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Study On The Application of Special Molding Tools In Brick Placing Work

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ABSTRACT
In brick installation work, mixed species is a material that is often wasted because the installation process and implementation time tend to be slower. Research purposes This is by developing tool designs and conducting experiments on variations in the length or width of the work area. The research was carried out using an experimental method of bricklaying work to determine the effect of using special molding tools on the implementation time and use of special materials. Specifically, two factors will be tested in this research, namely the design factor of the specific molding tool and the length of the work plane. There are two tool designs, namely Type 1 Tool and Type 2 Tool. Type 1 Tool is the tool design used in previous research. Tool Type 2 is a development and refinement of Tool Type 1. The working area consists of two, namely a plane with a length of 1 m x a height of 1 m (1 m ^{2}) and a plane with a length of 2 m x a height of 1 m (2 m^2). The experiment was carried out three times on each factor. The experimental results viewed from the implementation time aspect show that brick installation using Type 1 tools is slower than without using tools. Meanwhile, the use of Type 2 tools is not significantly different or the same as without using tools. This shows that the development carried out on Type 2 Tools has succeeded in reducing delays in using the tool. The experimental results viewed from the aspect of using spec materials show that the use of spec molding tools, both Type 1 Tools and Type 2 Tools, has succeeded in making the use of spec materials more efficient.
Keywords: *bricklaying work, special molding tools, experiments.*

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I. INTRODUCTION

The wall is one of the elements that has an important role in a building. Walls form the pattern and shape of the building. As a space divider, it delimits the outer and inner spaces as well as the function of one space from another. Walls protect buildings against external influences, such as weather, climate, and pollution. Brick is one of the materials commonly used as building wall material. Its use as a building material has been around since time immemorial. Brick is considered to be the first mixed building material used by humans (Suharjanto, 2011). Economically, bricks have a relatively cheap and affordable price. Brick can be a durable building material and also as an insulating coating material. Apart from that, these building materials are becoming increasingly closely related to all levels of society, so their use has become very common in society.

In carrying out brick installation work, consists of two main ingredients, namely the brick itself and a mixture of species as an adhesive consisting of a mixture of cement, sand, and water in a certain ratio. So the cost components in bricklaying work are largely influenced by these two materials apart from wage costs. In brick installation work, mixed species is a material that is wasted a lot during the installation process. Musyafa (2016) in his research found that mixed species materials were efficient by applying special molding tools. However, the implementation time using special molding tools tends to be slower. This research became the basis for carrying out this research. The review is developed by developing tool designs and conducting experiments on variations in the length or width of the work area. It is deemed that the tool design can be developed to further increase the efficiency of material use and implementation time. With the tool design developed in this research, it is hoped that work execution time can be accelerated compared to previous tool designs or even from implementation without the tools themselves. Meanwhile, the length of the work area is seen to influence the use of assistive devices, especially implementation time.

In this research, we want to see the effect of applying special molding tools in terms of implementation time and material usage. It is hoped that the results of this research can be used as a reference for the application of special molding tools in the implementation of brick installation in building construction. In addition, the results of this research will validate the results of previous research. This research aims to determine the effect of applying special molding tools to bricklaying work.

It is hoped that this research will provide benefits to related parties as well as develop construction science. The benefits that will be obtained from this research are: For contractors and workers, the results of this research can be used as a reference in applying specific molding tools and work methods for bricklaying work, and for construction science, the results of this research can increase the variety of techniques and methods for carrying out bricklaying work within the scope of construction project management.

II. THEOR ITICAL REVIEW

Brick is a material used for the construction of building walls, in the form of a long rectangular prism, made from clay and through a firing process (Indonesian National Standardization Agency, 2000). Currently, it is commonly used as a wall material in buildings in urban and rural areas. Starting from simple buildings to the construction of large buildings. The manufacturing process, from digging the soil, and mixing it with water and other ingredients, if necessary, to giving the shape can be done entirely by hand using wooden molds, or in the process using machines (Indonesian Normalization Fund Foundation. 1978). Making red bricks is generally done manually, so the sizes are not the same, depending on the maker (Susanta, 2007). Based on SNI 15-2094-2000, bricks for walls must meet the following quality requirements: 1) Appearance properties, must be in the form of a long rectangular prism, have angled edges, flat planes, and do not show cracks; 2) Size and tolerance of bricks for wall masonry ; 3) Average compressive strength and coefficient of brick variation permitted for wall masonry; 4) dangerous salt content ($MgSO_4$, Na_2SO_4, K_2SO_4) maximum 1%; 5) the minimum apparent density is 1.2 gram/cm^2; 6) Maximum water absorption is 20%.

