Factor Influencing Basecamp Location Selection of Highway Projects Based on Spatial Analysis

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Abstract. The highway project has a significant challenge in carrying out its work. The procurement of massive and constant materials is a significant problem. There are problems in basecamp selection: high transportation costs due to the distance to the raw material from the quarry, and on a managerial level, selection of basecamp location is the basis for construction firm management in controlling costs, time, and quality of the project. The literature review has mapped technical and non-technical factors in two decades. However, the lesson learned from historical data as a basis for decision-making is limited—the mileage factor between the quarry to the basecamp and from basecamp to the project site. This study aims to analyze the factors that influence determining the basecamp location for highwayprojects. The research method used is a case study, with a qualitative approach strategy using a questionnaire from experienced parties in similar projects. Analytical Hierarchy Process approach and in-depth interview with the former technical manager of highway project from a construction company were used as a decision support tool. The results showed that a priority of basecamp selection was determined based on the factor of the distance from the base camp to the project site, the distance from the basecamp to the quarry, the plan for independent material production. Apart from technical constraints, licensing and social issues were a factor in the location determination stage. This study contributes to the decision-making model for selecting basecamp locations at the managerial level in a construction company.

Keywords: *basecamp, location, highway, spatial analysis*

1. Introduction

Highway projects have characteristics where work locations have long-range basecamp and quarry areas that affect material supply and demand. During the project, the crushed stone material to be used will be cheaper and the quality maintained if it is produced by the contractor [1]. The amount of material available must also meet the minimum requirements so that the work can continue. In the early stages of road construction out of town, the most important is determining the location of the basecamp and quarry. After knowing the distance between the basecamp and the quarry, the production costs can be calculated. Production costs are essential because they affect 80% of the total project cost (major item). If the distance between the quarry, basecamp, and the project location is far, the costs will also be higher [2]**.** Technical and environmental factors influence considerations for choosing a basecamp location. Technical aspects include respect of tools and potential quarry materials that can be produced during the construction process. Technically, the area of the basecamp will significantly affect the management of the AMP (Asphalt Mixing Plant) due to the need for the placement of raw materials, stone crushers, warehouse placements, and raw materials outside the site (reinforcement iron, sand, and precast) and on-site (cement, spare parts, oil, workshops, keet directors, a mess for employees and workers [3]. Another problem related to determining the basecamp is environmental factors. Material production and distribution activities in and out of the basecamp access road can disturb the community due to noise from stone crushers and dust flying due to the stone crushing process. Material transportation equipment in dump trucks (capacity 8 tons) and dump trucks (capacity 25 tons) endangers road users.

The cost of the most important highway project is determining the location of the basecamp because it is the basis for calculating the total cost over the life of the project. Some of the obstacles that often arise in determining the location of the basecamp among others, in terms of costs (i.e. the high price of stone material from the quarry, the long distance to transport materials from the basecamp [4], additional rent for basecamp land due to less material area, additional costs due to social impacts. , work quality problems (hot mix asphalt hot mix material used in carrying out hot mix is less so that the quality decreases) [4–6] and completion time of work (material production capacity).

Darwis and Yusiana [7] examines the use of historical analysis methods to determine the production budget. The method used is historical data analysis of sales budgets for the last five years, and forecasting to determine future production budgets using the least squares forecasting method. The purpose of this research is to determine how much production in the future must be produced, so that the problem of shortage or excess inventory of finished goods can be overcome by forecasting the production budget in the future. Experiences recorded in historical data can be used as a reference in determining future projects.

The number of traffic accidents studied by Haryono et al. [8] with a study of the Automatic Clustering-Fuzzy Time Series-Markov Chain model in predicting historical data on the number of traffic accidents in the city of Malang. This study develops a fuzzy time series forecasting model with the formation of automatic clustering and the final forecasting process uses the Markov chain concept. The model is used to predict the number of traffic accidents in the city of Malang in the future. The use of historical data is also applied to indicate the number of casualties. While the comparison model used uses ordinary fuzzy time series and to find out how accurate the developed model is, MAPE (Mean Average Percentage Error) is used.

Gunawan [9] also uses historical data in an extended study of historical data representative of the stochastic model. A stochastic model generates new data sets based on historical data and has statistical parameters similar to statistical information. Forecasting methods were developed based on statistics and mathematics. Historical data is used in observation or sample data. Data limitations are the main obstacle in the data extrapolation process. Synthetic data were then used to calculate statistical parameters. The error of the resulting data is measured by the relative error. The relative error is the result of dividing and subtracting the statistical parameters from the generated data and the statistical parameters from the historical data the longest and statistical parameters from the generated data. The mean error of the resulting data must be lower than 5% so that the average of the resulting data has a minimum validation level of 95%.

