An analysis of building construction waste in Badung, Bali

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Abstract. Various activities in construction will produce waste, as a solid, liquid waste, or gas. Construction waste defines as a large number of an unused material from the construction process, such as overplus, broken, faulty materials, and can not be used, which disrupts the project's activities, financial losses, and environmental pollution. Handling the construction waste must involve all parties' commitment, good management, and a good understanding of the problem causing factors. As yet, waste management within the construction industry has been widely investigated by researchers. This research aims to identify and analysis the important causes of building construction waste, and the frequent activities, manage this waste in Badung, Bali, Indonesia. Data were collected through questionnaire survey and interviews with fifty contractors who has been handling building in 2014 to 2018. An analysis used is statistical factor analysis with SPSS 17, and scoring methods. The findings revealed that important causative factor of construction waste such as lack of skill and knowledge of the workforce, poor material handling, inferior material quality, and inappropriate work methods. The most frequent activity performed in existing projects are strict and regular monitoring of workers, material handling procedure and clear storage, an accurate estimate material to avoid overplus, good handling storage and reachable, well organized material delivery time.

1 Introduction

Increased budget allocation for infrastructure in Indonesia causes a significant influence on the number of construction projects. Construction project implementation always has positive and negative impacts. Construction waste is one of the project negative impacts, which disrupts the project's activities and causes environmental pollution. Construction and demolition account for a large share of total solid waste sent to the environment. Bossink & Brouwers [1] estimated that 15-30% of solid waste disposed of in a landfill is construction waste. This waste comes from the construction of new buildings as well as the old buildings. Wilson et al. [2] shown that more than half of the solid waste managed in 11 major cities in European is construction waste. While Ekanaya [3] pointed out that the amount of solid waste generated on construction in the Netherlands is 10% of the total amount of waste. In Indonesia, Nazez et al. [4] also researched the identification of

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construction wastes in road and highway construction projects in the greater Jakarta area. The study indicates that Work Execution has been identified as the most important group of causes of the construction wastes which 'inadequate proper construction equipment' has been suggested as the main contributor to this condition. As yet, waste management within the construction industry has not been handled properly. The parties involved assume that the construction waste is not useful, so he neglected without any action to exploit or reduce the volume in certain ways investigated. Therefore the research on the analysis of building construction waste in Badung is needed.

2 Literature review

2.1 Construction waste

Construction waste defines as a large number of unused material from the construction process, such as overplus, broken, faulty materials, and cannot be used. According to Yahya & Boussabaine [5] construction waste defined as an unused material as resulting from the construction process. While Skoyles & Skoyles [6] determine construction wastes is a material which needed to be transported elsewhere from the construction site due to damage, excess or non-use or which cannot be used due to non-compliance with the specifications. Another researcher defines construction waste a mixture of inert and non-inert materials arising from various construction activities like excavation, demolition, construction, renovation, and roadwork [7]. Based on all definitions, it should be understood that construction wastes are in the form of material losses, while the construction project was being carried out.

Investigating the main causes of waste generation on construction projects have become an active field of research in different countries [8]. According to [9-11], the findings of some noteworthy investigations in this regards are briefly illustrated in Table 1. All factors mentioned in Table 1 lead the construction waste which has an impact on the environment. Therefore, it is necessary for waste management to reduce and minimize a negative impact. According to [12], there are four important hierarchy in construction waste management:

1. The reduction is to reduce the use of materials which produce waste or the material efficiently, so it will directly reduce the waste generated.
2. Reuse is using the construction project materials as long as possible.
3. Recycling is reusing the remaining material by processing it into a reusable item.
4. Landfilling is the last option in waste management, i.e., the waste disposal to the final disposal site.

