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DEVELOPMENT OF RISK-BASED STANDARDIZED WBS (WORK BREAKDOWN STRUCTURE) FOR COST ESTIMATION OF APARTMENT'S PROJECT

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ABSTRACT

The Work Breakdown Structure (WBS) forms the base for most project management processes. Despite each project being unique, most building retain cognate, elemental options that provide the basis for any structure, and these can be standardized and used as a basis for a universal programme of construction works. The standardization of task would enable the automation of project planning processes and hence would result in reduced management cost. This paper proposes the development of WBS Standard and analyzing the possible risks that arise in project implementation then consider those risks for the estimation process. The research focused on investigation of risk factor in activities of Standard WBS from contractors' perspective. The scope of this study was limited to apartment's projects only. Data was gathered using questionnaire survey from contractors who have built apartments. Investigations on the risk factor involved 36 risk factors classified in 6 categories derived from WBS's levels. Risk analysis found 6 high risks in 3 categories.

The findings of this study are expected to assist the contractor in the estimation process by anticipating the risks that arise in the construction implementation.

Keyword: Standard WBS, Cost Estimation, Risk factors

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1. INTRODUCTION

To achieve the objectives of the construction project requires high project management skills and careful planning. Good project planning and control will bring the project to success in terms of time, cost and quality. In order for the project to be effectively implemented, the work needs to be broken down into smaller parts. The planning and execution of these parts of work refers to a structure called Work Breakdown Structure (WBS). WBS is a framework for project implementation, as well as a means for planning, monitoring and controlling a project. Hall (1993) [1] argues that the greatest contribution to the success of a project is the appropriate use of WBS. Using the WBS approach, the project team can summarize information from previous project data to assist in the speed and timeliness of subsequent projects. WBS is a recurring process that can be used as a template for subsequent projects.

Haugan (2002) [2] stated that WBS is not a new concept in project management, but sometimes there are some mistakes in formulating it and not being used as it should for maximum effectiveness. The diversity of project team members' understanding of WBS, sometimes creates misinterpretation among team members in project implementation. Therefore, the formulation of good WBS will make the target of project scope, time and cost fulfilled. Zang, Wang and Zhan (2013) [3] in their research conclusion explains the WBS template and database standards need to be used to provide more accurate cost estimation, and also more effective in avoiding the negative risks in the project procurement process. Devi and Reddy (2012) [4] highligt that WBS is the basis of project planning, cost estimation, scheduling and resource allocation, therefore efficiency of WBS standardization can determine the success of the project.

Blyth, Lewis and Kaka (2004) [5] stated that research on WBS standardization begins when many problems arise that cause the project not to meet the quality objectives, time and cost and the assumption that the complexity of the construction project is so high that a template is needed to reduce the project work more simply. By applying WBS standardization, cost and time savings in the project planning process such as cash flow forecasting, resource allocation and cost estimation and more accurate in scheduling.

Cost is one of the limits to be taken into account in the construction project planning stage. Project planners are required to undertake accurate project cost planning for the project to be completed effectively and efficiently. From the above description, first, this paper discusses the standardized WBS development and the key issues to be addressed in the development process. Then find the risk identification in cost estimation of apartment's construction based on standardized WBS.

2. RESEARCH OBJECTIVES

The objectives of this research are :

1. To obtain a WBS standard for apartment's construction
2. To identify risks on apartment's construction that impact on cost performance

3. LITERATURE REVIEW

3.1. The Work Breakdown Structure

The Project Management Institute PMI (2013) [6] define the WBS as "a hierarchical structure that defines and organises the total project scope based on deliverables, with each descending level in the hierarchy representing an increasingly detailed definition of the project work". The aim is to ensure complete and proper definition of the entire work. The highest level of the structure represents the entire project. This is then subdivided into smaller elements that represent the next level in the hierarchy. The process continues until such a level when the entire project is deemed to have been sufficiently decomposed to allow for effective and efficient project control. The last level entries in the structure are referred to as work package and represent the level where responsibility for the performance of the work in each work package is assigned to an individual or organization. Globerson (1994) [7] submits that the size of a work package can be measured in units (e.g. budget, man-hours) and for each work package, there is an optimum size.