The variety of problems and characteristics of highway project locations in Indonesia causes the decision-making process to select a basecamp location is not easy. Base practice, the decision-making method for choosing a basecamp location will be accurate if it is carried out by engineers who have sufficient experience. However, Indonesia's variety of environmental and social problems causes not many contractor companies to have sufficient competence and experience. In addition, the absence of a reliable historical database in the decision-making process to determine the basecamp location can be used sustainably. Depending on several experienced engineers in national contractor companies due to managerial decisions that often change positions after several project periods. The knowledge transfer gap in determining the location of this basecamp often causes the regeneration of technical managers to be not a priority for a company. Often with the completion of the project, the project team ends. Research on the use of historical project data and the competence of experienced engineers in a company in a decision-making model for determining the location of this basecamp is an innovation for the management of contractor companies in Indonesia. The learning process from the aspect of the typology of problems and the simplification of the location selection model based on engineering economics is an effort to fill the gap in the sustainability of the regeneration of valuation competencies in future highway construction projects. This study intends to formulate a managerial tool in making decisions to determine the location of the basecamp for highway projects in the form of a model that can represent the phenomenon of problems in the field based on historical project data. The purpose of this study is to analyze the influencing factors in determining the location of the basecamp and build a model framework for assessing the area of the basecamp using historical data from selected highway projects.

2. Data and Methods

2.1 Data Collections

Data collections are derived from historical data for out-of-town road projects from a contractor company. There are two types of data obtained, technical data and non-technical data. The technical data used was obtained from the former employee questionnaire survey from highway projects from the selected case study (Figure 2). Complementary to the questionnaire, survey data was corroborated in-deep interviews with the project manager and site manager about decision-making principles in selecting basecamp. There are two technical data used in this research, namely primary and secondary data. Primary data is taken directly from respondents who are experienced and competent in making basecamp decisions at contractors. He has more than ten years of experience and is involved in the process from the initial survey, calculating material production costs and identifying risks and opportunities in deciding basecamp. Interviews were conducted by providing a list of questions. Resource persons provide information about the main factors that are considered in choosing a basecamp. During the interview, the selection of factors for choosing the basecamp location was explored. Respondents were asked to explain the impacts that might occur in determining the basecamp and the estimated costs that might arise in a project. Secondary data observed from each project location that has been worked on includes: the distance from basecamp to quarry, distance from basecamp to work location, quarry location, basecamp area, land rent, land contour, land maturation costs, the access road to basecamp, distance from basecamp to residents' houses, Possible expansion of basecamp land. Secondary data is taken from the historical data of the final project report and the description of the experienced project team in it. Any information taken in secondary data consists of problems in the field and sketches of the project location. Non-technical data used in determining the location are all components that can cause basecamp operational costs. Operational costs include land rent, communication, and compensation costs for tree cutting and land acquisition coordination.

2.2 Research Method

Data analysis techniques are fundamental in identifying all the priority factors that influence decisions in determining basecamp. Basecamp, anywhere and what the obstacles are obtained from the answers given by the respondents. The consideration in taking the basecamp as the object of research was informed by seniors in out-of-town road projects which will later be related to the company's sustainable managerial development.

To find out the most dominant factor in the selection of basecamp, an in-depth interview was conducted and will be analyzed using the AHP method. The dominant factors from the AHP results will be continued by calculating the number of elements used in each type of basecamp. And then compare the composition of the basecamp type with the optimal basecamp composition in a financial feasibility study to determine which factors provide the most optimal level of convenience and profit.

3. Results and Discussion

Cost considerations are essential to be taken into account in the transportation of materials because the realization in the field will be different from what was planned [1]. Costs are affected by the state of the path to the location; the characteristics of the material, and the distance to be traveled. So that in some project locations it is very risky for losses due to transportation of this material. This study focuses more on the commercial aspect, with the main priority being the distance of material transport from the quarry to the basecamp [10].

Revealed the priority in deciding the location of the basecamp, namely the smooth distribution of goods in the work process, greatly determining the performance of the project. Mobilization from the basecamp location to the field and to the quarry is a determining factor for work capacity. In this case, the mobilization referred to is the movement to the project location, between locations within the project, and from within the project location to outside the project location. This is greatly influenced by the provision of project roads and the delivery time of tools or materials. This study focuses more on the capacity of the work to be carried out on time, and the priority of this research is the distance from basecamp to the quarry, and the travel time of the vehicle required to carry the material.

