# The Application of Analytic Hierarchy Process to Select Load out Method

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Abstract: In the construction of an offshore platform, one of the most important is the process of loadout. Loadout is the process of moving an offshore building from yard to top barge by moving the structure horizontally or by lifting method. The loadout process can be done in several ways by considering various factors both geometry and structure weight, as well as the availability of equipment needed during the loadout process. The Multi-Criteria Decision Making (MCDM) is a method of decision making to determine the best alternative from a number of alternatives based on certain criteria. This paper will discuss the best load out method for marine structures namely skidding, dolly and lifting method. The AHP results are derived from the expert judgments involve in marine structures. The Skidding method is the main priority with a weight of priority 0.521, then the Lifting method with a weight of priority 0.287 and Dolly method with a weight of priority 0.192.

## 1 INTRODUCTION

Construction of offshore platforms was built in an offshore fabricator. In the construction of an offshore platform, one of the important things is the process of loadout. Loadout is the process of moving an offshore building from yard to top barge by moving the structure horizontally or by lifting method (DNV.GL, 2017).

This process includes a fairly critical stage because the stability of the barge must be carefully calculated after the structure is a load on it (Chakrabarti, 2005). The load out process can be done in several ways by considering various factors both geometry and structure weight, as well as the availability of equipment needed during the load out process. One of the factors that is very important in the selection of load out methods is economic factors (Silvianita, et.al, 2016).

The Multi-Criteria Decision Making (MCDM) is a method of decision making to determine the best alternative from a number of alternatives based on certain criteria. Analytical Hierarchy Process (AHP) is the most popular method in Multicriteria Decision Making Method (MCDM). The AHP method is one of the most popular pair wise comparison methods used for decision making in Multi-Criteria Decision Making (MCDM). The AHP has been successfully applied in many areas to select the best alternatives (Silvianita, et.al, 2009; Shafiq and Silvianita, 2010; Silvianita and Kurian, 2013; Silvianita, et.al, 2018; Silvianita and Kurian, 2012, 2016).

## 2 BASIC THEORY

### 2.1 Loadout

Loadout is an activity to move the marine structures in the form of platforms, jackets, modules or other structures to the top of the barge to be transported to the site where the structure will be installed.Based on the method of moving the activity, process load out is divided into three types, namely (Silvianita, et.al, 2009) :

a. Skidding Method

Loadout activity with the skidding method is done by moving the structure onto the barge by placing the structure above the skid way. The structure is then tied with steel (sling) on the side of the barge.

b. Dolly (Trailer Method)

Loadout activity by this method is done by moving the structure using dolly (trailer). The advantages of



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this method lies in the ease of the process and the small chance of failure.

c. Lifting Method

Loadout activity with lifting method is carried out by lifting the structure by using several cranes which are then transferred to the barge.

## 2.2 Multi Criteria Decision Making (MCDM)

Multi-criteria decision making (MCDM) is a decision-making technique from several alternative options. Inside this MCDM contains elements of attribute, objective, and purpose. There are two categories of Multi-criteria decision making (MCDM), there are:

a. Multiple Objective Decision Making (MODM)
Multiple Objective Decision Making (MODM) concerns design issues, where optimization mathematical techniques are used, for very large numbers of alternatives (up to infinity) and for answering what and how many questions.

b. Multiple Attribute Decision Making (MADM)
Multiple Attribute Decision Making (MADM), concerning the issue of election, where mathematical analysis is not too much needed or can be used for selection only for a small number of alternatives. The Analytical Hierarchy Process (AHP) method is part of the MADM technique.

## 2.3 Analytical Hierarchy Process

Analytical Hierarchy Process (AHP) is a method of decision making with many criteria developed by Thomas L. Saaty by compiling several complex criteria into a structured and systematic hierarchy. The purpose of AHP is to calculate the overall score by combining the weights of various decision elements. The working principle of AHP is to form a problem structure (Saaty, 2003).

### 2.3.1 Basic Principles AHP

There are three basic principles in the AHP method, namely as follows (Saaty, 2003, 2008):

1. Decomposition

After the problem is defined, decomposition needs to be done, which is to divide the problem into smaller parts. The division process will produce several levels of problems. That is why the process of analysis is called hierarchy. In the hierariki's basic structure, the details of the relationship are displayed in a chart that is divided into 3 (three) levels. Level 1 is the goal of the hierarchy. Level 2 is a criterion in getting that goal. Level 3 is an alternative choice of these goals. The basic structure of the hierarchy can be seen in Fig.1.

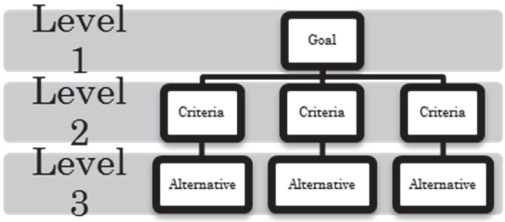


Figure 1: Basic Structure of Hierarchy.