2.2 Factor analysis

Factor analysis is one of multivariate statistical analysis technique, that aims to reduce data. Furthermore, factor analysis is a data analysis to determine the dominant factors in explaining a problem. The primary purpose of this technique is to make a summary of the information contained in a large number of variables into a smaller group of factors and to determine the linear combination of variables that will assist to investigate the interrelationships of those variables. In other words, it is used to identify the variables or factors that explain the relationship pattern in a set of variables. This technique is useful for reducing the amount of data to determine a small number of factors that define a larger variance [13]. Reduction or summation number of variables into smaller is done by looking at the interdependence of several variables, into one called the factor. So that found the variables or factors dominate to be analyzed further. Factor analysis can be viewed as an

extension of the major component analysis, which is aimed at obtaining a small number of factors that have properties, i.e., be able to explain as much as possible data diversity, these factors are mutually free, and each factor can be interpreted.

Table 1. The cause of construction waste on-site.

No	Cause of construction waste on-site
1	Material cutting process that causes the pieces of rest.
2	There is no material cutting plan.
3	Poor quality of materials so easily damaged.
4	Workers Behavior of using the remaining pieces of material.
5	Mistakes/carelessness of workers when working in the field.
6	Damaged materials/ broken/ scattered.
7	Absence of applying waste management system in the project.
8	The equipment used is not working properly.
9	Contractor incompetence in handling of material available.
10	Unappropriate working methods.
11	Inadequate workforce ability in operating the equipment.
12	No material storage.
13	Unskilled workers.
14	Inexperienced workers.
15	Mistake in material mixing.
16	Accidental construction material damage.
17	Incompatibility between material and its storage method.
18	The poor transfer of material from the warehouse to the construction site.
19	Lack of strict and periodic supervision.
20	Difference of material size prepared with required material size.
21	Bad weather conditions.
22	Uncoordinated material arrival.
23	Wet conditions of the warehouse.

3 Methods

In order to achieve the research objective, various waste management performance factors are identified through extensive literature reviews. The questionnaire used for this research was divided into two main categories comprising 1) assessment of the factors leading to the occurrence of construction waste on construction projects, 2) questions for determining the current solution to reduce the incidence of construction waste. This is regarding the level influence of each factor to the occurrence of construction waste in Badung and the current type of handling. The questionnaire was designed based on a five-point Likert rating scale comprising effect levels of very high = 5, high = 4, moderate = 3, low = 2, and very low = 1. The developed questionnaire was pilot tested by sending it to twenty project managers. Feedback obtained was incorporated into the questionnaire before delivering the survey to the population of interest. The target population included various types of contracts involving all kinds of construction activities in Badung. The target population covered both private sector companies and the government sector. Invitations were sent out to 60 companies in October 2016, and 50 responses were received by January 2017. Returned questionnaires resulted in considering 50 properly-completed questionnaires manifesting a response rate of 83.33 percent. Then the analysis using factor analysis and scoring methods.

4 Results and discussion

4.1 Data collection

In order to prepare the data for further statistical analysis, some preliminary data screening, and cleaning were carried out which involved Validity and Reliability Analysis. Validity testing aims to measure the accuracy of the instruments used to measure the causes of construction waste in building projects at Badung Regency. An instrument validity is determined by $r > r_{table}$. The analysis using SPSS 17 found that all questionable items in the questionnaire produce are higher than $r_{table} = 0.444$, so all questions are valid. While reliability testing is the process of measuring the consistency of an instrument. Statistical testing using SPSS 17 by looking at the Cronbach's Alpha. If Cronbach's Alpha is greater than 0.7, then the instrument is reliable. The analysis obtained that Cronbach's Alpha is $0.941 > 0.7$, therefore, all items are reliable and can be used for further investigation.

4.2 Factor analysis

Factor analysis aims to reduce/ summarize some variables into several factors. The parameters to be considered in the factor analysis are Kaiser-Meyer-Olkin (KMO), Significance Probability, and Loading factor. The study using the SPSS program is done until all results meet the minimum value. The analysis obtained that the value of KMO statistics is 0.796 meet the minimum requirement of 0.5, the value of Sig (P-Value) from the Bartlett test is 0.000 meet $< 0,05$, the value of the loading factor specified at least 0.5. There was four formed factor from the statistical analysis as shown in Table 2.

