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Subcontractor Selection and Risk Analysis Using Failure Mode Effect Analysis (FMEA) and Analytic Network Process (ANP) Methods (Case Study at PT. XYZ)

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Abstract- The purpose of this research is to investigate and analyze the subcontractor selection process in the context of PT. XYZ. This study also aims to apply two analytical methods, namely Failure Mode Effect Analysis (FMEA) and Analytic Network Process (ANP), in order to understand and manage the risks associated with the selected subcontractors. Selecting the right subcontractor for construction work is one of the keys to project success. Therefore, choosing a subcontractor requires the right decision. This study aims to create a subcontractor selection model for bored pile work by considering the risks of subcontractors by integrating the Analytic Network Process (ANP) and FMEA methods at PT XYZ. There are 7 criteria and 13 sub-criteria for boredpile subcontractors that have been confirmed by experts. While the criteria used include cost, work experience, quality, technical, HSE record, productivity, and financial capability. In addition, there are 8 identified risks for subcontractors from 7 criteria. Based on the results of the integration of the ANP and FMEA methods, the priority is for subcontractors B with a score of 0.7021, subcontractors A with a score of 0.6151 and subcontractors C with a score of 0.5524. From the results of the ANP and FMEA integration calculations, subcontractor B is a borepile work subcontractor that meets the criteria for selecting the right subcontractor and has a low risk compared to other subcontractors.

Keywords: Analytic Network Process (ANP); FMEA; subcontractor; Construction project.

1. INTRODUCTION

In toll road construction projects, there are several jobs that require specialist subcontractors (Raditya, Hardjomuljadi, & Amin, 2022) . The main contractor hands over specialist work to subcontractors with the aim that work can run more efficiently and minimize risks to work (Saputra, Yanti, Wiguna, & Nurcahyo, 2017) .

The selection of subcontractors is a matter of decision-making involving many people. At least in the selection of subcontractors, stakeholders must have confidence in the experience of previous subcontractors (Mahfuz, 2019) , knowing the track record and experts owned by the subcontractor, knowing the capacity of the subcontractor company and being able to weigh the workload on the ability of the subcontractor. This input was obtained from project stakeholders involving the Site Manager and Project Manager. Site Manager and Project Manager have perspective and experience in making decisions, and have responsibility for selecting subcontractors prior to implementing a project (Ruci & Kristiana, 2019) .

In practice, the selection process in the field has not used several criteria as a basis for evaluating subcontractor selection (Muhendra & Hasibuan, 2018) . In general, in the implementation of subcontractor selection, only the lowest price criterion is used. Therefore this research needs to be carried out as one of the improvements to the selection method system to minimize the risk of subcontractor selection errors. The use of the evaluation approach of the Analytic Network Process (ANP) method which is integrated with the Failure Mode Effect Analysis (FMEA) method is expected to realize the effective principle (Rizqiah, 2017) , efficient, competitive, transparent, fair and reasonable, accountable, responsible. and independent selection and clear selection criteria. With this research it is also possible to improvise methods at the stages of implementing subcontractor selection

2. METHOD

The subcontractor selection research method is based on the risk of subcontractor failure by integrating ANP and FMEA. This research will be conducted at PT. XYZ is a company engaged in the construction industry. The data needed in this research are primary data and secondary data. After getting the data, the next step is to perform data processing. Data processing is divided into two, namely data processing using ANP and FMEA.

The stages of data processing with ANP are as follows:

a. Develop a problem structure and develop a linkage model to determine the desired goals or objectives, determine criteria that refer to control criteria and determine alternative choices.
b. At this stage several experts will be given a pairwise comparison questionnaire using the ANP scale. The results of the questionnaire will be calculated the weight of each criterion. The weight calculation begins by adding up one column down for each criterion, then the value of each criterion will be divided by each of these sums. The results obtained will be averaged sideways on each criterion. The weight obtained at this stage will be processed at a later stage.
c. Then carry out a consistency test that aims to see the accuracy of the value assessment given by the expert. The consistency test calculation consists of the consistency ratio (CR) and the consistency index (CI).

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If the results of the consistency test show inconsistent weighting, then the numbers that are considered outliers will be removed and re-weighed. The results of the consistency ratio should not exceed 10% and the closer to 0 (zero) it indicates that the matrix is consistent.

d. Making a supermatrix consisting of 3 (three) stages, namely an unweighted supermatrix obtained from the results of weighting between criteria, a weighted supermatrix obtained from multiplying all elements of the unweighted supermatrix and a limit matrix.
e. The steps for calculating the ANP method will be carried out with the Super Decision software.
f. Calculating the rater agreement value from the data processing results of the Super Decision software.