2. Comparative Judgment

This assessment is the main point of the AHP method because it affects the priority of elements. The results of this assessment can be observed better if displayed in the form of Pairwise Comparison Matrix. namely a pairwise comparison matrix that contains the level of decision making preferences for alternatives based on existing criteria. The scale used to express the level of preference is the Saaty scale, where scale 1 shows the level of "equally important", scale 3 shows "moderate importance", scale 5 shows "importance", scale 7 shows "very important importance" and scale 9 shows the level of "extreme importance".

Table 1: Saaty's Scale.

| Level of Importance | Definition |
|---|---|
| 1 | As important as others |
| 3 | Moderate importance compared to others |
| 5 | Kuat pentingnya dibanding yang lain |
| 7 | Very strong importance compared to others |
| 9 | Extreme importance than others |
| 2,4,6,8 | The values between two assessments are close together |

3. Synthesis of Priority

From each Comparison Matrix, the eigenvector value is useful for obtaining local priorities. Because the Pairwise Comparison Matrix is available at each level, global priorities can be obtained by synthesizing between these local priorities.

4. Consistency Test

The consistency test is done in each paired matrix (pairwise comparison) to check whether the judgment is consistent or not. Measurement of consistency of a matrix is based on maximum eigen value. Thomas L. Saaty has proven that the consistency index of an

ordered matrix can be obtained by the following equation:

$$CI = \frac{(\lambda_{max} - n)}{(n-1)} \quad (1)$$

Where:
CI = Consistency ratio
λ_max = Maximum eigen value of matrix
n = matrix size

If CI is zero, the pairwise comparison matrix is consistent. The limit of inconsistency has been determined by Thomas L. Saaty by using the Consistency Ratio (CR). CR (Consistency Ratio) is a comparison between the consistency index value (CI) with the Random Index (RI) value. RI (Random Index) obtained from an experiment by the Oak Ridge National Laboratory was later developed by the Wharton School. The RI value depends on the order matrix n and can be seen in Table 2. Thus, the Consistency Ratio (CR) can be seen in the following equation:

$$CR = \frac{CI}{RI} \quad (2)$$

Where:
CI = Consistency Index
RI = Random Index

Table 2: Random Index Value (RI).

| n | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| RI | 0.0 | 0.0 | 0.58 | 0.9 | 1.12 | 1.24 | 1.32 | 1.41 |

| n | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|
| RI | 1.45 | 1.49 | 1.51 | 1.48 | 1.56 | 1.57 | 1.59 |

If the pairwise comparison has a CR value smaller or equal to 0.1, then inconsistencies may be accepted, otherwise the assessment needs to be repeated.

### 2.3.2 Steps for AHP Implementation

The steps in the application of AHP are as follows (Saaty, 1990):

1) Define the problem and determine the desired solution.
2) Create a hierarchical structure that begins with a general purpose, followed by selected criteria and alternatives.
3) Create a pairwise matrix depicting the relative contribution or influence of each element to a goal or criterion that is above the level. Comparisons are made by choice or judgment of decision makers by assessing the importance of an element over other elements.
4) Normalize the data by dividing the value of each element in the matrix in pairs with the total value of each column.
5) Calculating the eigenvector value and testing its consistency, if inconsistent then the data retrieval (preference) needs to be repeated. The eigenvector value in question is the maximum eigen vector value obtained.
6) Repeat steps 3, 4 and 5 for the entire hierarchy level.
7) Calculates eigen vectors from each paired comparison matrix. Eigenvector vector is the weight of each element.
8) Test the consistency of hierarchy. If it does not meet with CR ≤0,1 then the assessment should be repeated again.

## 3 RESEARCH METHODOLOGY

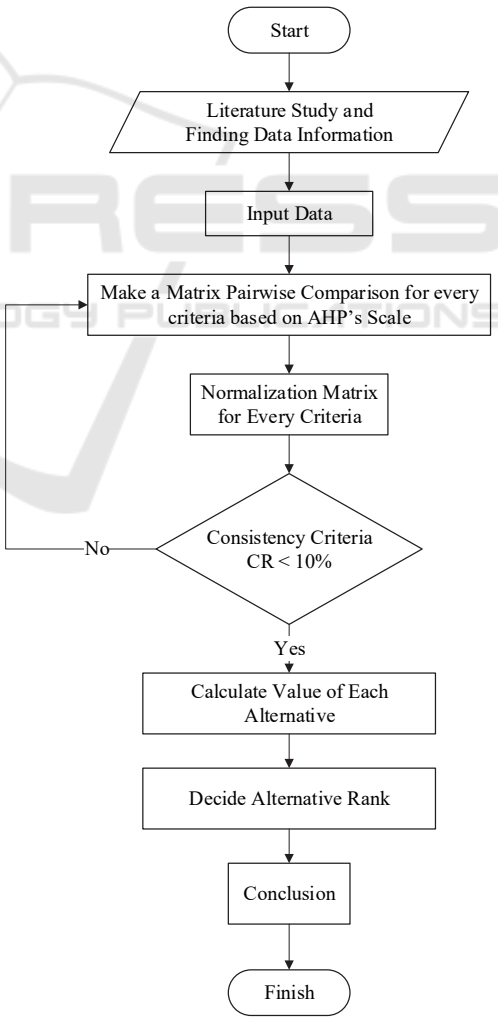


Figure 2: Research Methodology.