The materials needed for bricklaying work are bricks, cement, sand, boards, wooden blocks, and nails (Construction and Equipment Training Center of the Directorate General of Construction, 2016). Brick is the main material for masonry. Cement and sand are used as materials for special cement mortar mixtures. Meanwhile, boards, wooden blocks, and nails are used as materials for profiles or references in bricklaying work. In general, brick walls are formed by connecting the bricks with mortar as an adhesive so that they become a single wall. Vertical broadcasts are always endeavored so that they are not one line, they must be crossed. We generally choose vertical broadcasts of 1 cm and horizontal broadcasts of 1.5 cm thickness. In setting up this work area, several things need to be considered, namely (Construction and Equipment Training Center of the Directorate General of Construction, 2016). 1) The spec base should be placed approximately 60 cm from the partner area and approximately in the middle of the partner area; 2) Bricks are placed next to the base, arranged to stand in a wide direction with a distance of approximately 1 cm each with a maximum stack height of 3 layers.

Speci spoons are placed on the base of the speci while tools and other equipment are placed on the other side of the speci and bricks. The equipment and materials needed for stone masonry need to be prepared close to the place where the work will be carried out. This aims to make it easier to carry out work. Three important parameters are often associated as project targets according to Soeharto (1999), one of which is the schedule. The schedule implies that the project must be carried out within a predetermined implementation period. According to Ervianto (2002) implementing projects on time is one of the targets of implementing project management. Thus, implementation time is an important element that can influence success in implementing a job or project. Work execution time is generally closely related to worker productivity. Because worker productivity shows the ability of a worker or employee to produce many outputs or work results in a certain unit of time (work hours) (Limanto, 2008). So, by knowing the productivity standards of a job, you can estimate the standard implementation time and output produced.

Based on the Regulation of the Minister of Public Works and Public Housing Number 28/PRT/M/2016 concerning Guidelines for Analysis of Unit Prices for Public Works, for an area of 1 m ^{2} pairs of 1/2 bricks, a bricklayer requires 0.1 OH (person day). Referring to Equation 2.1, it is found that the productivity of one bricklayer for one day is 10 m^2. With an effective working time of 7 hours per day, the productivity per hour is 1.43 m^2. Referring to Equation 2.2, the implementation time for a wall area of 1 m2 ^{is} 0.7 hours or 42 minutes. Research conducted by Cahyo (2016) shows that the time for carrying out masonry work per m ^{2} is 42,247 minutes. The productivity interval for masonry work according to Limanto (2008) is between 0.53 m ^{2} /hour – 1.53 m ^{2} /hour. Or, the time for carrying out brickwork per m ^{2} is between 39.22 minutes – 113.21 minutes. Materials are one of the components in determining the costs of a construction project. Material usage is the most important part which has a fairly large percentage of the total project cost. Several studies state that material costs absorb 50-70% of project costs. Thus, efficiency in the use of materials is one of the efforts that can be made to minimize the costs of carrying out work in a construction project.

The materials used in brick installation work consist of two, namely brick and a mixture of cement and sand as a binder. Calculations of material usage requirements for brick installation work can be determined based on the implementer's experience, experimental results, and applicable standards. Based on the Regulation of the Minister of Public Works and Public Housing Number 28/PRT/M/2016 concerning Guidelines for Analysis of Unit Prices for Public Works, the brick requirement per m2 ^{for} bricks (size 5x11x22) for ½ stone pairs is 70, and for 1 stone pair is 140 fruit. The need for cement and sand for mixed species varies depending on the ratio applied. Theoretically, the material requirements for brick installation work can be determined by measuring the dimensions of the bricks and the mixture to be used. For example, for a brick measuring 5x11x22, add a vertical thickness of 1 cm and a horizontal thickness of 1 cm to the ½ brick pair. So, we get the efficiency value for 1 brick and the specs, namely length 23 cm and height 6 cm, area 0.0138 m^2. So the number of bricks per m^2 divided by the efficiency area of 1 brick and the spec is 72.5 pieces. The volume of the mixture of species per m2 ^{is} obtained by subtracting the efficiency area of 1 brick and the species with the efficiency area of 1 brick, then multiplying by 72.5 and the width of the brick. Thus, the volume of species per m ^{2} obtained is 0.0223 m^3.