This study conducted interviews with several respondents who have experience and play a role in determining the location of the basecamp as described in the research data. Respondent 1 believed that the main priority in deciding the basecamp is the distance to the BC location. It is said that the most important is when setting-up the project by setting the position of the quarry and basecamp. Because all work is transported the same distance and the frequency is by the total volume of material. Respondent 2 shared a similar opinion that the priority is on the assumption of purchasing materials to supply needs during the project. If the project produces its material, the basecamp position is closer to the quarry. This is done so that the material transportation costs become more economical. Second, if the project purchases materials from outside the area, the basecamp location will be brought closer to supporting transportation. For example, in East Kalimantan, the supply of crushed stone is taken from Buton Island, Sulawesi, using barges.

Barges transport crushed stone material by sea and carry out loading and unloading of goods at the port. Required loading and unloading equipment in the form of excavators and renting land at the port for unloading materials. From the temporary stock location at the port, the material is transported again to basecamp. The high cost is the cost of renting land at the port. So that the land lease time is not long, the transportation of materials must have a large capacity. The closer the basecamp to the port is, the lower the cost and the larger the capacity. Respondent 3 argues that from an operational point of view, the priority of determining the basecamp is based on the location of the basecamp being in the middle of the project link, far from settlements, easy access, free of flooding, and a minimum land area of 3 hectares. The middle position of the link is intended to obtain cheap transportation costs to all locations, both to STA zero and to STA locations at the end of the work.

Table 1. Priority Rank for Basecamp Location

Priority Rank	Respondent 1	Respondent 2	Respondent 3
1	The location of the quarry that meets the specifications and the deposit is sufficient	material purchasing assumptions	Basecamp position in the middle of Link
2	The location of BC is near the quarry and in the same direction as the project site	BC position near the quarry	Far from residential/ community house
3	BC access road	low cost of transporting materials	easy access
4	Social, customs, and security	Possible future projects (marketing)	Free from flood
5	Commercial		Minimum land area 3 hectares

The effectiveness of the transportation costs alone affects most of the material costs themselves, because the calculation is according to the distance function. The next factor is far from settlements, ensuring that disturbances while operating at basecamp and the work process can be minimized. Easy access is also an important factor, because it affects the capacity of dump trucks used during the project. So that with easy access the costs incurred become more efficient. On the other hand, it is also checked whether the location is flooded or not when it will be used for basecamp land. Checks can be seen through the contours of the local land, or from information from residents about the surrounding area during rainy weather. The water that rises from the surface of the river can overflow and become a flood. Thus, it needs to be avoided if the location is close to the river and has a lower elevation than the surrounding land. Then the location of land that is wider than 3 hectares also affects. The different experiences of the three respondents show the diversity of priorities in determining the location of basecamp. However, commercial factors are very dominant in determining the selection of the basecamp to be built. The priority rank of the three respondents is presented in Table 1.

As a justification of the interviews with the three respondents, the AHP analysis was continued with the priority order of basecamp selection as presented in Table 2.

Table 2. Priority Factors Basecamp Choice

No	Factors	Normalized	Idealized
1	Basecamp distance to Quarry	0.3023	1.0000
2	Distance from basecamp to job location	0.2003	0.6626
3	Assumptions Independent material production or purchase	0.1492	0.4937
4	Basecamp land area	0.1026	0.3396
5	Access road to basecamp	0.0800	0.2646
6	Basecamp land rental and maturation costs	0.0564	0.1867
7	Community culture/customs	0.0418	0.1381
8	Basecamp land ownership status	0.0271	0.0896
9	Distance from basecamp to resident's house	0.0251	0.0830
10	Social conditions / community livelihoods	0.0152	0.0504

Based on Table 2, the priority for selecting basecamps in Highway projects is the most dominant commercial factors, namely the distance between quarry to basecamp, distance from basecamp to work location, and the assumption of material purchases. Other aspects such as culture and the condition of the access road closest to the basecamp location are still not a priority.

The last stage in this research is synthesizing historical data on the basecamp typology from 14 project sites that contractor companies have carried out. The synthesis method is carried out by comparing the similarity of the characteristics of the basecamp location based on ten factors that influence decision-making by engineering managers at contracting companies. Basecamp typology, according to its features, is divided into six types. Basecamp activities are distinguished based on the production characteristics of the AMP material as the primary basis for site selection. BC's distance to community settlements and the existence of local access are the second-level considerations. The third level is the location permit factor based on the number of landowners and the type of ownership, as customary land or family-owned land. The results of the typology of the basecamp location are presented in Figure 1.

