International Journal of Civil Engineering and Infrastructure
Vol. 1, No. 2, October 2021

ANALYSIS OF REDUNDANT BUILDING CONSTRUCTION MATERIAL: A CASE STUDY FOR A HOSPITAL BUILDING PROJECT IN BOGOR

Aditya Gilang Rakasiwi[1], Trijeti[2], Rachmad Irwanto[3]
[1]Civil Engineering Study Program, University of Muhammadiyah Jakarta, Jl. Cempaka Putih Tengah 27, Indonesia
Correspondence email: arakasiwi1907@gmail.com
[2]Civil Engineering Study Program, University of Muhammadiyah Jakarta, Jl. Cempaka Putih Tengah 27, Indonesia
Email: trijeti@umj.ac.id
[3]Civil Engineering Study Program, University of Muhammadiyah Jakarta, Jl. Cempaka Putih Tengah 27, Indonesia
Email: rachmad.irwanto@umj.ac.id

Received June 17, 2021 | Accepted September 1, 2021

ABSTRACT

Construction materials are very significant spending in a construction project. They may create losses to Implementation Budget Plan (IBP) whenever the number is excessive. This paper is intended to find causes of redundant materials for guidelines to next projects to avoid excessive number of redundant materials. This paper details driving factors to material redundancy, total value of redundant materials and percentage ratio of redundant materials total value over IBP value. To obtain those factors causing redundant materials, this research run a set of questionnaires referenced from journals and refined by expert professionals. The questionnaires set was then handed to managerial peers and other non-managerial respondents to acquire their responses. The questionnaire outcome provides clues on major driving factors. They are lack of control at site, lack of supervision and lack of allocated facility for redundant materials. Further studies in this paper using price details in IBP and unit conversion on redundant materials have come to a material redundant value of Rp. 383.940.000 from an IBP value of Rp. 31.125.169.000. The highest percentage ratio of redundant materials is from ceramics fitting works at 34.18% while total value percentage ratio of redundant materials over IBP is 1.23%.

Keywords: *Construction Materials, Redundant Materials, Driving Factors, IBP, Percentage Ratio*

1. PRELIMINARY

The hospital building being reviewed here is a 4-stories building with a basement. The building, is an extended branch building, provides medical services for general medical checkup, hospitalized and outpatients. The construction project of hospital building is

observed using Execution Budgeting Schedule/Implementation Budget Plan (IBP).

The observed hospital building construction project uses ribbed steel bars D39, D24, K-300 concrete, M10 wire mesh, sands and other materials. It was noted that there were a number of redundant materials following the hospital building construction project completion.

A record shows that there are factors causing redundant materials from a construction work perspective or another point of view. Construction materials are significant spendings in a construction project, thus they may create losses in Implementation Budget Plan (IBP) whenever the number of redundant materials is excessive. Some of those redundant materials are physically still in good condition and fit to be used for another project assuming the same specifications apply.

2. THEORETICAL BASIC

Basic Concept

Construction materials are purchased or produces items to be used in any other day, to be directly installed, to be further processed or to be re-traded. Construction materials are among considerable capital spendings and time consuming, thus managing them is important. A proper use of construction materials should follow time and cost schedule and require efficient use of construction materials by the labor force without sacrificing quality.

A management plan related to potential redundant of construction materials is required to make the site works more effective and efficient and to avoid material redundances during the work. This paper analyzes redundant construction materials on a hospital building project.

Material management is described as an organizational approach involving management and technical abilities to solve redundant construction materials issues. Material management addresses those issues to avoid or limit loss due to redundant materials.

Construction Materials

There are two types of construction materials. (Ervianto,2007) One is permanent type and the other is transient type.

Theory of Material types

During construction, materials are classified into two major categories. They are:

1. Consumable materials. These are materials that will be part of physical building structure. Materials such cement, sands, crushed stones, brick stones, steel bars, ceramics, paints and alike fall into this category.
2. Non-Consumable materials. These materials are used during the construction work but will not be part of physical building structure. These materials are repetitive in their use following the project completion and considered as redundant materials. Back propping, frameworks and temporary retaining wall fall into this category.

Material Requirements Planning (MRP)

Material Requirements Planning (MRP) is a system to quantify materials and components needed to produce a product. MRP constitutes of three main steps starting from existing materials and components inventory listing, identifying required additions and scheduling of production or purchase.

The causes of redundant materials

There are factors causing high percentage occurrence of redundant materials. Regardless of the used types of materials, what happens is that the higher the occurrence the higher the percentage and vice versa.

