-Ease of Access to and from the batch plants (site)	0.500	0.500	5.000	6.000	0.250	1.000	0.333	0.250	0.333	0.500	0.500	3.000	8.000
7-Emergency Ingress/Egress	0.333	1.000	5.000	7.000	0.200	3.000	1.000	0.500	1.000	1.000	2.000	4.000	9.000
8-Availability of Employment skill level.	0.500	1.000	4.000	8.000	0.167	4.000	2.000	1.000	2.000	2.000	3.000	5.000	9.000
9-Oxygen richness	0.500	1.000	4.000	8.000	0.200	3.000	1.000	0.500	1.000	1.000	2.000	6.000	9.000
10-Potential Future extension of CBP or potential future land use in other activities	0.500	1.000	3.000	7.000	0.200	2.000	1.000	0.500	1.000	1.000	1.000	6.000	9.000
11-Investment incentives.	0.333	1.000	4.000	6.000	0.250	2.000	0.500	0.333	0.500	1.000	1.000	4.000	8.000
12-Temperature Degree	0.250	0.333	1.000	1.000	0.125	0.333	0.250	0.200	0.167	0.167	0.250	1.000	9.000
13-Prime locations for advertising	0.125	0.143	0.167	0.167	0.111	0.125	0.111	0.111	0.111	0.111	0.125	0.111	1.000

This procedure will display screen comparisons in the questionnaire mode. Therefore, the first pairwise comparison questions are asked from the perspective of what is more important factors with respect to the selection of CBP site location "Goal" which is shown in **table 4.** As a result the following weighting present in the following figure, 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% as shown in **figure 4**

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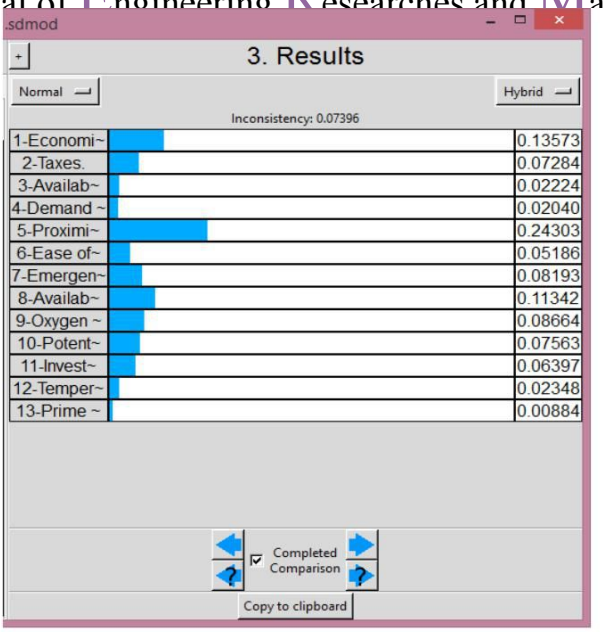

Figure 4: Snapshot of the Result of Factors Importance Weight With Respect To Goal

The second pairwise comparison questions are asked from the perspective of what is more important Alternative with respect to the each factors that affecting on selection of CBP site location "criteria" which is shown in **table 5**

Table 5: Snapshot of the Questionnaire Mode for Comparisons With Respect To Each Criterion

Economic and Cultural Problems	CBP location in region	CBP location outside region
CBP location in region	1.000	6.000
CBP location outside region	0.167	1.000

Availability of Employment Skill Level	CBP location in region	CBP location outside region
CBP location in region	1.000	4.000
CBP location outside region	0.250	1.000

Also the SUPERDECISION software can create the HTML file of reports about the model. The report shows the names and descriptions of the nodes and clusters and important priorities of each alternatives. As shown in **figure 5:**