Colenso (2000) [8] detailed the necessary steps to follow in creating a WBS as follows:

1. Identify main deliverables from project statement of work or other project concept documentation. For a construction project, these documentations can be in the form of detailed drawings, specifications and bill of quantities.
2. Logically decompose each main deliverable into lower level entries. The process continues for all subsequent lower level entries until an appropriate level of detail is reached. Decomposition should be based on the 100% rule as follows: "The next level decomposition of a WBS element (child level) is 100 percent of the work applicable to the next higher (parent level)" (Haugan, 2002) [2].
3. Examine, adjust and validate the WBS. This is for checking completeness, making adjustments where necessary and ensuring that the developed structure addresses the main objectives of the project.

3.2. Risk Identification for Cost Estimation

In estimating project cost, we need to identify the main problem first, and take anticipation action to eliminate negative risk so that the cost estimation will improved. According to Perrot (2004) [9], cost estimates are an evaluation of all elements of a project that are given by agreement on a scope of work. While Dysert (2006) [10] discloses that cost estimation is a predictor of the costs required by a project based on the data and scope of the project provided and implemented at a predetermined location and time. Based on PMBOK (2013) [6], cost estimation is the process of developing the estimated financial resources required in the project The main benefit of this process is to determine the amount of costs required to complete the project. Costs should take into account the overall resources required in a project, including labour, materials, equipment. The purpose of making a cost estimate is:

1. As a basis for making project budgets
2. As a tool to control project costs
3. To monitor progress by comparing estimations and actual costs
4. To create a cost database that can be used for further planning

According to PMBOK 5th edition (2013) [6], risk is a potentially adverse event so that it does not reach the desired target or target. And project risk is an uncertain event or condition where, if it arises, it has a positive or negative effect on one or more project objectives in relation to the scope, scheduling, cost and quality of the project. A risk can have one or more causes and if it arises, it can have one or more impacts. A cause may be a particular potential requirement, assumption, constraint, or condition that makes possible a positive or negative outcome.

PMBOK 5th edition (2013) [6] also states that Project Risk Management is a process that includes, plans for risk management, identification, analysis, response plans and risk control in a project and Risk Management is a formal process in which risk factors are systematically identified, analyzed and addressed. In dealing with risk, Kezner (2005) [11] states tha there are four stages of the process that must be done namely:

1. Identify risks, ie observe conditions, identify and clarify potential risk events. There are various methods for identifying these risks. All sources of information that can determine the source of the problem can be used as a tool for risk identification.
2. Risk analysis, ie determining the possibility of a risk and its consequences. The result of this analysis is the acquisition of a level on risk factors. At this stage, a risk management option can be developed.
3. Risk Response (risk handling), that is handling of risk factors
4. Lesson Learned, a lesson from the previous case, which summarizes every analysis, findings and lessons learned in managing risk for the foreseeable future.

In a construction project, firstly we do the cost planning process. Costs for risk control need to be added in the overall project fund allocation. In addition, the provisions concerning contingency costs to be reserved should also be specified in risk management planning so that later costs will not be a barrier if a risk arises and exerts a substantial impact on the project.

Several researchers have identified risk factors in construction projects. In a study, Karim et al (2012) [12] identified a total 25 risk factors classified in 5 groups. And the most significant risk occurred in construction and finance. The major factors responsible for these risks are shortage of material, slow delivery in material, inadequate of technology, inadequate of quality and cashflow difficulty. Mansfield et al. (1994) [13] using a questionnaire survey conducted with contractors, consultants and developer, found 16 major causes of delays and cost overruns in Nigerian construction project, and they concluded that overruns are attributed to finance and payment arrangements, poor contract management, material shortages, inaccurate estimating and overall price fluctuations.

4. METHODOLOGY

This research is using qualitative approach to achieve formulation of standardized WBS for apartment construction. Secondary data analysis is conducted, using Bill of Quantity of 5 apartment's projects. A survey and deep interview was also conducted by means of a structured questionnaire to contractor's experts who have had more than 20 years experience in high-rise building construction projects. And the result is shown below:

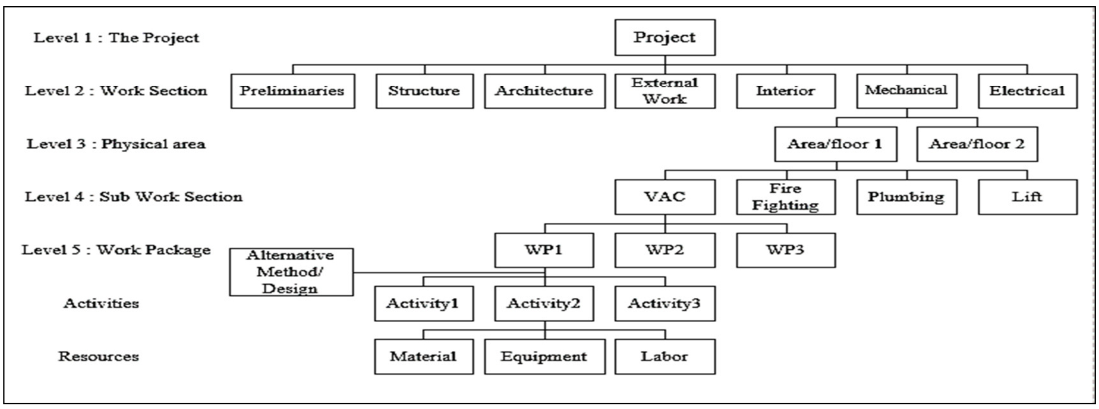

Figure 1 WBS for Apartment's Construction

Level 1 is for the project itself, level 2 is work sections, preliminaries, structure, architecture, external work, interior, mechanical and electrical works. Level 3 is for physical location, level 4 for sub work sections, in the above figure, VAC, firefighting, plumbing and lift are sub works for mechanical work. Level 5 is work package. The decomposition continues with activities and resources for the next levels.

After obtaining standard wbs, the next process is to identify risks based on the work packages and their activities from the standard WBS. Extensive literature review was carried out to identify common risk factor that may occure in construction projects that affect cost performance. The category or group of risk factor is work package, including its activities and resources. This resulted in identifying a total of 36 factors categorized in group as 1) Work Package 2) Alternative Method/Design 3) Activities 4) Material 5) Equipment 6) Labour. Based on the above, the risk variables used in this study are as follows:

Table 1 Risk Variables

CATEGORY	RISK EVENTS	
Work Package	X1	Poor in calculating volume of work
	X2	Work not scheduled
	X3	Inadequate contractor qualification
	X4	The determination of the subcontracted work type is not as necessary
	X5	Slow in deliver contract amount from contractor to subcontractor
	X6	Inadequate subcontractor's productivity
	X7	Unrealistic subcontractor's price
Alternative Method/ Design	X8	Poor in forecasting construction methods toward field condition
	X9	Improper construction methods planning
Activity	X10	Installation does not conform to specifications or plan drawings
	X11	Mistakes during construction
Material	X12	Scarcity of material as specification
	X13	Delay in material delivery
	X14	Excess usage of material
	X15	Material quality variance from specification
	X16	Change in material price
	X17	Poor material scheduling
	X18	Materials were stolen
	X19	Deviation of material volume purchased and ordered
Equipment	X20	Variance planned equipment's productivity from speccification
	X21	Equipment failure
	X22	Overpriced equipment
	X23	Poor equipment scheduling
	X24	Equipment not suited toward planned construction method
	X25	Improper of equipment specification
Labour	X26	Low Labour productivity
	X27	Lack of specialized labour
	X28	Shortage of labour

	X29	Labour on the implementation phase does not match the needs
	X30	Poor labour scheduling
	X31	Labour not ready to implement new construction methods
	X32	Loss of working hours due to labour accidents
	X33	Lack of qualified labour
	X34	The duties and authority of the workers are not as planned
	X35	Too much overtime
	X36	Over estimate labour's wage

Data Collection was carried out using questionnaire survey to understand the perception of the practitioners to the risk factors. The target respondents were the practitioner who had experience in apartment's construction project. Five point Likert scale was selected to obtain the probability of the risk factors in construction project that are identified in the literature review. A 5-point Likert scale was adopted, where 1) represents "rare" 2) "occasional" 3) "somewhat frequent" 4) "frequent", and 5) "very frequent". Likewise, the Likert scale was also selected to obtain the impact of the risk factors where 1) represented "very low", 2) "low" 3) "medium" 4) "high" and 5) "very high". Once the probabilities and impacts are determined, the risk score can be calculated with following expression:

$$R = P \times I \tag{1}$$

Where, R = risk factor, P = probability and I = impact. The probability and impact matrix or risk level matrix (Table 2) illustrates a risk rating assignment for risk factors. The risk matrix shows the combination of impact and probability as shown below:

Table 2 Risk Level Matrix

			Impact				
			Very Low	**Low**	**Med**	**High**	**Very High**
			1	2	3	4	5
Probability	Very frequent	5	5	10	15	20	25
	Frequent	4	4	8	12	16	20
	Somewhat frequent	3	3	6	9	12	15
	Occasionally	2	2	4	6	8	10
	Rare	1	1	2	3	4	5