Theory of Implementation Budget Plan (IBP)

Implementation Budget Plan is a real costing detail applied by a contractor at site during a set of execution activities of a project to its completion counting all materials and labors.

Cost Analysis

Expenditure budget for a project execution consists of six variables. They are materials, labors, equipment, subcontracts, overhead and profits and risks. According to studies, material cost as one of expenditure budget has been deemed to be 30-40 % of total project cost.

Relation between Material Management and Labor Productivity

In constructions works, a dropping productivity maybe from several factors. They are whether, daily working period, changes of works and instructional and monitoring mistakes. Studies show that material deficit is one main cause of productivity decrease. Other studies have concluded that averagely a foreman needs 2 hours per day to set up a purchase plan and obtain his required materials (Bell & Stuckhart, 2007). Similar studies also report 20-30% idle time due to delays of not readily materials and equipment.

3. RESEARCH METHODOLOGY

Below is a flowchart carried out during preparation of this paper.

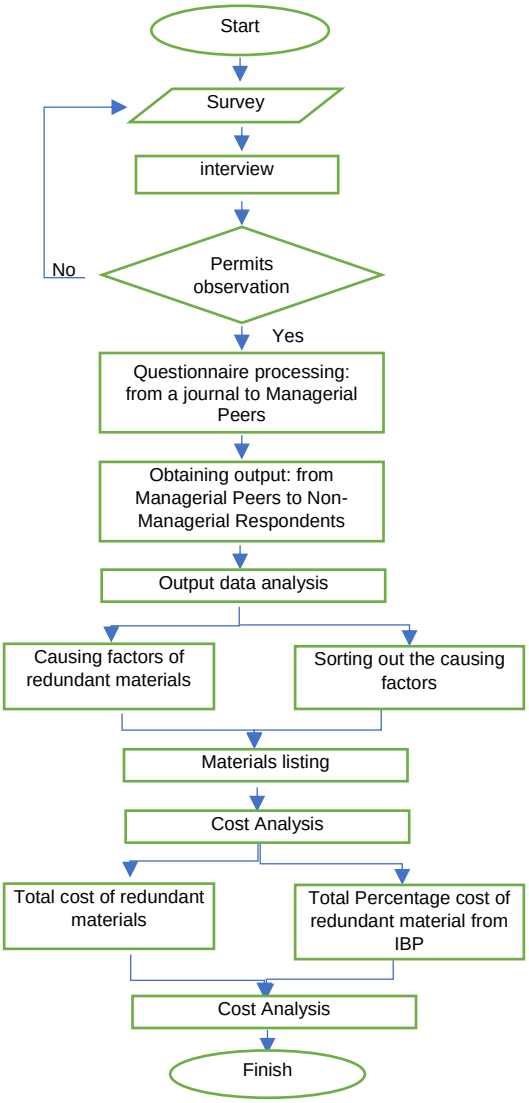

Figure 1. Flowchart

List of Materials

List of materials here is a collection of data and information obtained directly from proper sources. In this case, efforts have been carried out are as follow:

1. Survey (Interviews)
2. Observations

Data Collection Techniques

Data collection techniques that have been implemented in regard of this paper are:

1. Questionnaires are in the form of a set of questions

2. Interviews to obtain information from sources are in the form of face-to-face interview meetings

Respondents

Qualified respondents that are counted during data acquisition for this paper are:

1. Site Manager
2. Contractor Supervisor
3. Site Supervisors
4. Foremen

Analytical Technique

Analysis here is a systematic implementation of statistical technique and logic to describe and illustrate, to summarize and outline and to evaluate data.

Descriptive statistical analysis

Descriptive statistical analysis here is an applied statistics to assess data by means of describing it out or a collected data set as it is without making common conclusion and generalization (Arikonto, 2010)

Table 1. Stage and activities to define material type

Analytical Stage	Required data	Activities	Outcome
Quantification of required materials	Implementation Budget Plan (IBP)	1. Identifying each unit work and their required material types 2. Summarizing quantity and material types used in each unit work	Summary of required materials

Table 2. Stages and activities of quantitative data analysis

Analytical Stages	Required data	Activities	Outcome
Quantification of redundant materials	Output from questionnaire 1	Data processing from questionnaire 1 output	Quantity of redundant materials
Percentage ratio conversion of total redundant materials cost to overall IBP	Implementation Budget Plan (IBP) on redundant materials quantity	$\frac{\text{E}xcess\ material\ total\ value}{IBP\ total\ value}$ X 100 %	Percentage of total redundant material over overall IBP

4. RESULT AND DISCUSSION

Questionnaire processing

1. Questionnaire to Managerial Peers

Managerial Peers here are directors with 12 years of experience, purchase manager with 15 years of experience and operational directors of 11 years' experience. Outcomes would not be processed for conditions such; delayed work execution and revised drawing distribution, opted for low quality product specifications, designers do not have good knowledge of materials to be used and materials are disqualified or damaged materials.