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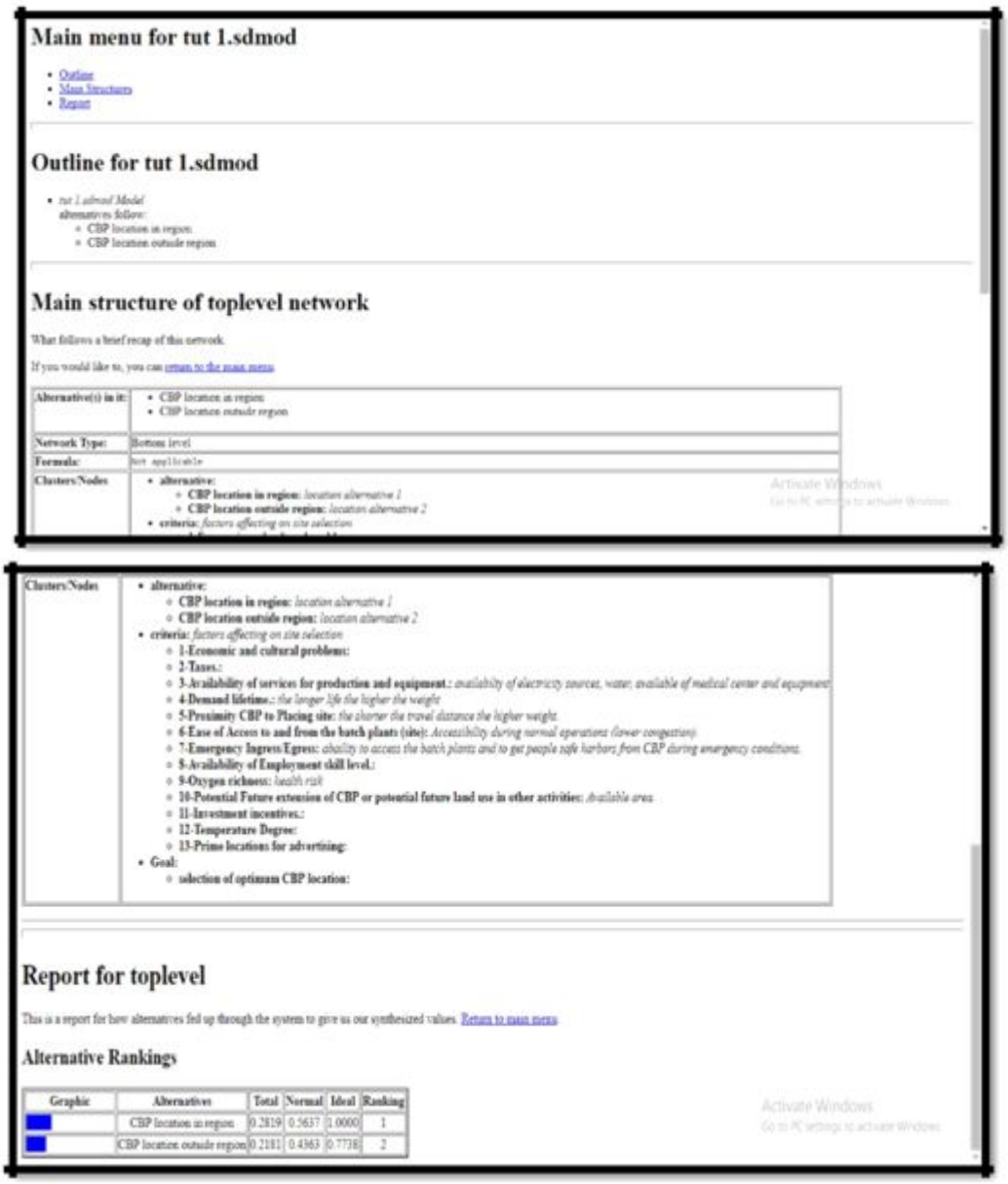

7. CONCLUSION

It is acquired final results for (The Selection of Optimum CBP Location) model by selecting the most optimum site location according to the importance of each factor. The results have appeared as follows: (CBP location in region) is preferred by 56.4% (CBP location outside region) is preferred by 43.6% as shown in **Figure 6**. Which Normalized values are obtained from them by summing and dividing each by the sum

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IMPACT FACTOR- 3.775

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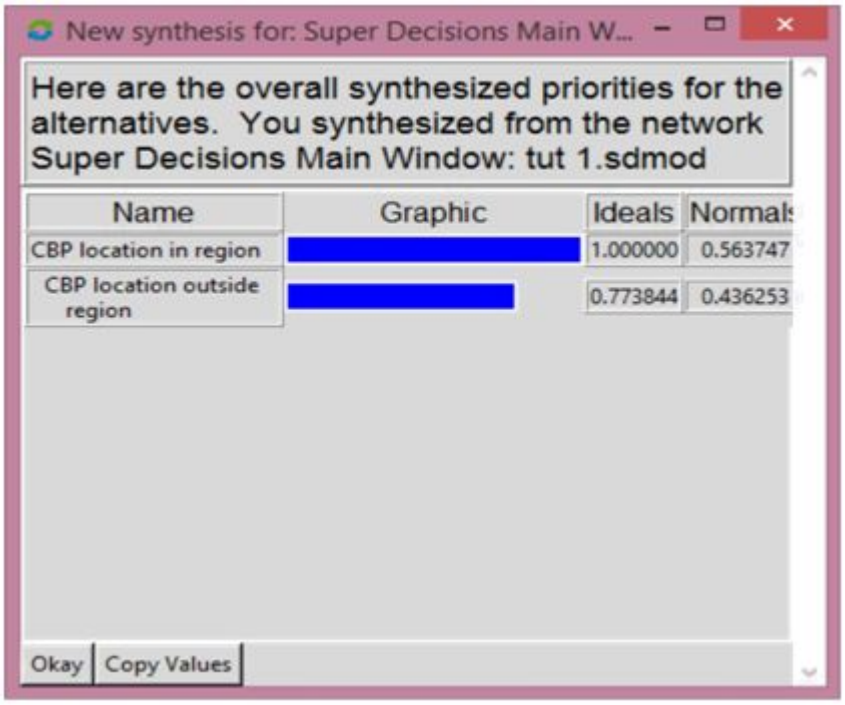

Figure 6: the result for the best CBP location

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ISSN: 2394-7659
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International Journal of Engineering Researches and Management Studies

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