Each of the risks placed in the table will fall under one of the categories in different colors. Here are some details on each of the categories:

1. High: the risks that fall in the cells marked with red color, are the risks that are most critical and that must be addressed on a high priority basis. The project team should gear up for immediate action, so as to eliminate the risk completely.
2. Moderate: the risk falls in one of the yellow cells, may affect cost performance, handled directly at the project level (project manager).
3. Low Risk: the risks that fall in the blue cells slightly effect on cost performance and handled directly by engineer or related parties

5. RESULT AND DISCUSSION

5.1. Demography Result

A total of 55 questionnaires were distributed of which 35 valid responses with rate of 70% were received back. The profile of respondents as summarized in table below:

Table 1 Profile of Respondents

No	Description	Total
1	**Position**	
	Manager, PM	4
	Coordinator/Supervisor	5
	Engineer	26
	Staff	5
2	**Work Experience**	
	≤ 5 years	26
	6 - 10 years	9
	11 - 15 years	2
	≥ 16 years	3
3	**Education**	
	Technical Highschool	4
	Vocational/Diploma	3
	Bachelor degree	29
	Master degree	4
	Total	40

And illustrated as shown below

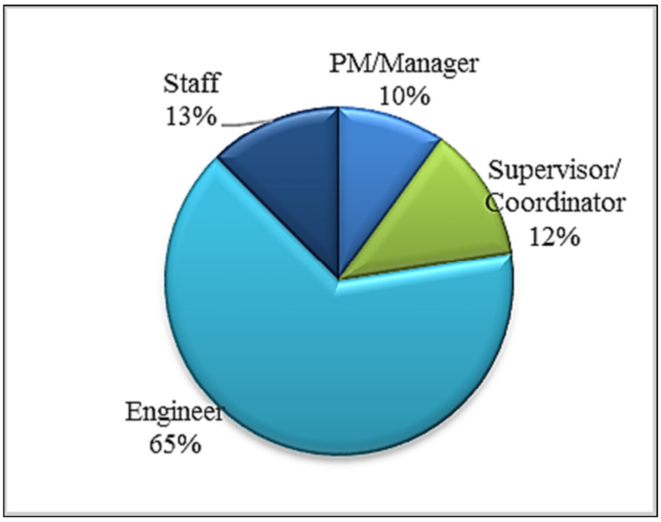

Figure 1 Rate of respondents based on position

Figure 2 indicates that the most respondents were engineers 65%, staff 13%, PM or managers 10% and coordinators 12%. As shown in figure 3, the respondents had various lengths of years of experience in handling apartment project.

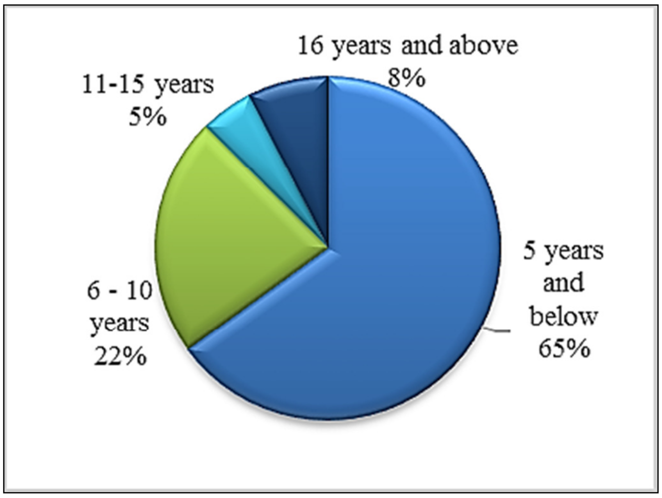

Figure 2 Rate of respondents based on working experience

Figure 3 shows that majority (65%) of respondent had working experience below 5 years, while 22% of respondents had working experience of 6 – 10 years, 5% of repondents had 11 - 15 years working experience and 8% of the respondents had working expeerience of more than 16 years. As shown in figure 4, the respondents had various education background.