III. RESEARCH METHODOLOGY

Based on its approach, this research uses quantitative research which aims to test hypotheses from data that has been collected in accordance with previous theories and concepts. Based on its type, this research is included in experimental research . The research location was carried out in Banjarbaru, on private land located at Jalan Pondok Labu Pondok Al-Baiti Complex Blok E No.3 RT. 019 RW. 008, North Loktabat Village, North Banjarbaru District, Banjarbaru City, South Kalimantan Province. The experimental unit is the object from which the values of the variables are measured. In this research (Figure 1), the experimental unit is bricklaying work. Bricklaying work consists of several elements, namely the craftsman or worker carrying it out, equipment and materials. In general, the experiments carried out in this research were carrying out brick installation with and without using special molding tools. So, we can know the effect of using special molding tools on implementation time and material usage. Specifically, there are two factors that will be tested in this research, namely the design factor of the specific molding tool and the length of the work plane.

The design of the specific molding tools in this research was developed from research that had been carried out previously (Musyafa, 2016). To see the influence of tool design, two tool designs were used, namely the first is the tool design used in previous research and the second is the tool design developed in this research. The first tool design will be called Type 1 Tool (see Figure 2.12) and the second tool design will be called Type 2 Tool (Figure 3.3). A comparison of Type 1 and 2 tool designs is explained in Table 3.2. In addition, in the Type 2 tool, the Type 1 tool is used in the joint between the first brick and the sloof. The working area or experimental wall area in previous research was 1 m long and 1 m high (1 m2 area). In this research, development was carried out to add experiments to a wider working area, namely 2 m long and 1 m high (2 m2 area). So, the work area factor consists of two work areas, namely the work area 1 m long x 1 m high (area 1 m ^{2}) and the working area 2 m long x 1 m high (area 2 m^2).

The variables in this experiment consist of 2 (two), namely the independent variable *and* the *dependent variable.* Independent variables are variables that influence or cause changes or emergence of dependent variables. Meanwhile, the dependent variable is a variable that is influenced or is a result of the existence of an independent variable. The independent variable in this experiment consists of two factors, namely as follows: 1) Application of special molding tools, with Type 1 and Type 2 tools; 2) Length of work area, 1 m long x 1 m high (1 m ^{3}), 2 m long x 1 m high (2 m ^{3}). The dependent variables in this experiment are as follows: 1) Work execution time; 2) Volume of material usage (species).

model that will be used for this research is a two-factor factorial design. Form of data collection table for a *completely randomized design factorial (CRD) experimental design model* with two factors . In this research, initial measurements will be carried out, namely brick installation work without using special molding tools 3 times each for areas 1 m long x 1 m high (1 m ^{2}) and 2 m long x 1 m high (2 m ^{2}). Then treat A1B1, A1B2, A2B1, and A2B2 3 times each. Based on this, the work fields for experiments that must be prepared consist of 9 fields with an area of 1 m^2 and 9 fields with an area of 2 m^2.