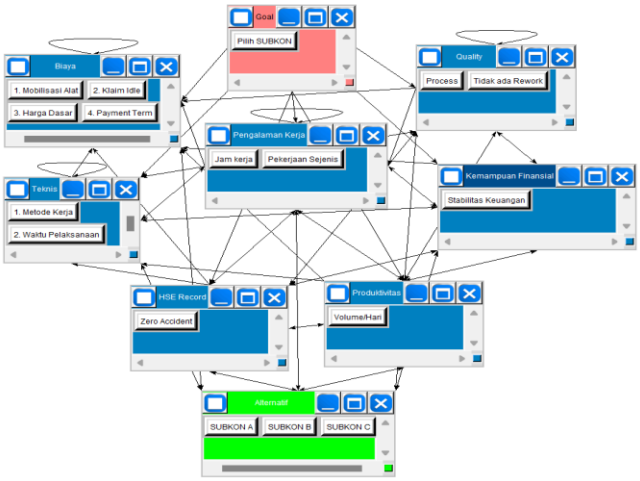

Figure 1. ANP Network Model

The next stage is to carry out a risk assessment using the FMEA method. In every construction activity it is necessary to evaluate the potential risks that may occur, both negative risks and positive risks. To obtain a list of risks, the selection of subcontractors for borepile work is carried out by conducting *interviews with project stakeholders to identify the appropriate risk profile.*

Table 1. Selection of the Risk List of Borepil Work Subcontractors

Criteria	***Fail mode***	***Effect Potential***	***Causes of Risk***	***Current Control***
cost	Increase in material prices (iron)	Decrease in company profits	There is an increase in the base price of iron ore (iron ore) in the global market	Include in the contract that the contract unit price cannot be changed and is the risk of the Subcontractor
	Rise in fuel prices	Decrease in company profits	There has been a change in government regulations	Include in the contract that changes in unit prices due to fuel price increases can be received *back to back* by *the Owner*
Work experience	Completion of work on time	Not achieving production targets	The process of carrying out work is hampered	Carry out *a Pre Construction Meeting* with an explanation of the implementation method before carrying out the work
Quality	Defects in work output	*Rework* and *repair*	an execution error occurred	Conduct periodic evaluations and control the suitability of the implementation method

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Technical	Incompatibility of implementation methods	Owner does not accept work	a work method error has occurred	Carry out *a Pre Construction Meeting* with an explanation of the implementation method before carrying out the work
HSE Records	work accidents occur to employees	The company's reputation is getting worse	Falls, object damage and drilling errors occur	Evaluate and control subcontractors regarding occupational health and safety.
Productivity	Delay in Completion of Work	Inhibiting the demands of the physical progress of work	Tool damage	*standby* mechanics at the project site
Financial ability	Maybe the performance is bad	Delayed work progress	Subcontractor negative *cash flow*	Evaluate the subcontractor

Data processing using the FMEA method consists of several stages, including:

a. Identification of subcontractor failure modes based on the selected subcontractor selection criteria. In identifying potential failures for each criterion, the researchers conducted discussions with experts.
b. Identify consequences of failures and potential causes of problems that occur.
c. Determine the Severity value, namely how big the impact of the failure that occurred.
d. Determine the occurrence rate, which refers to how often the failure occurs.
e. The determination of the detection value refers to the possibility of the detection method being able to detect the failure that has occurred.
f. Calculating the risk priority number or RPN

After getting the weight results from the ANP method and the RPN results from the FMEA method, then the ANP and FMEA integration stages are carried out with the following equation:

$$Risk\ discount = Bobot\ Kriteria\ dari\ ANP\ x\ (1 - Risk)$$

The weights obtained from processing ANP and RPN data obtained from data processing using the FMEA method will be input at this stage. The results obtained from this stage are the final weights used for subcontractor selection decision analysis.

3. RESULTS AND DISCUSSION

The selection of criteria and sub-criteria models is based on several literatures (Setiyadi & Agustia, 2018) . There are several aspects that researchers can use to determine criteria based on consideration of research needs. Considerations for subcontractor selection can be influenced by several criteria related to the subcontractor's reputation as assessed by experts (Susilo & Mahrozi, 2020) . Based on the criteria submitted to the expert, which consists of 7 criteria and 13 approved sub-criteria.