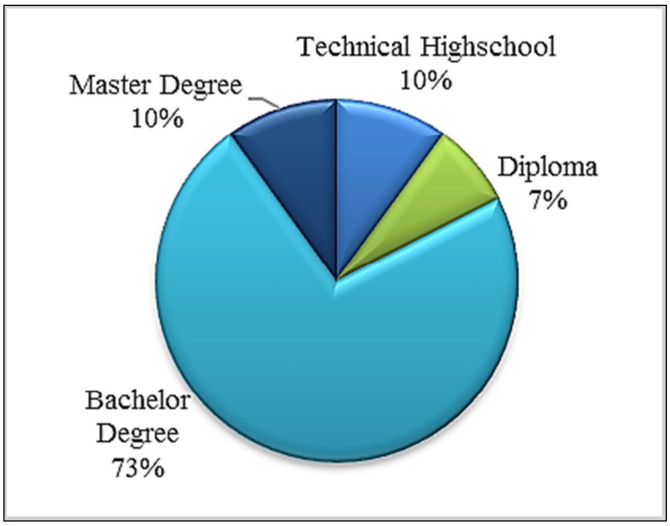

Figure 3 Rate of respondents based on education background

Figure 4 shows that majority (73%) of respondent had Bachelor degree, 10% of respondents had master degree, 10% from technical high school and 7% of the respondents had vocational education or diploma.

5.2. Validity and Reliability Test

In validity test, Pearson's correlation r was used to determine the validity of questionnaire. It was calculated using SPSS. First, all variables was calculated to see the correlation of each item variable with the total score, then compared the correlation value with table r with the level of significance α and degree of freedom N - 2. If r count > r table, then the item variable is valid, and vice versa if r count < r table then the variable is invalid. In this study, r table is seen at 95% confidence level or 5% significance for 2 side test with 40 respondents, so it has degree of freedom (df) = N - 2 = 38. Then we get r table = 0.312. Meanwhile, for r count obtained from data processing with SPSS, like the following table:

Table 4 SPSS Output for validity

Pearson's Correlation				
X1	.446**		X19	.583**
X2	.668**		X20	.775**
X3	.561**		X21	.727**
X4	.617**		X22	.735**
X5	.504**		X23	.797**
X6	.503**		X24	.665**
X7	.538**		X25	.747**
X8	.644**		X26	.697**
X9	.748**		X27	.764**
X10	.697**		X28	.691**
X11	.710**		X29	.778**
X12	.588**		X30	.841**
X13	.567**		X31	.753**
X14	.672**		X32	.626**
X15	.791**		X33	.826**
X16	.752**		X34	.782**
X17	.844**		X35	.808**
X18	.623**		X36	.742**
**. Correlation is significant at the 0.01 level (2-tailed).				
*. Correlation is significant at the 0.05 level (2-tailed).				

From the table above shows that all values of rare greater than 0.312. Based on the above table, the research instrument is valid.

In reliability test, cronbach alpha, α coefficient of reliability test was used to determine the consistency of the data obtained. It was calculated using SPSS and the result obtained was 0.756. This value indicates that the data were highly reliable compared to cut-off value of 0.7 (Note that a reliability coefficient of .70 or higher is considered "acceptable" in most social science research situations).

5.3. Ranking Study of Risk Factor

The six most important risk factors in this research are excess usage of material, poor in calculating volume of work, too much overtime, low labour productivity, change in material price, and inadequate labour. These significant factors are from three groups that is material, work package and labour.

Table 5 Ranking of Risk Factor

Variable	Risk Factor	Score	Rank	Category
X14	Excess usage of material	10.375	1	Material
X1	Poor in calculating volume of work	10.250	2	Work Package
X35	Too much overtime	10.225	3	Labour
X26	Low Labour productivity	10.150	4	Labour
X16	Change in material price	10.125	5	Material

X28	Inadequate labour	10.050	6	Labour
X27	Lack of specialized labour	9.400	7	Labour
X13	Delay in material delivery	9.225	8	Material
X18	Materials were stolen	8.725	9	Material
X6	Inadequate subcontractor's productivity	8.550	10	Work Package
X36	Over estimate labour's wage	8.550	11	Labour
X29	Labour on the implementation phase does not match the needs	8.525	12	Labour
X12	Scarcity of material as specification	8.450	13	Material
X2	Work not scheduled	8.350	14	Work Package
X8	Poor in forecasting construction methods toward field conditiion	8.300	15	Alt Method
X22	Overpriced equipment	8.300	16	Equipment
X33	Lack of qualified labour	8.150	17	Labour
X23	Poor equipment scheduling	8.100	18	Equipment
X9	Improper construction methods planning	7.900	19	Alt Method
X11	Mistakes during construction	7.825	20	Activities
X30	Poor labour scheduling	7.725	21	Labour
X20	Variance planned equipment’s productivity from speccification	7.675	22	Equipment
X31	Labour not ready to implement new construction methods	7.625	23	Labour
X17	Poor material scheduling	7.575	24	Material
X5	Slow in deliver contract amount from contractor to subcontractor	7.375	25	Work Package
X21	Equipment failure	7.375	26	Equipment
X3	Inadequate contractor qualification	7.100	27	Work Package
X10	Installation does not conform to specifications or plan drawings	7.075	28	Activities
X34	The duties and authority of the workers are not as planned	7.050	29	Labour
X19	Deviation of material volume purchased and ordered	6.900	30	Material
X15	Material quality variance from specification	6.875	31	Material
X32	Loss of working hours due to labour accidents	6.875	32	Labour
X7	Unrealistic subcontractor’s price	6.825	33	Work Package
X24	Equipment not suited toward planned construction method	5.775	34	Equipment
X25	Improper of equipment specification	5.500	35	Equipment
X4	The determination of the subcontracted work type is not as necessary	4.750	36	Work Package