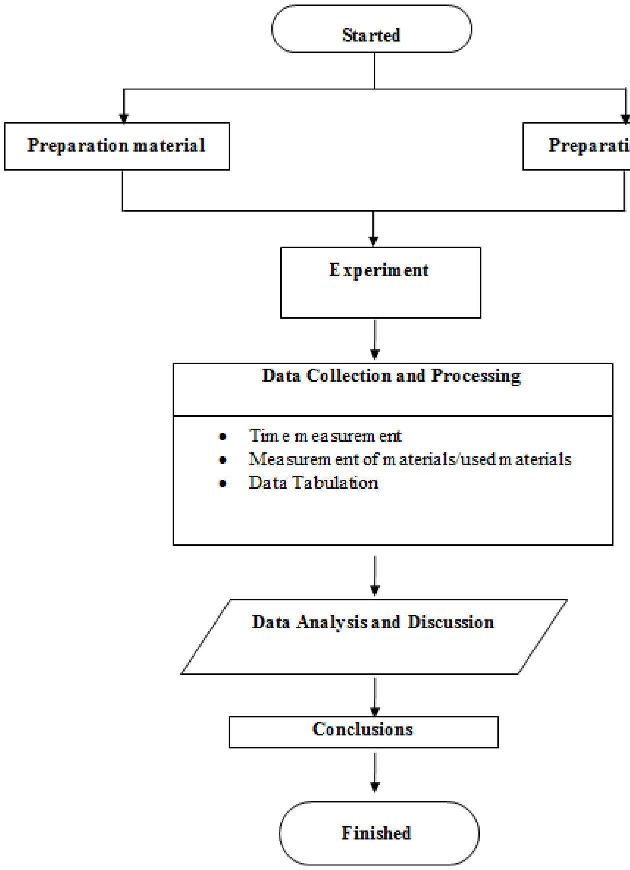

Figure 1. Research Procedure Chart

IV. RESULTS AND DISCUSSION

Data from measurements in this experiment consists of two, namely data on installation time and volume of use of the species before treatment (pretest) and after treatment (posttest). Data before treatment is data on the implementation of brick installation without using special molding tools. Meanwhile, the data after treatment is data on the implementation of brick installation using a special molding tool consisting of two tool designs. Data on measuring implementation time and volume of speci usage without using spec molding tools (pretest) can be seen in Table 1. Data on measuring the implementation time and volume of speci usage using the spec molding tool (posttest), can be seen in Table 2.

Table 1. Data for measuring implementation time and specimen volume without using spec molding tools (pretest)

Test	Field 1 P= 1m, T= 1 m (1 m ^{2})		Field 2 P= 2 m, T= 1 m (2 m ^{2})	
	Time (second)	Specific Volume per 1m ^{2} (m ^{3})	Time (second)	Specific Volume per 1m ^{2} (m ^{3})
1	2846.32	0.0615	2246.77	0.0550
2	2804.91	0.0600	2122.79	0.0575
3	2942.10	0.0625	2268.57	0.0545

Table 2. Data from measurements of implementation time and volume of speci usage using spec molding tools (posttest)

Tool Factor (B)	Field Length Factor (A)			
	P= 1 m, T= 1 m (1 m ^{2}) (A1)		P= 2m, T= 1 m (2 m ^{2}) (A2)	
	Time (second)	Specific Volume per 1m ^{2} (m ^{3})	Time (second)	Specific Volume per 1m ^{2} (m ^{3})
Tool Type 1 (B1)	3299.23	0.0475	2442.25	0.0485
	3526.19	0.0485	2504.62	0.0478
	3282.10	0.0448	2545.71	0.0480
Tool Factor (B)	Field Length Factor (A)			
	P= 1 m, T= 1 m (1 m ^{2}) (A1)		P= 2 m, T= 1 m (2 m ^{2}) (A2)	
	Time (second)	Specific Volume per 1m ^{2} (m ^{3})	Time (second)	Specific Volume per 1m ^{2} (m ^{3})
Type 2 Tool (B2)	2762.30	0.0453	2275.29	0.0443
	2420.00	0.0470	2294.85	0.0440
	2939.21	0.0420	2210.14	0.0450

After the measurement data is obtained, then a statistical description is carried out. This is done to describe the distinctive characteristics of the sample or data that has been collected. The typical characteristics in question include average value, minimum value, maximum value, standard deviation, etc. In this research, a statistical description of the measurement data results was obtained with the help of the SPSS application. A statistical description of the measurement data results is shown in Table 3.

Table 3. Descriptive statistics of measurement data

Data	N	Minimum	Maximum	Mean	Std. Deviation
Time Without Aids 1m x 1m Field (Pretest)	3	2804.91	2942.10	2864.44	70.37
Time With Type 1 Tools 1m x 1m Field (Treatment A1B1)	3	3282.10	3526.19	3369.17	136.25
Time with Type 2 Assistive Equipment 1m x 1m Field (Treatment A1B2)	3	2420.00	2939.21	2707.17	263.96
Time Without Aids 2m x 1m Field (Pretest)	3	2122.79	2268.57	2212.71	78.63
Time with Type 1 Assistive Equipment 2m x 1m Field (Treatment A2B1)	3	2442.25	2545.71	2497.53	52.09
Data	N	Minimum	Maximum	Mean	Std. Deviation
Time with Type 2 Assistive Equipment 2m x 1m Field (Treatment A2B2)	3	2210.14	2294.85	2260.09	44.35
Volume Without Field Aids 1m x 1m (Pretest)	3	0.0600	0.0625	0.0613	0.0013
Volume With Type 1 Auxiliary Equipment 1m x 1m Field (Treatment A1B1)	3	0.0448	0.0485	0.0469	0.0019
Volume With Auxiliary Equipment Type 2 Area 1m x 1m (Treatment A1B2)	3	0.0420	0.0470	0.0448	0.0025
Volume Without Field Aids 2m x 1m (Pretest)	3	0.0545	0.0575	0.0557	0.0016
Volume With Auxiliary Equipment Type 1 Field 2m x 1m (Treatment A2B1)	3	0.0478	0.0485	0.0481	0.0004
Volume With Auxiliary Equipment Type 2 Area 2m x 1m (Treatment A2B2)	3	0.0440	0.0450	0.0 / 444	0.0005
Valid N (listwise)	3				

