The estimated cost of work and K3 construction of retaining walls

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ABSTRACT

One of the methods used to control the stability of the soil so as not to experience a landslide is to build a retaining wall. In carrying out the work, of course, it is necessary to pay attention to occupational safety and health for all those involved in a project, including the community around the project, therefore, it is important to calculate costs before starting work, so that the project can be carried out properly according to regulations, objectives, functions, benefits, impacts, costs, quality, time, and K3 or occupational safety and health. This study aims to determine the cost of retaining a cliff wall using the main material of mountain stone/split stone, including labor costs, materials, tools, and occupational safety and health (K3) costs. This research uses quantitative descriptive method. To complete this research, we need data on the budget plan for the construction project for the construction of retaining walls, and factual costs at the project site. The data sources consist of project documents, contract documents, and direct observations on site. This research has identified the cost of materials, tools, labor, and K3 in units converted to cost/m^3, and produced a coefficient of unit price analysis for retaining wall work. The results of this study can contribute to estimating the cost of retaining wall work using mountain/split stone specifications at an early stage during planning, using unit costs/m3 of work, both by planners, contractors and the general public.

KEYWORDS
Estimated costs
Retaining wall
Landslide
K3 Cost
Job fee

1. Introduction

The land is a foothold and a place for a building to stand, so land is an important aspect that needs to be reviewed in construction planning, therefore, it is very important to pay attention to the soil stability factor [1]. One of the methods used to control the stability of the soil so as not to experience a landslide is to build a retaining wall [2]. A retaining wall is a structure built to hold soil that has a slope where the stability of the soil cannot be guaranteed by the soil itself [3]. Retaining wall buildings are used to withstand lateral soil pressures caused by fill soils or unstable original soils due to topographic conditions [4]. The construction of retaining walls must be based on the calculation of stability and safety factors because errors that occur in the construction of retaining walls can have fatal consequences, namely property loss and loss of life [5]. Therefore, we need a retaining wall design that is really stable and efficient, stable in terms of strength to support the magnitude of the overturning and shearing forces. The need for costs in making retaining walls directs us to the importance of having a Budget Plan (RAB), so there needs to be an estimate of costs in planning a job [6].

Cost estimation is a calculation carried out to plan the needs that will later be needed to complete a job [7]. In planning a construction project, cost estimation plays an important role in project implementation [8]. In the early stages, cost estimation is used to find out how much it will cost to realize a project [9]. Cost estimates on a construction project must be prepared before a project is

implemented, to determine the possible costs of a project [10]. Cost estimation is closely related to cost analysis, namely work that involves assessing the costs of previous activities that will be used as material for preparing cost estimates [11]. In other words, preparing a cost estimate means looking into the future, calculating, and making estimates of things that will and may happen. While the cost analysis focuses on the assessment and discussion of past activity costs that will be used as input [12]. In practice, the estimation of construction costs requires several different estimates based on the intended use or designation [13]. In the early stages of the project such as during concept preparation, feasibility studies, and preliminary design, it is clear that it is not possible to estimate based on the calculation of the quantity (volume) of work because usually job descriptions and specifications do not exist [14]. However, at these stages, an estimate is already needed in order to take into account project financing [15].

The importance of cost estimation does not make contractors forget the importance of occupational safety and health (K3), because occupational safety and health is the supervision of people, machines, materials, and methods that include the work environment so that workers do not get injured [16]. The cost of implementing SMK3 construction in the field of public works is allocated in general costs which include: preparation of RK3K, promotion of K3, work protective equipment, personal protective equipment, insurance and licensing, K3 personnel, health facilities, signs, and others related to risk control K3 [17].

The main purpose of this study was to determine the need for labor costs, material costs, tool costs, and the cost of the need for equipment for occupational health and safety equipment on retaining wall work. In addition, this study also aims to find out how long the work will take, and how much it will cost, and to produce a unit cost analysis coefficient in retaining wall work using mountain stone/split stone as the main material. The expected contribution of this research, for government agencies, planning consultants, project owners, contractors, and the community, it becomes easier to estimate the cost of retaining wall work, so that they can determine and prepare a budget before project implementation.