2. Questionnaire to Non-Managerial respondents

Following output from questionnaire to managerial peers, the same questionnaire was then handed to another set of non-managerial respondents consists of project manager, engineer, quantity surveyor, drafter, quality control, engineer assistants, assistants of professional staffers, supervisors, logistic staffers, administrators, consultants, inspectors and founders. All of them were 47 people.

Respondent character data based on highest education

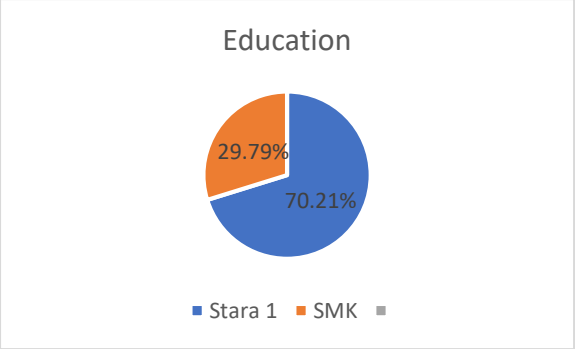

Figure 2. Respondents based on highest education

Factors causing redundant materials

1. Lack of control at site

The project being observed happened to have lack of control issues that caused unnecessary redundant materials. This lack of control issues occurred in structural works such columns and floor slab specifically on steel bar and wire mesh.

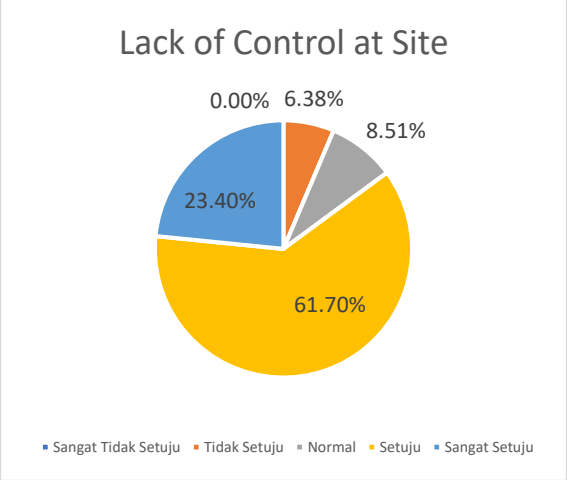

Figure 3. Lack of control at site

2. Lack of supervision

Lack of supervision in material purchase orders and during receiving them at site had been another reason behind redundant materials. During receiving material at site, lack of supervision had let the order quantity mismatches the received quantity.

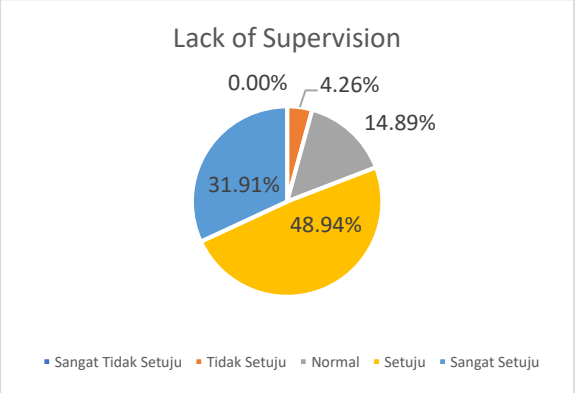

Figure 4. Lack of supervision

3. Lack of allocated facilities to manage redundant materials

It was noted at the project site had a limited allocated facility area that is deemed to generate redundant materials. The limited facility area designated for material storage had caused damages to stored materials.