The results of the T-test compare the time for brick installation between using special molding tools and not shows several things as follows:

1. The use of Type 1 tools has a significant influence or difference on implementation time.
2. The use of Type 2 tools has no influence or does not differ significantly on implementation time.

The two results above show that there is a difference in results between Type 1 Tools and Type 2 Tools. Using Type 1 tools makes brick installation slower when compared to those without using tools. In a field with a length of 1 m and a height of 1 m, the average execution time is 504.73 seconds slower per m^2 of brick area. In a field with a length of 2 m and a height of 1 m, the average execution time is slower, 284.82 seconds per m^2 of brick area. Meanwhile, the use of Type 2 tools tends to be the same when compared to not using tools. In a field with a length of 1 m and a height of 1 m, the average implementation time tends to be faster, 157.27 seconds per m^2 of brick area. In a field with a length of 2 m and a height of 1 m, the average execution time is slower, 47.38 seconds per m^2 of brick area.

Based on observations made during the experiment, the Type 1 Tool does not have support to maintain the position of the bricklayer as found in the Type 2 Tool. So each time you fill the Type 1 Tool requires a longer setting time. Meanwhile, the Type 2 tool only needs to be shifted. So the cumulative implementation time using Type 2 Tools is faster than with Type 1 Tools, and even tends to be the same as without using tools.

In this experiment, it was specifically seen that the use of Type 2 Tools tended to slow down on longer fields. Based on observations made, this is caused by differences in tool length. The length of the tool has implications for how the tool is used at different plane lengths. So it has an impact on implementation time.

How to use a Type 1 tool on a layer of masonry includes placing the tool on top of the layer of masonry, filling the spec, lifting and moving the tool (if necessary) or lowering the tool, and installing the brick. Meanwhile, how to use Type 2 Tools includes placing the tool on top of the bricklayer, filling the spec, moving the tool (if necessary) or lowering the tool, and installing the bricks. In general, both tools have the same number of stages, namely 4 stages. However, the difference in the length of the tool, where the Type 2 tool is shorter than the Type 1 tool, as well as the difference in the length of the plane, makes the number of stages different. Description and time calculation for the stages referred to about the length of the tool and the length of the field, based on the results of observations.

The length of the Type 2 tool is shorter than the Type 1 tool, making the number of stages of using the tool greater. Then the longer the work area, the more the number of stages of tool use. Even though the total time used for Type 2 Tools is still faster than Type 1 Tools, the difference in time in the 1 m and 2 m areas shows a decrease. From a difference of 8.5 seconds on a field length of 1 m to a difference of 6 seconds on a field length of 2 m. This proves that the shorter length of the Type 2 Tool means it tends to slow down or become less effective on longer areas.

In this case, the development of the Type 2 Tool was successful in certain aspects, such as making the tool easier to slide, adding a handle, and widening the area for filling the species. All these aspects make it easier to use the tool and make it more efficient. However, in terms of tool length, it is less successful, especially in longer work areas. Thus, the aspect of tool length requires further review, especially about the work area module, material, and tool weight.

In general, the use of spec molding tools, both Type 1 Tools and Type 2 Tools, affects the volume of specs used. The volume of specimen usage becomes more efficient with the use of spec molding tools. This applies both to field lengths of 1 m and 2 m.