2. Method

This study uses a quantitative descriptive method. The research was carried out on the work of making retaining walls with a case study on the Cibaraja – Kadudampit road segment, Selajambe village, Cisaat sub-district, Sukabumi district with a volume of 204.82 m^3, using the main material of mountain stone/split stone. The equipment used in this study is a measuring instrument, stationery, and some other handyman equipment. To find out the costs used in the work of retaining walls, namely by making direct observations at the project site, and supported by other data, then analyzed using a mathematical formula into a unit of cost/m^3. This unit cost/m^3 includes the cost of materials, tools, labor, and K3 (Occupational Health and Safety) costs, and produces a coefficient of Work unit price analysis.

2.1. Research Data

The data used in this study is in the form of contract documents from the Public Works Department consisting of (SPK, HPS, drawings, tender documents, and others). The main data that need to be obtained during direct observation are:

- Volume/quantity of each work item
- The workforce that is employed includes workers, builders, head builders, foremen, and drivers
- Labor wages include workers, handymen, head craftsmen, foremen, and drivers
- The ingredients used, as well as the quantity
- Prices of materials used
- Equipment used in the work and its price
- Equipment used to control occupational safety and health (K3) and their costs.

2.2. Research Flow

There is a problem in financing the retaining wall work, especially related to the cost of occupational safety and health (K3), so this research begins with problem formulation, literature study, identification

of research data needs, data collection, data analysis, interpretation of analysis results, and so on. An illustration of the flow of this research is presented in Figure 1.