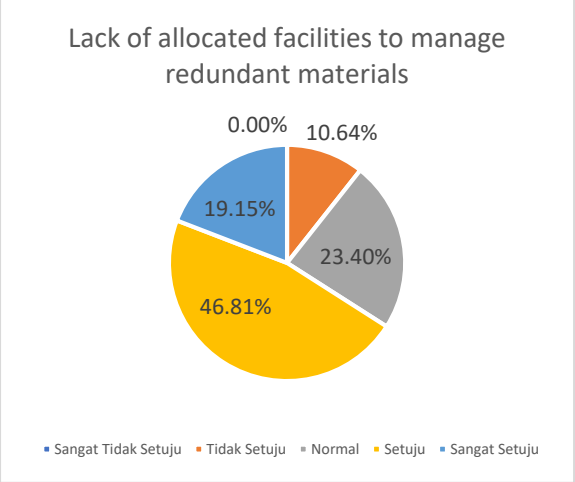

Figure 5. Lack of allocated storage facility

4. Accidents due to Negligence

Accidents due to human negligence have created redundant materials. The negligence here generally was from less precision installation practices by labors which later also damaged the materials. This issue happened at architectural fitting works such ceramics fitting and ceiling installation.

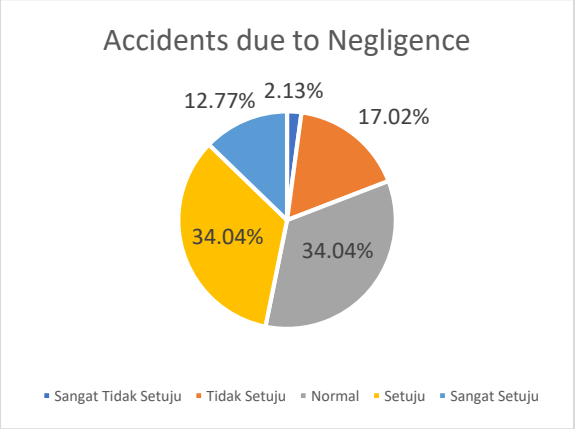

Figure 6. Accidents due to Negligence

5. Equipment/Tools Damages

Tools damage during installation works here was instigated by prior less-than-good condition of the tools themselves which was then also causing damages to materials. This tools issues happened during architectural fitting works and created redundant materials.

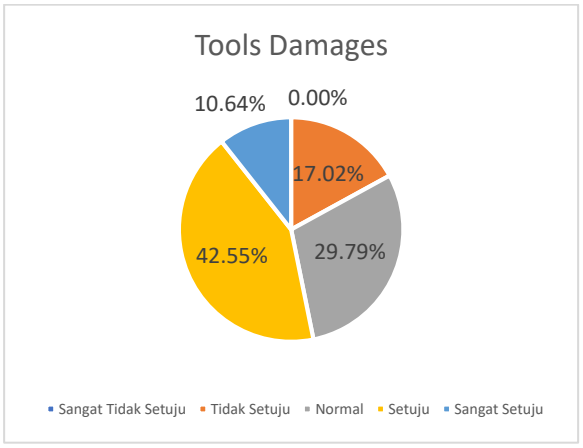

Figure 7. Tools damages

6. Improperly packed materials

Improperly packed materials happened during pre-order purchase causing potential damages. The damages follow in the process of loading/unloading and unwrapping packages. This led to repeat order, exceeded BOQ quantity and later caused unusable redundant materials. This issue happened to architectural fitting work materials.

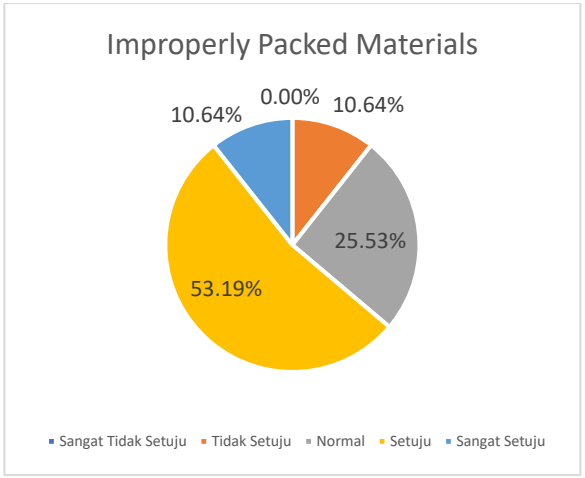

Figure 8. Improperly packed materials

7. Throwing off Materials

Another reason behind material damages was due to when labors rushing their works handing off materials among them by throwing off during loading-unloading process.