Several things that cause the use of spec molding tools to make the use of specs more economical and efficient include the following:

1. Spec molding tools make the spec thickness more consistent.
2. Spec molding aids reduce the volume of wasted spec.

At a field length of 1 m, the average volume of species used without using tools per square meter is 0.0613 m^3. The average volume of species used using Type 1 and Type 2 tools is 0.0469 m^3 and 0.0448 m^3 respectively. The comparison of the average volume of spec usage between using spec molding tools and without using tools can be explained in Table 5 below.

Table 5. Comparison of the average volume of specimen usage between the use of spec molding aids and without using tools at a field length of 1 m

Tool Type	Comparison Without Using Tools	
	Savings (m^3)	Efficiency (%)
Type 1 Tool	0.0144	23.49
Type 2 Tool	0.0165	26.92

These results also show that the average volume of species used using Type 2 Tools is 0.0021 m^3 more efficient or 3.43% more efficient than using Type 1 Tools.

At a field length of 2 m, the average volume of species used without using tools per square meter is 0.0557m^3. The average volume of species used using Type 1 and Type 2 tools is 0.0481 m^3 and 0.0444 m^3 respectively. The comparison of the average volume of spec usage between using spec molding tools and without using tools can be explained as in Table 6 below.

Table 6. Comparison of the average volume of specimen usage between the use of spec molding tools and without using tools at a field length of 2 m

Tool Type	Comparison Without Using Tools	
	Savings (m^3)	Efficiency (%)
Type 1 Tool	0.0076	13.64
Type 2 Tool	0.0133	23.87

The results also show that the average volume of species used using Type 2 Tools is 0.0057 m^3 more efficient or 10.23% more efficient than using Type 1 Tools.

The results of the ANOVA test carried out on the volume of species used showed that the tool, field factors, and the interaction between tool and field factors had a significant influence on the volume of species used. These results strengthen the results of previous tests which stated that the use of a molding tool can save species or make the use of species more efficient. Apart from that, in particular, the use of Type 2 tools is more economical and efficient than Type 1 tools. The design of the tool affects the savings or efficiency resulting from the use of Type 2 tools.

The refinement and development of the tool design carried out on the Type 2 tool succeeded in making it more economical and efficient than the Type 1 tool used in previous research. Aspects of tool design that support this include the width of the mold to fill the spec and the width of the field to fill the spec. The width of the specimen filling mold is the width of the specimen installed on the horizontal broadcast. The width of the specimen filling mold on Type 2 Tools is 8 cm while on Type 1 Tools it is 8.5 cm. So that at the same broadcast thickness, the volume of the species installed on the Type 2 Tool will be less. The width of the field for filling in the species is the free space required for filling in the species. In Type 1 tools the width is 2.5 cm for each side. Meanwhile, the Type 2 tool is widened to 8 cm each. So that workers have more freedom when filling in specifications. In addition, the mix of species that fall becomes small.

V. CONCLUSION

Based on the results of the research and analysis that have been carried out to achieve the research objectives, the following conclusions can be drawn:

1. Installation using Type 1 type molding tools, which is the design of the tools used in previous research, when viewed from the time aspect, is slower than without using special molding tools. Meanwhile, brick installation using Type 2 type molding tools, which is a development of the Type 1 tool design, when viewed from the time aspect, tends to be the same or no different compared to without using special molding tools.
2. The design of the tool affects the implementation time resulting from the use of Tool Types 1 and 2. The developments made to the Type 2 Tool make it easier to use and make it more efficient than the Type 1 Tool. However, the shorter length of the Type 2 Tool makes it less efficient when used in the field. which is longer.
3. Viewed from the aspect of material use, the use of type 1 and Type 2 molding aids significantly influences material efficiency. When compared with not using a tool, on a shorter area (1 m long x 1 m high) Type 1 tools can save 0.0144 m^3 or 23.49% more efficiently. Meanwhile, Type 2 equipment can save 0.0165 m3 ^{or} 26.92% more efficiency. On longer fields (2 m long x 1 m high) Type 1 equipment can save 0.0076 m^3 or 13.64% more efficiency. Meanwhile, Type 2 equipment can save 0.0133 m^3 or 23.87% more efficiently.
4. The difference in results between the use of Type 1 and 2 tools in terms of the aspect of using the specific material in this experiment is influenced by the design of the tool. Tool design influences the savings or efficiency resulting from the use of Type 2 Tools. The refinement and development of tool design carried out on Type 2 Tools has succeeded in making them more economical and efficient than Type 1 Tools.

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