After the criteria and sub-criteria have been determined, identification of the relationship between the criteria and sub-criteria is carried out where this relationship greatly influences the feedback given from the criteria and sub-criteria. After knowing the relationship between the criteria and sub-criteria, the weight calculation is carried out for each criterion, sub-criteria and subcontractor (Kurniawan, Hasibuan, & Nugroho, 2017) . In calculating the weight of the ANP model, there are several stages consisting of building a network model, weighting, results of pairwise comparisons on subcriteria, results of pairwise comparisons of subcriteria-subcontractors, and sensitivity testing.

The model criteria and sub-criteria used for subcontractor selection are as follows:

Table 2. List of Criteria and Sub-criteria Confirmed by Expert

NO.	Criteria	Subcriteria	Description
1	cost	Tool Mobilization	Funding in mobilizing tools to work locations.
		Jobless claims	Claim costs for tool idle due to field constraints.

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		Basic price	Base price on borepile work.
		Term of payment	The ability of sub-contractors to provide companies with easy payment terms.
2	Work experience	Working hours	Number of hours worked by the subcontractor.
		Similar Jobs	Have experience in similar work on other projects.
3	Quality	Process	Ability to complete work with good process and quality.
		No Rework	The lack of rework due to the quality of the work does not meet specifications.
4	Technical	Working Method	Suitability of work with the method used.
		Execution time	Appropriateness of time in the execution of work.
5	HSE Records	Zero Accidents	Absence of events and ability to carry out HSE field procedures.
6	Productivity	Volumes/Day	Production capability of daily borepile jobs.
7	Financial ability	Financial Stability	Have good financial stability in the form of remaining real ability to complete work.

The next step after the ANP network model is formed is to calculate the weights where the results of the questionnaires from several experts are inputted into the Super Decisions application. According to Saaty (2016) the value of the inconsistency ratio in the application of Super Decisions must be less than 0.1.

After the calculation results from the Super Decisions application are continued to determine the calculation of the weight of the criteria, sub-criteria and alternatives that can be used for the decision-making stage in the subcontractor selection process. There are two types of weight calculations in ANP, namely local weights and global weights (Rimantho, Fathurohman, Cahyadi, & Sodikun, 2017) . Where the local weights are obtained from the results of the ANP network model obtained with the Super Decisions application. To determine the global weight calculations that are processed in Ms.Exel data results from the Super Decisions application so as to get the best weight results for subcontractor selection.

In the results of pairwise comparisons of criteria, sub-criteria and alternatives, there is an inconsistency ratio that measures the level of consistency of experts in providing an assessment of the questionnaire (Nurajizah, Ambarwati, & Muryani, 2020) . The results of the inconsistency of the criteria and sub-criteria for each expert are as follows:

Table 3. *Inconsistency Ratio* on Subcriteria

Criteria	Sub Criteria	R1	R2	R3	R4	R5	R6	R7	R8
cost	Tool Mobilization	0.0327	0.0870	0.0731	0.0258	0.0224	0.0183	0.0801	0.0151
	Jobless claims	0.0678	0.0701	0.0241	0.0625	0.0846	0.0293	0.0585	0.0202
	Basic price	0.0368	0.0508	0.0304	0.0410	0.0739	0.0255	0.0172	0.0610

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	Term of payment	0.0264	0.0179	0.0764	0.0658	0.0202	0.0604	0.0489	0.0565
Work experience	Working hours	0.0847	0.0570	0.0518	0.0886	0.0884	0.0695	0.0738	0.0636
	Similar Jobs	0.0409	0.0619	0.0643	0.0227	0.0151	0.0670	0.0409	0.0474
Technical	Working Method	0.0365	0.0276	0.0293	0.0242	0.0795	0.0725	0.0884	0.0872
	Execution time	0.0362	0.0481	0.0752	0.0159	0.0535	0.0499	0.0305	0.0684
Quality	Process	0.0479	0.0325	0.0801	0.0505	0.0649	0.0441	0.0258	0.0319
	No Reset	0.0366	0.0569	0.0564	0.0809	0.0363	0.0472	0.0879	0.0183
HSE Records	Zero Accidents	0.0186	0.0772	0.0527	0.0596	0.0211	0.0560	0.0575	0.0245
Productivity	Volumes/Day	0.0467	0.0697	0.0477	0.0453	0.0311	0.0586	0.0165	0.0846
Financial ability	Financial Stability	0.0516	0.0184	0.0228	0.0313	0.0254	0.0169	0.0837	0.0814