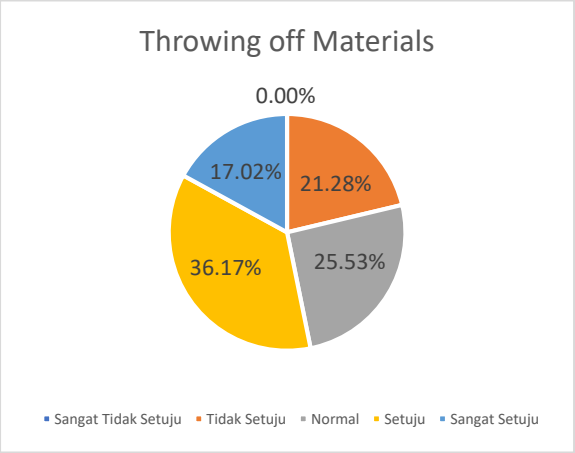

Figure 9. Throwing off materials

List of Materials

Once a list of redundant materials was obtained, the list then went through a process to outline in which steel bars is converted from bars into Kg by:

Steel length x cross section area x steel density

Wire mesh is converted from sheets into Kg by:

Wire mesh M10 quantity x Wire mesh M10 weight (referring to table of wire mesh weight)

Ceramics and ceiling are converted from pieces into m^2 by:

Ceramics area x ceramics quantity x number of ceramics in 1 Pcs

Pipes are converted from meter into m^2 by:

Length of 1 pc pipe x quantity

Table 3. Price list of materials

Category	ITEM	weight	unit	Unit price	Price
Civil Works	Ribbed steel bar D 39 BJTP-39 Pot 1m	3205,89	Kg	Rp. 12.680,-	Rp. 40.650.685,-
	Ribbed steel bar D 39 BJTP-39 Pot 30cm	1105,61	Kg	Rp. 12.680 ,-	Rp. 14.019.134,-
	Ribbed steel bar D 39	887,50	Kg	Rp. 12.680 ,-	Rp. 11.253.500,-

Category	ITEM	weight	unit	Unit price	Price
	BJTP-39 Pot 20cm				
	Ribbed steel bar D 24 BJTP-24 Pot 20cm	479,16	Kg	Rp. 12.410,-	Rp. 5.946.375,-
	Ribbed steel bar D 24 BJTP-24 Pot 10cm	196,50	Kg	Rp. 12.410,-	Rp. 2.438.565,-
	Ribbed steel bar D 24 BJTP-24 Pot 5cm	82,39	Kg	Rp. 12.410,-	Rp. 1.022.459,-
	Wire mesh M10 SNI 07-0663-1995	3572,35	Kg	Rp 15.780,-	Rp. 56.371.683,-
	Cement 3 Roda	38	bag	Rp. 50.000,-	Rp. 1.900.000,-
	Bondex 0,75 mm thickness	5,208	M2	Rp. 212.650,-	Rp. 1.123.105,-
Architectural fittings	Homogeneous Tiles floor 60 x 60 cm similar specs to Garuda	12,24	M2	Rp. 214.620,-	Rp. 2.626.948,-
	Ceramic Tiles for staircase 30 x 30 cm similar specs to Asia Tile	47,52	M2	Rp. 124.770,-	Rp. 5.929.070,-
	Ceramic tiles for Toilet 20 x 20 cm (Anti Slip) similar specs to Asia Tile	52,00	M2	Rp. 134.270,-	Rp. 6.982.040,-

Category	ITEM	weight	unit	Unit price	Price
	Gypsumboard Ceiling 9 mm	224,64	M2	Rp. 114.230,-	Rp. 25.660.627,-
	GRCboard Ceiling 4 mm	184,32	M2	Rp. 109.210,-	Rp. 20.129.587,-
	Hollow truss 2 x 4 cm L 4 m	368	M'	Rp. 18.900,-	Rp. 6.955.200,-
Mechanical Electrical, and Plumbing	Clean water & waste water pipes PVC AW 4"	232	M'	Rp. 114.003,-	Rp. 26.448.696,-
	Clean water & waste water pipes PVC AW 3"	188	M'	Rp. 82.897,-	Rp. 15.584.636,-
	Clean water & waste water pipes PVC AW 2"	140	M'	Rp. 47.037,-	Rp. 6.585.180,-
	Clean water pipes PPR-PN 10 ½"	132	M'	Rp. 58.848,-	Rp. 7.767.936,-
	Feeder cables	200	M'	Rp. 323.326,-	Rp. 64.665.200,-
	Electricity power point Broco	30	pc	Rp. 37.080,-	Rp. 1.112.400,-
	Single Switch Broco	40	pc	Rp. 50.040,-	Rp. 2.001.600,-
	Double Switch Broco	45	pc	Rp. 57.040,-	Rp. 2.566.800,-
	Panel Power	2	Unit	Rp.27.103.000,-	Rp. 54.206.000,-
Total					Rp. 383.947.430,-
Roundup					Rp. 383.940.000,-