5.4. Risk Response

Further, the validation of high risk factor is conducted by the experts who have had more than 20 years experience in apartment/highrise building project. Also conducted deep interview to analyze impact and cause also its preventive and corrective action.

Excess usage of material is the most dominant factor that is placed at rank 1. This result is true as materials are very important component in construction project, which attribute 70% of the total value of project [12]. Therefore, any problems related to construction materials would significantly affect the project [12]. This risk occurs because of inappropriate in calculating volume and poor supervision system. Preventive action needs to be taken is improving supervision system and hire competen estimator. The impacts of this risk are high waste of material and cost overruns. Thus, corrective action should be taken is to develop effective material usage procedure and material usage control.

Poor in calculating volume of work is the second rank of dominant factor. Poor in calculating the volume of work has an effect on the estimated cost. Cost estimates are highly dependent on the volume of work. This risk caused by, among others, the complexity of activities, changes in the scope of work, lack of team planning to understand the work, inconsistencies between drawings and work instructions. The preventive action need to be done are do recheck and hire competent cost estimator. Impact of this risk, the estimated cost becomes inaccurate and cost overrun occurs. Corrective action for this is do re-estimating.

The 3rd ranked risk factor is variable X35 that is too much overtime. This is occurs because of labour shortage and low labour productivity. Preventive action needs to be taken is project supervisor should increase supervision of labour or to do more simple construction method. This risk gives impact cost overrun and project objective not achieved. Corrective action for this risk is increase the number of labour.

The fourth ranked risk factor is variable X26, low labour productivity. This risk usually due to lack of skills and understanding of work method or it may be due to the low motivation of the worker. The preventive action is, for special works that require expertise; the contractor may hire a certified workforce. Impact of this risk is productivity target not achieved and delay. So corrective action need to be taken, among others, conducting training for workers and holding overtime hours.

The fifth rank risk factor is variable X16, change in material price. This is may be caused by scarcity of material in the market or lack of strategy in vendor selection. Preventive action for this cause are conduct survey to supplier to ensure the supplier's production capacity is adequate. Impact of this risk, among others, cost overruns and delay. Corrective action should be taken is conduct comprehensive selection of suppliers.

The sixth ranked risk factor is variable X28 that is shortage of labour. Labour shortage usually occurs in jobs that require special skills. The corrective solutions that can be done is increase the number of workers and add some equipment. Improving the supervision also can reduce this risk. The preventive solution is calculating and evaluates volume of work appropriately, so the number of workers required is appropriate as well providing experienced and competent workers.

6. CONCLUSIONS

The objective of this research is to develop standard WBS of apartment construction project and to identify risks which affecting to project cost performance.

First, the standard WBS developed with 5-level element WBS and 2-level its derivative, which is level 1 is for the project itself, level 2 is works section that is preliminaries work, civil/structure work, architecture, external work, interior, mechanical and electrical. Level 3 is for physical area/location, level 4 is sub work section and level 5 is for work packages. The 2-level its derivatives are level 6 for activities and level 7 for resources (material, equipment and labour).

Second, the risk identification which affects to cost performance that is a total of 36 risk factors classified in six group which is work package, alternative method/design, activity, material resource, equipment resource and human resource (labour). 6 high risks obtained are excess usage of material, poor in calculating volume of work, too much overtime, low labour productivity, change in material price and shortage of labour. Those risks are from 3 categories, work package, material resource and labour. Respon actions to those risks are also explained in this study. To minimize cost overruns, it is necessary to anticipate those risks in the cost planning process.

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