Table 4. *Inconsistency* Ratio on Criteria

Criteria	R1	R2	R3	R4	R5	R6	R7	R8
cost	0.0670	0.0241	0.0528	0.0117	0.0496	0.0668	0.0853	0.0814
Work experience	0.0462	0.0323	0.0673	0.0774	0.0555	0.0354	0.0877	0.0101
Technical	0.0781	0.0504	0.0793	0.0556	0.0563	0.0193	0.0262	0.0106
Quality	0.0791	0.0244	0.0142	0.0618	0.0201	0.0526	0.0358	0.0310
HSE Records	0.0631	0.0597	0.0477	0.0634	0.0277	0.0572	0.0101	0.0774
Productivity	0.0427	0.0139	0.0739	0.0143	0.0507	0.0103	0.0620	0.0339
Financial ability	0.0836	0.0703	0.0341	0.0531	0.0718	0.0467	0.0591	0.0502

Then enter the stage of calculating the weight values and ranking on the criteria and sub-criteria elements that affect the alternative weight values in the selection of subcontractors. At this stage, the results of comparing the pairwise relationships between criteria and sub-criteria by getting feedback from the alternatives that have been processed in the Super Decision application produce local weight values called Normalized By Clusters.

Table 5. Comparison of the relationship between the local weight values of sub-criteria pairs

Criteria	Sub-Criteria	*Normalized By Cluster*							
		R1	R2	R3	R4	R5	R6	R7	R8
cost	Tool Mobilization	0.1939	0.2082	0.1562	0.2011	0.1834	0.1869	0.1781	0.1971
	Idle Claims	0.2275	0.2290	0.2000	0.2380	0.2248	0.2088	0.2169	0.2156

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	Basic price	0.2657	0.2629	0.3843	0.2500	0.3215	0.3502	0.3441	0.2872
	Term of payment	0.3129	0.2999	0.2595	0.3109	0.2703	0.2542	0.2610	0.3002
Work experience	Working hours	0.4445	0.5714	0.4615	0.5455	0.5455	0.5882	0.5455	0.5882
	Similar Jobs	0.5556	0.4286	0.5385	0.4545	0.4545	0.4118	0.4546	0.4118
Technical	Working Method	0.4445	0.5455	0.5714	0.4348	0.4615	0.4348	0.4615	0.5000
	Execution time	0.5556	0.4545	0.4286	0.5652	0.5385	0.5652	0.5385	0.5000
Quality	Process	0.4445	0.4615	0.5000	0.4615	0.4444	0.5455	0.4615	0.5455
	No Reset	0.5556	0.5385	0.5000	0.5385	0.5556	0.4545	0.5385	0.4546
HSE Records	Zero Accidents	1	1	1	1	1	1	1	1
Productivity	Volumes/Day	1	1	1	1	1	1	1	1
Financial ability	Financial Stability	1	1	1	1	1	1	1	1

Comparison of pairs of sub-criteria elements for each criterion where the number of sub-criteria is not given a comparison of its own criteria and will be compared with other criteria so that criteria with only one sub-criteria will get a constant value which can also take into account the selection of subcontractors (Djingga & Heryanto, 2021) . in table 5 the local weight values are obtained from the results of the comparison of the sub-criteria obtained from the results of the expert questionnaire. For the local weight value, the pairwise comparison relationship between the criteria for the results of the expert assessment can be seen in table 6.

Table 6. Comparison of Local Weighted Values Comparison of Criteria Pairs

Criteria	***Normalized By Cluster***							
	R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**
cost	0.1341	0.1232	0.1359	0.1216	0.1228	0.1208	0.1278	0.1182
Work experience	0.0869	0.0849	0.0989	0.0844	0.0753	0.0792	0.0770	0.0822
Technical	0.1288	0.1183	0.1316	0.1174	0.1253	0.1234	0.1375	0.1174
Quality	0.1281	0.1196	0.1205	0.1280	0.1147	0.1286	0.1344	0.1217
HSE Records	0.1433	0.1449	0.1079	0.1396	0.1120	0.1269	0.1330	0.1349
Productivity	0.1644	0.2242	0.2044	0.2182	0.2505	0.2187	0.1605	0.2196
Financial ability	0.2145	0.1850	0.2009	0.1909	0.1994	0.2025	0.2299	0.2059

After calculating the local weight value of the criteria and sub-criteria elements, the results of the calculation of the alternative element local weight values are obtained, where all criteria and sub-criteria provide a comparison relationship for each alternative. So that alternatives provide feedback to all elements in order to

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provide value which greatly influences the selection of subcontractors on alternative elements. in table 7 the results of alternative local weights from comparison relationships that have feedback.