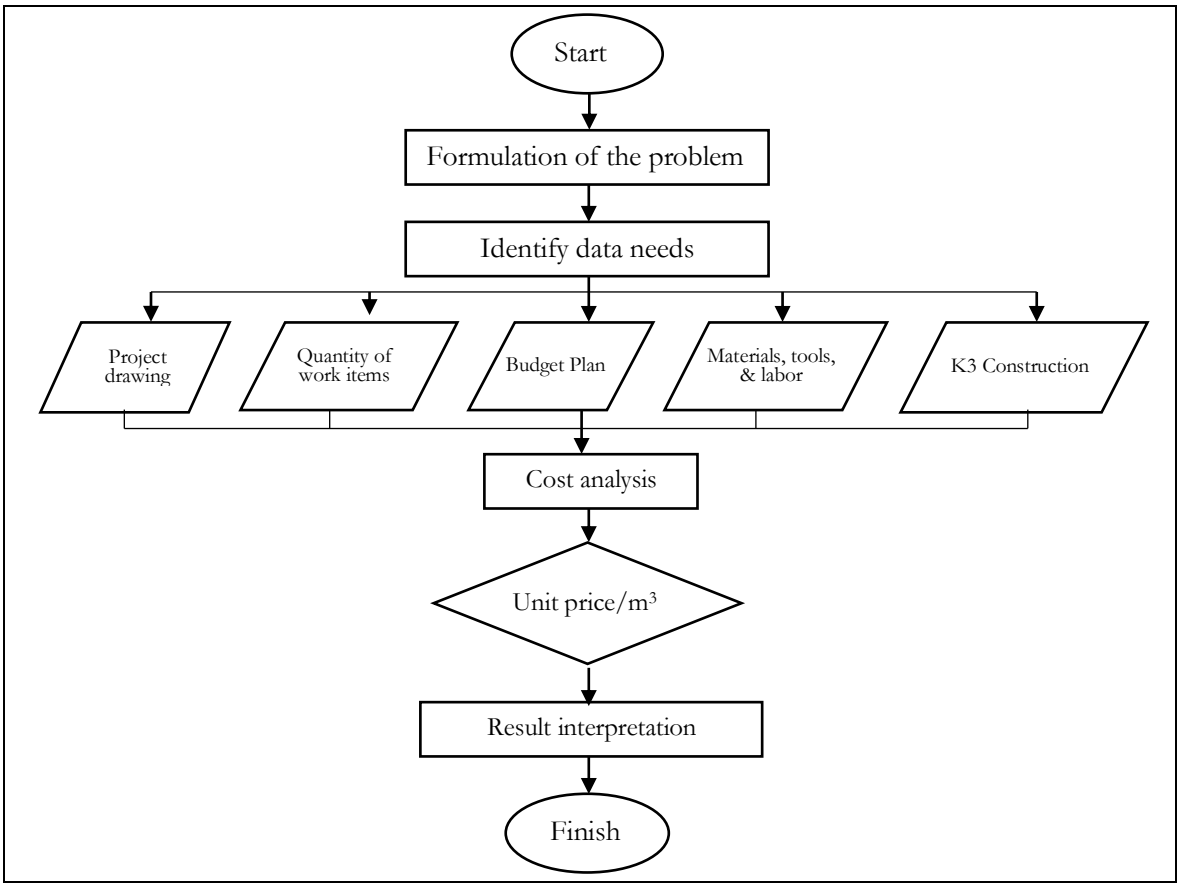

Fig. 1. Research flow

3. Results and Discussion

3.1. Retaining Soil Wall Works

The retaining wall referred to in this study is a retaining cliff due to the steep land elevation between the vacant land and the road, where there is drainage on the side of the road, and after drainage is a slope/cliff with a height of 2 m. The condition of the retaining wall is visualized in Figure 2.

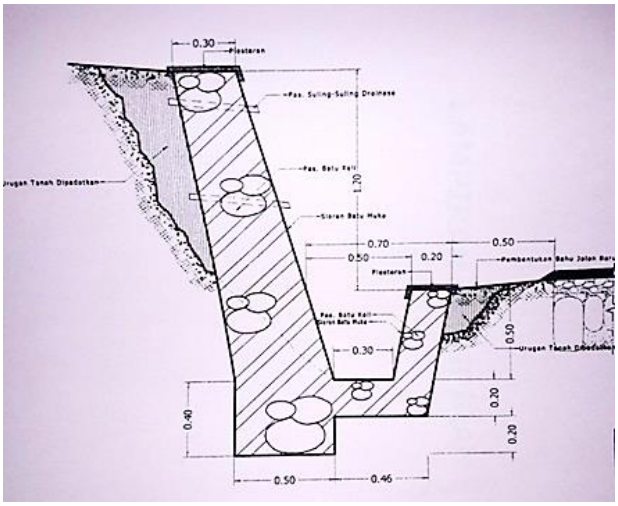

Fig. 2. Retaining soil wall

The technical specifications used in this retaining wall work consist of rock/split stone, sand, gravel, and cement. The work volume of this retaining wall is 204.82 m^3. Based on the results of observations and construction drawing data as shown in Figure 2, it is known that the quantity of each work item in the installation of this retaining wall, as explained in Table 1.

Table 1. Retaining Wall Work Quantity and Items

N	Description	Quantity
1	Digging depth 0-2 m	173.36 m3
2	Ordinary earthfill/fill work	63.39 m3
3	Mounting stone / rock	204.82 m3

3.2. Retaining Wall Work Cost

The cost of retaining wall works reviewed in this study consists of material costs, equipment costs, labor costs, and occupational safety and health (K3) costs, so this discussion is discussed in further discussion sections.

3.2.1. Material Cost

In identifying material costs, it is necessary to know what materials are used, how many quantities of materials are, and what the unit price of the material is [18]. After being identified, the total costs incurred for the purchase of materials are calculated, then the material costs are calculated in units/m^3 of retaining wall work. The results of the survey and observation show that the material, quantity, and unit price of the material are as shown in Table 2.

Table 2. Material Usage and Unit Price

N	Material name	Quantity	Unit	Unit price	Amount (Rp)
1	Mountain rock/crushed stone	239.64	M3	200,000	47,927,880
2	Semen	36,048.32	Kg	1,160	41,816,051
3	Sand	92.80	M3	205,000	19,024,808
			Total (Rp)		108,768,739

It is known that the total material cost is Rp. 108,768,739 as described in Table 2, while the volume of retaining wall works is 204.82 m^3 as described in Table 1, so the material cost/m^3 of retaining wall work can be calculated using Equation 1 as follows:

$$\frac{Total\ material\ cost}{Retaining\ wall\ work\ volume} = \frac{108.768.739}{204.82} = \text{Rp. } 531.046 \quad (1)$$

After being analyzed so that it can be stated that the cost of retaining wall work/m^3 is Rp. 531.046.