Implementation Budget Plan (IBP)

Every project must have an IBP. IBP is a real costing detail a contractor applies at site. This paper presents details IBP of the hospital building project. The hospital building project was noted to have an Implementation Budget Plan (IBP) of Rp. 31.125.169.000, -

Total Percentage value of redundant materials over IBP value

Following the obtained total Implementation Budget Plan (IBP) is to quantify total percentage ratio of redundant material total value over Implementation Budget Plan (IBP) total value. Below is how it is calculated.

Known:

Total value of redundant materials: Rp. 383.940.000, -

Total value of Implementation Budget Plan:

Rp. 31.125.169.000, -

Questioned:

Total percentage ratio of redundant material over IBP?

Answered:

$$\frac{\text{Total value of redundant materials}}{\text{Total value of IBP}} \text{ X } 100\ \%$$

$$\frac{\text{Rp. } 383.940.000\ ,-}{\text{Rp. } 31.125.169.000\ ,-} \text{ X } 100\ \%$$

$$= 1{,}23\ \%$$

Evaluation of Redundant Materials

The next step subsequent to establishing redundant material volume, total value of redundant material and percentage ratio of redundant material over IBP of the project is to evaluate and summarize them to be guidelines to next projects to avoid.

Below are summary and evaluation of the redundant materials:

1. To monitor and choose supervisor's performance at site to avoid negligence and lack of control at site. This lack of control at site has caused redundant materials. Site supervisors with lack of monitoring attitude have been noted to cause unnecessary redundant cuts of steel bars, material damages due to incorrect work methods which then lead to another pre-order that eventually make the total quantity exceeds the required quantity in BOQ; and also, material damages during loading and unloading.
2. To manage a good governance at site in order to provide proper material storage facility. Management must allocate spaces in the site plan to allow material storage, warehouse and material loading-unloading. Should management fail to allocate proper space for material storage, disorders in storing materials can damage materials which then adds to redundant materials due to insufficient storage facility.

5. CONCLUSIONS

From above elaboration, conclusions from this research are:

1. Driving factors behind redundant materials are:
   a. Lack of control at site
   b. Lack of supervision
   c. Lack of allocated facilities to manage redundant materials
   d. Improperly packed materials
   e. Equipment/tools damages
   f. Throwing off materials
   g. Accidents due to negligence
2. Total cost of redundant material in the aforementioned project is Rp. 383.940.000. It consists of Rp. 134.725.508, - from civil works, Rp. 68.283.473, - from architectural fittings, dan Rp. 180.938.448, - from MEP works.

3. The three highest percentage ratios of redundant materials over total used materials are from homogeneous tile floor 60x60 cm at 34.18 %, staircase tile floor 30x30 cm at 18.94% and Brocco double switch at 18.44%
4. Percentage ratio of total value of redundant materials over Implementation Budget Plan (IBP) is 1.23%. It is contributed from civil works at 0.43%, architectural fittings at 0.22% and MEP works at 0.58%.

REFERENCES

[1] I Gusti Putu Adi Suartika Putra, G. C. (2018). Penanganan *Waste* Material Pada Proyek Konstruksi Gedung Bertingat.

[2] Muhammad Khoerul, N. S. (2017). Perhitungan Rencana Anggaran Pelaksanaan Pada Proyek Pembangunan Gedung Untility PT. Kimia Farma (Persero) Tbk.

[3] Rizky Sudiro, A. M. (2017). Analisis Sisa Material Pekerjaan Struktur Pada Proyek Konstruksi.

[4] Sri Fajar, V. H. (2018). Evaluasi dan Analisa Sisa Material Konstruksi

[5] Sugiarto, W. H. (2017). Analisis dan Identifikasi Sisa Material Konstruksi Dalam Proyek Pembangunan dan Peningkatan Jalan Solo-Gemolong-Genyer, Kab. Sragen.

[6] Suryanto Intan, R. S. (2018). Analisa dan Evaluasi Sisa Material Konstruksi: Sumber Penyebab, Kuantitas, dan Biaya.