Table 7. Alternative Local Weight Value

Alternative	*Normalized By Cluster*							
	R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**
SUBCOTRACTOR A	2.2306	2.0674	2.0458	2.3313	2.4014	2.2028	2.5021	2.0014
SUBCONTRACTOR B	2.5014	2.3813	2.5986	2.1264	2.3563	2.6625	2.3604	2.5785
SUBCONTRACTOR C	2.2132	2.4951	2,3	2.4868	2.1868	2.0792	2.0826	2.3646

After calculating the local weight values for the criteria, sub-criteria and alternative elements, the next step is to calculate the global weight values and assign a rating to each element. Calculation of the global weight value uses the Geometry average, where the Geometry average is the average value obtained by multiplying all the data in one sample group. Then raised to the power of the number of sample data.

Table 8. Global Weighted Score Sub-criteria and Ranking on Each Criterion

Criteria	Sub Criteria	Global Weight	Rank
cost	Tool Mobilization	1.3132	4
	Idle Claims	1.5319	3
	Basic price	2.1403	1
	Term of payment	1.9333	2
Work experience	Working hours	3.9042	1
	Similar Jobs	3,034	2
Technical	Working Method	3.1799	2
	Execution time	3.7563	1
Quality	Process	3.4007	1
	No Rework	3,516	2
HSE Records	Zero Accidents	1	
Productivity	Volumes/Day	1	
Financial ability	Financial Stability	1	

In assessing the global weight and ranking of the sub-criteria for each criterion, where the highest sub-criteria weight value provides a more important comparison compared to the other sub-criteria for each criterion. In the global weight value in table 8, each sub-criteria has a ranking for each criterion where the highest global weight value will have the number one ranking value then based on the weight value obtained, as well as the global weight value in the criteria in table 9.

Table 9. Global Weighted Score and Rating Criteria

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Criteria	Global Weight	Rank
cost	0.1254	4
Work experience	0.0833	7
Technical	0.1248	5
Quality	0.1243	6
HSE Records	0.1296	3
Productivity	0.2054	1
Financial ability	0.2032	2

After calculating the global weight of the criteria and sub-criteria, then the calculation of the alternative global weight values obtained from the calculation results of the comparison of the local weight of the criteria and sub-criteria, making it easier to calculate alternative global weights that can be used to evaluate the selection of subcontractors to be selected. The results of calculating the global weight value along with the ranking of each subcontractor can be seen in table 10.

Table 10. Global Weighted Score and Alternative Ratings

Alternative	Global Weight	Rank
SUBCONTRACTOR A	0.3192	3
SUBCONTRACTOR B	0.3514	1
SUBCONTRACTOR C	0.3270	2

The results of calculating alternative global weight values and ranking where Subcontractor A gets the lowest global weight value, B Subcontractor B gets the highest global weight value and Subcontractor C has a global weight value between Subcontractor A and B Subcontractor. The global weight value can determine the best ranking, Table 10 shows that The first rank is in Subcontractor B where the global weight value is 0.3514, while Subcontractor C gets the global weight value of 0.3270 and gets the second rank and Subcontractor A gets the lowest score, namely 0.3192 so that Subcontractor A is the third ranked choice.

The selection of subcontractors in this study does not only use the appraisal method, but also considers unexpected deviations (failure modes) from subcontractor performance in accordance with the subcontractor selection criteria that have been set in the previous stage. This analysis phase uses the Failure Mode and Effect Analysis (FMEA) method to identify risks associated with unexpected deviations from subcontractor performance. (SANTOSO, 2021) . Each failure mode will identify the potential impact that will occur if the failure mode occurs (potential effect), then analyze the cause of the failure mode (risk cause) and analyze the controls being carried out (current control). The stages of conducting an FMEA assessment consist of identifying failure modes, assessing the severity value,

At the risk assessment stage that has been identified based on the subcontractor's assessment criteria refers to the assessment scale of previous studies. The scale used in the risk assessment in this study is 1-10 consisting of severity, occurrence and detection. Determination of severity, occurrence and detection values is adjusted to conditions and company policies through discussions with experts and based on subcontractor selection criteria.