# 4 RESULTS AND DISCUSSIONS

## 4.1 Hierarchy Selection of Loadout Method

The Analytical Hierarchy Process Method (AHP) has four levels: first level is the goal, the second level is the criterion, the third level is the subcriteria and the fourth level is the alternative. The structure of the hierarchy can be seen in Figure 3.

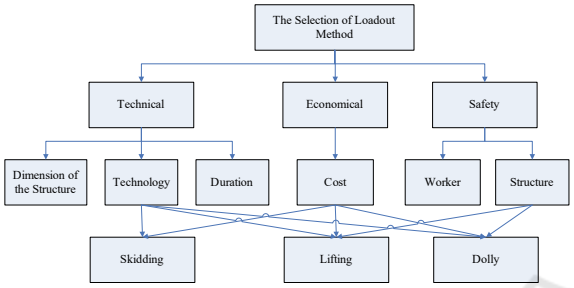


Figure 3: The hierarchy of Selection Load out Method.

## 4.2 Pairwise Comparison at Criteria Level

The data for criterion priority assessment is obtained from the expert judgment using Saaty's Scale of AHP. The results of the calculations are shown in table 3.

Table 3: AHP Output on Selection of Load out Method.

| Selection of Load Out Method | | | | | | |
|---|---|---|---|---|---|---|
| Critical Factor | Priority | Sub Factor | Priority | Skidding | Dolly | Lifting |
| Technical | 0.457 | Dimension | 0.340 | 0.249 | 0.066 | 0.025 |
| | | Technology | 0.054 | 0.041 | 0.005 | 0.009 |
| | | Duration | 0.006 | 0.006 | 0.009 | 0.048 |
| Economical | 0.240 | Cost | 0.240 | 0.169 | 0.051 | 0.020 |
| Safety | 0.303 | Worker | 0.248 | 0.020 | 0.047 | 0.181 |
| | | Structure | 0.055 | 0.033 | 0.013 | 0.009 |
| Priority of Maintenance on the Basis of Consequences | | | | 0.521 | 0.287 | 0.192 |
| Ranking | | | | 1 | 2 | 3 |

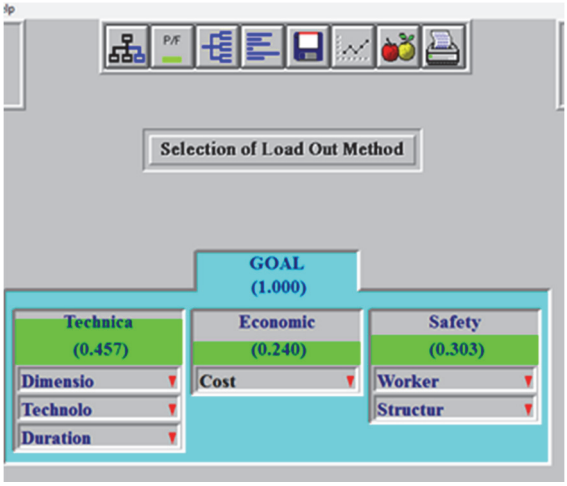


Figure 4: The Hierarchy using Expert Choice Software.

Fig 4 shows the hierarchy structure develop using Expert Choice Software. The Expert Choice Software gives the local and global priority. Fig 5 shows the weight of priority of the best load out method is Skidding with 0.521.

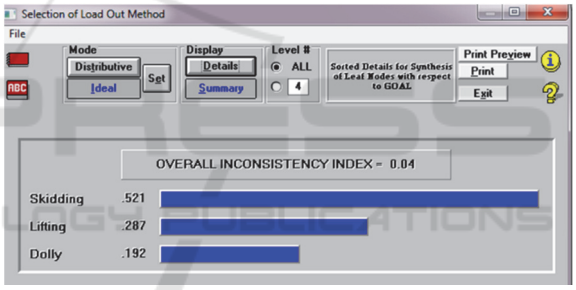


Figure 5: The weight priority of Load out Method.

# 5 CONCLUSIONS

From the analysis that has been done, it can be taken some conclusions as follows:

1. The criteria and subcriteria to select the best load out method using AHP are consisting of :
   a. Technical (dimensions of the structure, technology, and duration).
   b. Economical (cost)
   c. Safety (worker and structure)

2. The best alternative of load out process based on expert judgements are:
   a. Skidding method with a weight of 0.521
   b. Lifting method with weight of 0.287
   c. Dolly method with a weight of 0.192

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