From Table 2, the loading factor of the measured variable meets the minimum requirement of 0.5. Loading factor can be seen in the rotated component matrix table from SPSS output, which loading factor shows the amount of correlation formed between the variables measured by the cause of construction waste. For example, an item Q20 loading factor is 0.76 indicates that item Q20 correlates 76% with the occurrence of construction waste. So there are four factors causing construction waste in building construction, i.e., Lack of skill and knowledge, poor material handling, poor material quality, and inappropriate work methods.

Table 2. Cause factor of construction waste.

Factor	Code	Description item	Loading factor	New factor formed
Factor 1	Q13	Less skilled and expertise on labor	0.857	Lack of skill and knowledge
	Q14	Inexperienced/ less working experience of workforce	0.804	
	Q17	Incompatibility between material and its storage method	0.754	
	Q11	The ability of worker to operating kinds of tools	0.728	
	Q15	Error in mixing of material	0.720	
	Q12	Unprepared places of materials storage (warehouses)	0.650	
	Q16	Construction material due to accidental damage from a particular party	0.623	
Factor 2	Q23	Wet conditions of the warehouse	0.733	Poor material handling
	Q18	Transfer of material from warehouse to construction site	0.703	
	Q22	Arrival of material without coordinated	0.693	
	Q8	Equipment not working properly	0.510	
Factor 3	Q2	There is no planning on cutting material before the project starts	0.843	Inferior material quality
	Q4	Workers behavior in using waste materials	0.739	
	Q3	Using a poor material quality	0.732	
	Q5	Mistakes or carelessness of workers in the field	0.656	
Factor 4	Q10	Unappropriate working methods due to knowledge of work force	0.813	Unappropriate works methods
	Q21	Bad weather conditions	0.795	
	Q20	Differences between prepared material, size, and it's required	0.760	
	Q7	The absence of waste management system in the project field	0.703	

4.2 Dominant factor

Value of variance from the formers factor and the percent value of each factor variance determine the dominant factor which causes a construction waste. Factors with the largest percentage are the dominant factors causing construction waste. As shown in Table 3, the dominant factor, respectively lack of skill and knowledge, poor material handling, inferior material quality, and inappropriate work methods.

Table 3. Percentage value of variance

Factor name	Number of formed variable	Percent value of variance
Lack of skill and knowledge	7	42.28%
Poor material handling	4	13.20%
Inferior material quality	4	10.25%
Unappropriate works methods	4	5.86%

Table 4. Construction waste management.

Construction waste management	Scoring
Strict monitoring and regular of worker	85%
Have a clear material handling procedure	83%
A carefully estimating of material requirements to avoid over estimate	82%
Good material storage, easy to reach and avoid the weather	80%
Good coordination when delivery of material	78%
Make sure that equipment working properly.	76%
Using material base on its standard size	75%
Good cooperation with third parties as a reliable waste collector	73%
Segregation of organic and non-organic waste	73%
A clearly label of temporary dump	72%
Focus on material handling at temporary disposal sites	72%
Using the remaining material which enables to use	69%
Using good quality of material to avoid a construction waste	66%
The possibility of using fabrication material	66%
To identify and communicate waste management responsibilities	62%
Use of modular components	62%
Waste management training of worker	56%
Regular monitoring and evaluation of waste management	50%
Documentation and evaluation of waste weight and volume	49%
Identifying construction waste which allows for recycling	44%
Setting time for the recycling process	39%
Provide workers with rewards and incentives for their efforts and hard work in planning and manage of construction waste	37%

4.3 Construction waste management

Based on factors influencing the construction waste in Badung regency, then identification of the management activities undertaken. The analysis used scoring to determine the weighting of the management activities as shown in Table 4.

5 Conclusions

The finding of the research that contribute to the causes of construction waste of building projects in Badung Regency if sorted from the most dominant is, lack of skill and knowledge, poor material handling, inferior material quality, and inappropriate work methods. The most common management of construction waste building projects in Badung Regency categorized as 'reductions' such as strict monitoring and regular of worker, having a clear material handling procedure, a carefully estimating of material requirements to avoid overestimate, good material storage, easy to reach and avoid the weather and good coordination when delivery of material.

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