The severity rating is used to assess how much impact the failure factor has, while events are used to assess the likelihood of the failure factor occurring (Mawarni & Moesriati, 2021) . Furthermore, detection assessment is used to detect the causes of failure factors before they occur. Questionnaires were distributed to experts to obtain a risk score for each subcontractor (Ocean, Hatmoko, & Wibowo, 2023) . The result obtained from this assessment process is the value of the risk priority number (RPN). The results of the assessment of each failure mode for each subcontractor can be seen in table 11 – table 13.

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Table 11. Failure Mode Value Subcontractor

Criteria	Fail mode	SUBCONTRACTOR A					
		S	HI	D	R	ep	RPN
cost	Increase in material prices (iron)	7	3	4	21	1.15	0.1589
	Rise in fuel prices	8	3	4	24	1.15	0.1866
Work experience	Completion of work on time	7	6	5	42	1.05	0.3963
Quality	Defects in work output	6	5	8	30	0.75	0.3982
Technical	Incompatibility of implementation methods	5	4	7	20	0.85	0.2458
HSE Records	work accidents occur to employees	10	3	5	30	1.05	0.2755
Productivity	Delay in Completion of Work	7	5	6	35	0.95	0.3623
Financial ability	An overachievement occurred	4	2	8	8	0.75	0.1371

Table 12. Subcontractor B Failure Mode Value

Criteria	Fail mode	SUBCOTRACTOR B					
		S	HI	D	R	ep	RPN
cost	Increase in material prices (iron)	7	7	5	49	1.05	0.4676
	Rise in fuel prices	8	7	5	56	1.05	0.5395
Work experience	Completion of work on time	7	4	6	28	0.95	0.2910
Quality	Defects in work output	8	3	8	24	0.75	0.3346
Technical	Incompatibility of implementation methods	5	3	8	15	0.75	0.2306
HSE Records	work accidents occur to employees	10	3	5	30	1.05	0.2755
Productivity	Delay in Completion of Work	7	4	5	28	1.05	0.2556
Financial ability	Maybe the performance is bad	4	2	8	8	0.75	0.1371

Table 13. Failure Mode Subcontractor Value C

Criteria	Fail mode	SUBCOTRACTOR C

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		S	HI	D	R	ep	RPN
cost	Increase in material prices (iron)	7	5	3	35	1.25	0.2629
	Rise in fuel prices	8	5	3	40	1.25	0.3121
Work experience	Completion of work on time	7	7	6	49	0.95	0.5027
Quality	Defects in work output	8	7	5	56	1.05	0.5395
Technical	Incompatibility of implementation methods	5	7	7	35	0.85	0.4032
HSE Records	There was an accident at work on the employee	10	4	5	40	1.05	0.3760
Productivity	Delay in Completion of Work	7	6	7	42	0.85	0.4727
Financial ability	Maybe the performance is bad	4	3	8	12	0.75	0.1925

The results obtained with the ANP method are the weight of subcontractors which are seen based on the performance or ability of each subcontractor, while data processing with FMEA is carried out a risk assessment for each previously identified subcontractor. The risk discount score is the final weight where the weight obtained from ANP will be given a discount based on the risk assessment that will occur to each subcontractor. The following is the result of calculating the Risk-discounted score which can be seen in table 14.

Table 14. Risk discounted score calculation results

Criteria	ANP			FMEA			Risk Discount Score		
	Subcon A	B subcontract	Subcon c C	Subcon A	B subcontract	Subcon c C	Subcon A	B subcontract	Subcon c C
cost	0.1878	0.1254	0.1232	0.1728	0.5036	0.2875	0.1554	0.0623	0.0878
Work experience	0.0825	0.0834	0.0865	0.3963	0.2910	0.5027	0.0498	0.0591	0.0430
quality	0.1371	0.1258	0.1186	0.3982	0.3246	0.5395	0.0825	0.0849	0.0546
Technical	0.0280	0.1243	0.1196	0.2458	0.2306	0.4032	0.0211	0.0956	0.0714
HSE Records	0.0848	0.0962	0.0449	0.2755	0.2751	0.3760	0.0614	0.0697	0.0280