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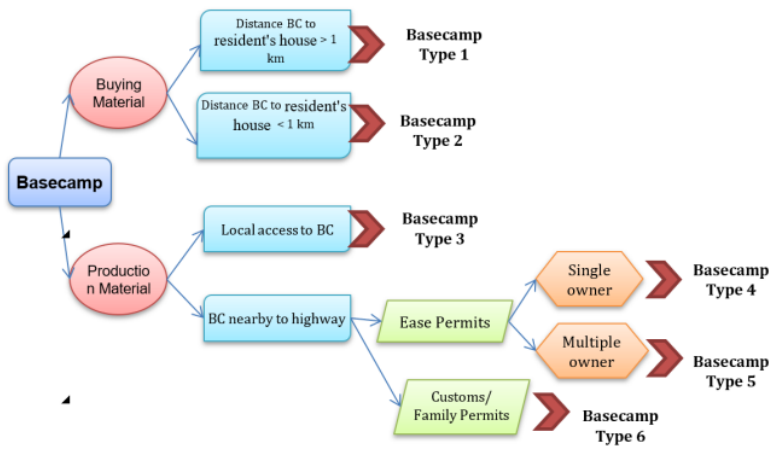

Figure 1. Typology of Basecamp from Historical Data

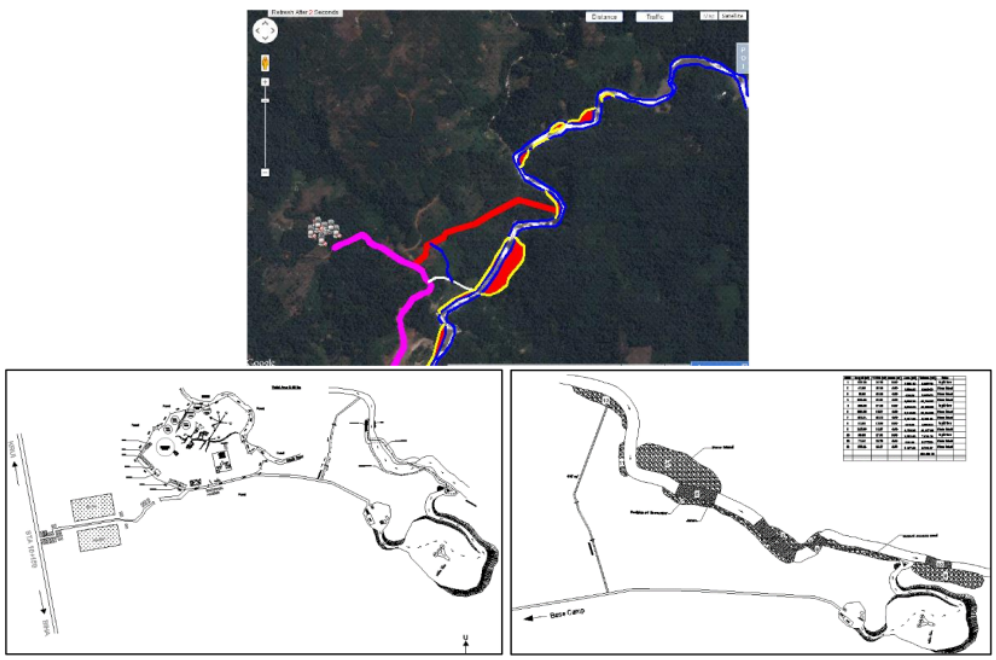

Figure 2. Case Study Basecamp Arrangement at Way Tenumbang

4. Conclusion

Local community livelihoods. The most influential factors in determining the basecamp location are technical factors related to commercial aspects, including the distance from the basecamp to the work location, the distance from the basecamp to the quarry, the assumption of independent material production or purchase and the area of the basecamp land. Non-technical factors are not a priority even they play a role in the decision of BC location. In addition, access roads to basecamp, distance from basecamp to residents' homes, rental fees and basecamp land maturation, culture/customs of the community around basecamp, status of basecamp land ownership, social conditions. The synthesis of these influencing factors can provide six basecamp locations typologies based on historical data on road projects used in this study. Building a decision-making model for selecting a basecamp location with historical data has the advantage of providing realistic boundaries at the managerial level. Automation of historical data-based decision-making processes is a necessity in the digital era. Transferring knowledge to inexperienced engineers would be a part of the lesson learned of sustainability in the construction industry.

5. Acknowledgments

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