After knowing the material cost/m^3 of retaining wall work, then it is necessary to explain how much material is used/m^3. How to calculate the amount of material used in each volume of retaining wall work is to divide the amount of material used by the total volume of retaining wall work, as exemplified in calculating stone materials using Equation 2 as follows:

$$\frac{Total\ use\ of\ stone\ materials}{Retaining\ wall\ work\ volume} = \frac{239.6394}{204.82} = 1.17\ m^3 \quad (2)$$

Based on the analysis using Equation 2, it can be seen that the use of mountain stones/split stones in each volume of retaining wall work is 1.17 m^3. The use of rock material/split stone, cement, and sand in every 1 volume of retaining wall work is presented in Table 3.

Table 3. Use of Materials/M³, Retaining Soil Wall Works

N	Material	Unit	Quantity (Coefficient)
1	Mountain rock/crushed stone	M^3	1.17
2	Cement	Kg	176
3	Sand	M^3	0.4531

With the results of this analysis, it can be determined that the coefficient of material for the retaining wall is 1.17 m^3 of mountain stone, 176 kg of cement, and 0.4531 m^3 of sand.

3.2.2. Tool Cost

To calculate the cost of tools, it is necessary to identify what tools are needed, in what quantity, and at what cost. Ownership of equipment in retaining wall works consists of direct purchases of simple tools, and by way of rental for heavy equipment, such as concrete mixers, dump trucks, water tankers, and tampers. Based on the observations that the tools used, the quantity, and the price of the tools are as described in Table 4.

Table 4. Quantity and Cost of Retaining Soil Wall Work Tools

N	Description	Unit	Quantity	Unit price (Rp)	Amount (Rp)
1	Concrete mixer 0.3-0.6 m3	Hour	20	156,948	3,138,969
2	Dump truck 3,5 ton	Hour	40	296,443	11,857,732
3	Water tanker 3000-4500 L	Hour	40	285,050	11,402,005
4	Tamper	Hour	4	43,593	174,373
5	Soil hoe	Unit	1	85,000	85,000
6	Soil fork	Unit	1	85,000	85,000
7	Dustpan	Unit	2	12,000	24,000
		Total (Rp)			26,767,079

The results of the analysis show that the total cost of the tool is Rp. 26,767,079, and the cost/m^3 of retaining wall work, calculated using Equation 1, and the result is Rp 130,686/m^3. The need for tools/m^3 for retaining wall work, which can then be used as a calculating coefficient, as shown in Table 5.

Table 5. Need for Equipment/M³ Retaining Soil Wall Works (Coefficient of Tools)

Description	Coefficient
Concrete mixer 0.3-0.6 m3	0.0976
Dump truck 3,5 ton	0.1953
Water tanker 3000-4500 L	0.1953
Temper	0.0195
Soil hoe	0.0049
Soil fork	0.0049
Dustpan	0.0098

3.2.3. Labor Costs

Labor productivity is very influential on the costs incurred, the higher the productivity of the workforce, the cheaper the cost, and the lower the productivity, the more expensive the labor costs [19]. In general, in construction projects, the workforce that he employs consists of workers, builders, head builders, foremen, and drivers. In the retaining wall work, it is known that the manpower employed consists of workers, builders, and foremen, without using the head of a handyman, while the driver's financing has been included in the cost of equipment.

To find out the cost of labor, first, it is necessary to know the number of workers employed, wages/hours or daily wages, and length of work, and based on observations it is known as described in Table 6.

Table 6. Identification of Labor, Wages, and Length of Work

Labor Description	Number of workers/day	Number of working days	Wage/day	Amount (Rp)
	a	*b*	*c*	*d= a x b x c*
Pekerja	10	29.5	83,571	24,653,445
Tukang	5	29.5	115,571	17,046,723
Mandor	1	29.5	129,286	3,813,937
Total (Rp)				45,514,105

Based on the information presented in Table 6, it is known that the total labor cost is Rp. 45,578,748, while the volume of retaining wall work as described in Table 1 is 204.82 m3, so the labor cost/m^3 of retaining wall work is calculated using Equation 1 is Rp. 222,531.