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Productivity	0.1343	0.2055	0.2242	0.3623	0.2551	0.4727	0.0856	0.1531	0.1182
Financial ability	0.1845	0.2032	0.1850	0.1371	0.1271	0.1925	0.1592	0.1774	0.1494
Total	**0.8391**	**0.9638**	**0.9019**	**1.9880**	**2.0072**	**2.7740**	**0.6151**	**0.7021**	**0.5524**

In the process of selecting subcontractors at PT. XYZ integrates two methods, namely the ANP and FMEA methods, where the result of the FMEA calculation is the RPN value which will be used as a subcontractor subcontractor weight reduction obtained from calculations with ANP. The greater the value of the RPN, the greater the reduction in subcontractor weight. The subcontractor selection process in this study does not only look at the subcontractor's (positive) performance but also looks at the possible risks that will occur to the subcontractor. So that a subcontractor that has good performance and has a low risk will be the selected subcontractor or the best subcontractor. Table 15 shows a comparison of the results of subcontractor weights using the ANP, FMEA and ANP-FMEA integration methods.

Table 15. Subcontractor Weight Yield Comparison

Method	Subcontractor A		B subcontractor		C subcontractor	
ANP	0.3192	(Rank 3)	0.3514	(Rank 1)	0.3270	(2nd)
FMEA	1.9880		2.0072		2.7740	
ANP-FMEA integration	0.6151	(2nd)	0.7021	(Rank 1)	0.5524	(Rank 3)

In the results of integration calculations between the ANP and FMEA methods, when viewed from the subcontractor's weight value using the ANP method where this method assesses the subcontractor's performance meeting the subcontractor selection criteria, then subcontractor B is in first place. position with a weight of 0.3514. Furthermore, subcontractor C is ranked second with a weight of 0.3270, while subcontractor A is ranked third with a weight of 0.3192. However, there are differences in the results of the integration of ANP and FMEA, where the subcontractor selection process does not only consider the subcontractor's performance but also considers the risks that will occur.

It can be seen in table 15 that subcontractor B gets the highest weight of 0.7021 and is still in first place. While subcontractor A is ranked second with a weight of 0.6151 and subcontractor C is ranked third with a weight of 0.5524. Subcontractor B still ranks first in the assessment of subcontractors with ANP as well as with the integration of ANP and FMEA because subcontractor B has a low risk. Whereas for subcontractor C, even though it has the second position ANP weight, it has a high enough risk that it will provide a significant reduction in weight and make subcontractor C's rating change from second to third. So it can be concluded that subcontractor B is a subcontractor who meets the criteria and sub-criteria for subcontractor selection at PT.

4. CONCLUSION

Based on the results of the analysis and discussion, several conclusions are obtained as follows : The criteria and sub-criteria for subcontractor selection were obtained from several literature reviews conducted in research on the selection of subcontractors in construction companies. Of the several criteria and sub-criteria submitted to the expert, there are 7 criteria and 13 sub-criteria that have been confirmed by the expert. The weight of each criterion was obtained from the ANP method used, namely Productivity (0.2054), Financial Ability (0.2032), HSE Record (0.1296), Cost (0.1254), Technical (0.1248), Quality (0.1243) and Work Experience (0.0833)). The results of risk identification of subcontractors PT. XYZ, there are 8 identified risks from 7 criteria. Based on the analysis conducted, subcontractor A has the three highest RPN values, namely the risk of defects in work results, timely completion of work and delays in completion of work with consecutive values of 0.3982; 0.3963 and 0.3623. Subcontractor B has the three highest RPN values, namely the risk of rising fuel prices, rising prices of materials (iron), and defects in workmanship with consecutive values of 0.5395; 0.4676 and 0.3346.

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Subcontractor C has the three highest RPN values, namely the risk of defects in work results, timely completion of work and delays in completion of work with consecutive values of 0.5395, 0.5027 and 0.4727. Based on the results of the integration of the ANP and FMEA methods obtained from the risk discounted score calculation, subcontractor B gets the highest weight of 0.7021 in the first rank. While subcontractor A is ranked second with a weight of 0.6151 and subcontractor C is ranked third with a weight of 0.5524. From the results of these calculations it can be seen that subcontractor B is a subcontractor that is in accordance with PT. XYZ and has less risk than other subcontractors.

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