Next, it is necessary to calculate the productivity of the workforce daily. Based on observations of labor productivity from day 1 to 30, there are differences, so it is necessary to calculate the average productivity in each day. The retaining wall work is carried out daily by 10 workers, 5 craftsmen, 1 foreman, and is completed within 30 days, therefore the average daily productivity can be calculated using Equation 3.

$$Average\ daily\ productivity = \frac{Retaining\ wall\ work\ volume}{Completion\ period} = \frac{204.82}{29.5} = 6{,}943\ m^3 \quad (3)$$

The results of the analysis using Equation 3, it can be seen that the average daily labor productivity is 6.943 m3. Based on this information, the contribution of labor in completing the retaining wall work can be calculated using Equation 4 as follows:

$$Lc\ \frac{Nc}{Tm} \quad (4)$$

Lc = Labor contribution

Nc = Number of work competencies a day

Tm = Total manpower

Based on the formula of Equation 4, the contribution of labor in completing the retaining wall work by workers is 10/16 = 0.625, because the number of workers every day is 10, while the total number of workers is 16. Based on the analysis using Equation 4, the contribution of labor in retaining wall work is described in Table 7.

Table 7. Labor Contribution of Retaining Soil Wall Works

Labor Description	Number of workers/competencies	How to count	Labor contribution
Workers	10	$=\frac{10}{16}$	0.625
Craftsman	5	$=\frac{5}{16}$	0.3125
Foreman	1	$=\frac{1}{16}$	0.0625

The next step is to determine the labor coefficient. This labor coefficient can then be used to analyze the cost of labor wages on retaining wall work in the next project. This coefficient will be determined for workers, builders, and foremen. It is known that the average daily productivity is 6.943 m^3, carried out by 10 workers, 5 craftsmen, and 1 foreman, so the labor coefficient can be determined using Equation 5 as follows:

$$Coefficient = \frac{Average\ daily\ productivity}{Number\ of\ daily\ worker\ competencies} \quad (5)$$

$$Worker\ coefficient = \frac{6.943}{10} = 1.465/m^3 \quad (6)$$

$$Craftsman\ coefficient = \frac{6.943}{5} = 0.732/m^3 \quad (7)$$

$$Foreman\ coefficient = \frac{6.943}{1} = 0.146/\text{m}^3 \quad (8)$$

Based on the results of the analysis using Equation 5, the labor coefficient on retaining wall work is summarized in Table 8.

Table 8. Labor Coefficient

Labor description	Coefficient	Unit
Workers	1.465	person/day
craftsman	0.732	person/day
Foreman	0.146	person/day

3.2.4. Cost of Occupational Safety and Health (K3)

The work of retaining walls (TPT) has a potential hazard to the workforce, and the results of the investigation identified that the potential hazards consist of:

- Injured if crushed by a tidal stone
- Buried by the ground
- Injured by digging tools, hoes, crowbars, and others
- There was an accident due to traffic
- An accident or injury occurs due to the distance between workers is too close
- Hurt by a fallen tree branch.

With these potential hazards, steps to anticipate and prevent the dangers caused by the work of laying and compacting the HRS-WC work, namely:

- Prepare and provide medical equipment in a first aid kit
- Builders and workers must wear clothing and equipment (safety clothing, safety boots, gloves) that comply with the standard
- Maintain and care for each other between workers
- Ensure that no outsiders or other workers are in the place where the car is unloading the material
- Install temporary signs and regulate traffic to keep it running smoothly by wearing appropriate clothing
- Maintain a safe distance between workers from one another

Given the potential hazards, then taking steps to anticipate occupational safety and health on retaining wall work, it can be seen that the costs incurred for K3 are as described in Table 9.

Table 9. Cost of Occupational Safety and Health (K3)

Description	Unit	Quantity	Unit price	Amont (RP)
Occupational safety and health management (K3)	Ls	1	6,335,000	6,335,000
safety helmet	pcs	18	80,000	1,440,000
Project safety vest	pcs	18	20,000	360,000
Safety boots	pcs	18	135,000	2,430,000
Gloves	pcs	18	10,000	180,000
Total (Rp)				10.745.000

By referring to Table 9, the K3 coefficient is as described in Table 10.

Table 10. Coefficient of Occupational Safety and Health (K3)

Description	Coefficient

Occupational safety and health management (K3)	0.005
safety helmet	0.088
Project safety vest	0.088
Safety boots	0.088
Gloves	0.088

3.3. Time and Cost of Retaining Soil Wall Works

Completing work on time as specified can benefit various parties, both service providers or service users, or contractors or developers [20]. This retaining wall works to hold the cliff on the side of the road because if it is not reinforced the soil can slide and damage the road, which will eventually disrupt the smooth transportation [21], [22]. The volume of retaining wall works is 204.82 m^3 which was completed in 29.5 days. The workforce employed are 10 workers, 5 handymen, and 1 foreman. It is also known that the average daily productivity is 6,943 m^3. After discussing the cost of retaining wall work which consists of the cost of materials, tools, labor, and K3 (Occupational Health and Safety) costs, the total cost and percentage of the cost of this work are as described in Table 11.

Table 11. Cost and Percentage of Retaining Soil Wall Works

Description	Amount (Rp)	Percentage (%)
Material cost	108,768,739	56.69%
Tool cost	26,767,079	13.95%
Labor cost	45,578,748	23.76%
K3 Cost	10,745,000	5.60%
Total (Rp)	191,859,566	100%

In addition to costs, it is also known that the coefficients of materials, tools, labor, and K3 are summarized in Table 12.

Table 12. Coefficient 1M3 Retaining Soil Wall Works

N	Description	Unit	Coefficient
	Materials		
1	Mountain stone/Split stone	M3	1.17
2	Cements	kg	176
3	Sands	M3	0.4531
	Tools		
1	Concrete mixer 0.3-0.6 m3	unit	0.0976
2	Dump truck 3,5 ton	unit	0.1953
3	Water tanker 3000-4500 L	unit	0.1953
4	Tamper	unit	0.0195
5	Soil hoe	unit	0.0049
6	Soil fork	unit	0.0049
7	Dustpan	unit	0.0098
	Labor		
1	Workers	person/day	1.465
2	craftsman	person/day	0.732
3	Foreman	person/day	0.146
	Occupational Health and Safety (K3)		
1	Occupational safety and health management (K3)	Ls/hari	0.005
2	safety helmet	pcs/hari	0.088
3	Project safety vest	pcs/hari	0.088
4	Safety boots	pcs/hari	0.088
5	Gloves	pcs/hari	0.088

4. Conclusion

This research has identified that the retaining wall work with a working volume of 204.82 m^3 costs Rp. 191,859,566 with a cost/m^3 of Rp. 936,723. This cost consists of material costs of Rp. 108,768,739, tools Rp. 26,767,079, labor Rp. 45578.748, and K3 Rp. 10,745,000. It is known that the percentage of materials is 56.69%, tools 13.95%, labor 23.76%, and Occupational Safety and Health (K3) is 5.60%. In addition, this research has also produced a retaining wall work coefficient in every m^3 of work, which consists of the coefficients of materials, tools, labor, and K3. It is known that the material coefficient consists of 1.17 m^3 rock/split stone, 176 kg cement, and 0.4531 m^3 sand. The coefficient of the tool consists of a concrete mixer coefficient of 0.3-0.6 m3 0.0976unit, dump truck 3.5ton 0.1953unit, water tanker 3000-4500 L 0.1953unit, tamper 0.0195unit, soil hoe 0.0049unit, ground fork 0 .0049 units, and dustpan 0.0098 units. The labor coefficient consists of the coefficient of workers 1.465 person/day, craftsman 0.732 person/day, foreman 0.146 person/day. The K3 coefficient consists of occupational safety and health management (K3) 0.005 Ls, safety helmet 0.088 pcs, project safety vest 0.088 pcs, safety boots 0.088 pcs, and gloves 0.088 pcs. The results of this study can be used as a reference for estimating the cost of similar retaining wall works in other projects. The coefficients generated in this study can be used as a reference in the analysis of the unit price of retaining wall work using the main material of mountain stone/split stone. This unit price and the coefficient can be used by consultants, contractors, project owners, and the general public, to facilitate budget planning for retaining soil wall works.

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