Construction Time Determination Model, Automatically Detected Resource Needs Using Programs

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Abstract: This research is discussing about the construction project scheduling that is integrated between the implementation time with the resources needed periodically and in total. Because, determining the time of implementation of construction is very important as a basic reference, when the commencement of work and when the work must be completed. So far, the project scheduling method that is often used by engineers is the time schedule bar chart method, S curve method, Critical Path Method (CPM) method and other methods. After that, the time schedule is developed into scheduling material procurement and manpower, but the scheduling planning system is often out of sync with the implementation time schedule, material supply schedule and manpower supply schedule, therefore construction project delays often occur due to improper supply of material and manpower. That is part of the cause of the loss, therefore there needs to be an integrated scheduling program. How to produce an integrated program is, conducting research by combining methods namely, time schedule bar chart method, S curve method, CPM method, BOW analysis, SNI analysis, statistics, and supported by 60 random sampling data of project documents, consisting of, construction drawings, BOQ, and cost budget plan. Through the process according to these methods, an integrated program will be produced. Why is it necessary to use a program that results from this research, because this program is easy to use, simply enter the building area and planned implementation time at the input layer, the implementation schedule, and the required resources, will be detected automatically, both periodically and in total. This program uses Microsoft Excel applications and is very simple. This program can only be used for scheduling residential construction projects 1 level to 2 levels, with a building area between 36 m^2 to 290 m^2. Cannot be used in other projects because each construction project has different characteristics.

Keywords: automatic program, scheduling models, project management, automatic scheduling.

I. INTRODUCTION

Resources are the most important factor in the success of project activities, because to achieve triple constraints (cost, quality, and time) depends on productivity, the number and quality of labor and the availability of material before the project is carried out [1].

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Several cases occurred, that productivity, labor quality, improper preparation of materials became a construction problem, which hampered the completion of construction projects, and caused project cost overruns [2-3]. Proper management of resources in construction projects can save a lot of time and money [4-5]. Therefore, resource management must be applied in project scheduling so that there is a balance between the time of project implementation and the resources that must be prepared [6-7].

To overcome this problem, previous researchers conducted a lot of research on scheduling construction projects using the Critical Path Method (CPM) method, BOW (*Burgerlijke Openbare Werken*), S curve, etc. [8-10]. Furthermore, time schedule was developed to schedule material procurement and manpower. The scheduling planning system is often out of sync with the implementation time schedule, material supply schedule and manpower supply schedule, therefore delays in construction projects often occur due to improper supply of material and manpower [11-12]. At present, to predict resource requirements, many rely on the experience of contractors through the project foreman [13-14]. That happened because the method was included in the complicated category and through a long process, in planning the time schedule of project implementation, scheduling material delivery and scheduling of workforce [15-16]. In addition, the S curve method only determines scheduling based on the target of progress in the achievement of work, not equipped with the amount of material and labor that must be prepared.

Whereas the Critical Path Method (CPM) method only targets that a job must be done based on the order of work and the time specified, but does not explain how much material and labor must be provided in the implementation of construction [17-18].

Based on the problems that have been submitted then, this research is very important to get a model. To produce a construction project scheduling method that is very easy to use by multiple disciplines, the model is then used as a formula to create a construction project scheduling program. So, this research will produce a model also produces a construction project scheduling program.

The hypothesis of this study is, by entering information on building area data and planned implementation time targets, it will be detected automatically, material resources and manpower needed, in accordance with the order of work in each period.

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The results of this study are expected to reduce the level of complexity and speed up the process of calculating the materials and manpower needed at the construction project planning stage.

So that in the construction project implementation phase, the required resources can be prepared optimally. The program that will be created in this research is expected to be able to complement the weaknesses of the previous method. This research is carried out on residential construction projects, so the scheduling program for construction projects that will be generated in this research is specifically for residential construction projects, whereas for different construction projects, it cannot be determined yet, because each construction project has different characteristics [19-20].

II. RELATED WORKS

In this section the authors present the findings of various previous researchers [21]. Findings O, Olatunji S et al, explained that the main role of an architect is to translate the needs of building users, engineers concentrate on calculating the strength of structures and requirements, the role of surveyors is mostly related to management and cost control systems in construction projects. The implementation of construction is the main role of production management. The performance of construction professionals is largely influenced by remuneration, motivation, incentives, promotion opportunities and influenced by supervision and co-workers. The demographic factors that most influence professionals are experience gender and age [22].

Muzamil et al, in their research stated that, the construction industry is one of the activities that use the most manpower and large costs. Manpower productivity has always been a major problem for the project. There are three main factors, identified as critical factors that can affect manpower productivity, in road construction in Pakistan namely, regarding poor salaries, poor execution, equipment and inefficient planning [23]. Olsen et al, said that there was a change in the construction industry towards Building Information Modeling (BIM) based on quantity take-off (QTO). Although BIM has gained popularity in recent years, but models supplied to contractors often do not have the quality that makes it possible to extract precise quantity estimation data. In addition to calculating the materials needed for building construction projects, the waste factor must also be calculated. This process requires a very long time and is very detailed, because there are many variables so that errors often occur, therefore it is necessary to carry out quantity take-off (QTO) and develop practical models to the level that makes it possible to identify the total quantity to take-off quantity (QTO) [24] Nojedehi, stated that, in implementing construction projects labor productivity played a very important role in supporting the successful implementation of the project itself. His research presents a System Dynamic based approach to modeling labor productivity. A qualitative model of labor productivity was built to control the problems caused. Then, the relationship between various factors is determined by the quantitative model of work productivity built. Using the proposed system dynamics model, labor productivity is simulated with the results of all the factors that influence it. The effect of labor productivity on different project performance is also assessed in terms of time and cost. Using the proposed model, project managers can find the root causes of decreased productivity, therefore labor productivity can be increased by applying appropriate solutions [25]

Lannelongue et al, in their study explained that labor productivity as a benchmark for the performance of labor, will be moderated by work intensity. Using calculations based on the multiple regression model, reveals that environmental management has a positive impact on labor productivity with low work intensity, even though the impact is negative in the case of high work intensity [26]

Manto, in his research revealed that the problem of work duration is one of the phenomenal things. Job Unit Price Analysis (AHSP) as a basis for identifying the duration of work time, using the network planning method combined with the scheduling and cost control method in a bar chart. The result can find out the longest work duration with the most labor [27]

Kumar et al, argued in his research that renovation of buildings after the disaster was very important and had to prepare skilled workers in the implementation of the renovation project. With the System Dynamics (SD) model they propose to emulate and explore labor issues, namely management of construction workers. The model illustrates work behavior in housing restoration. This provides insight into the interaction between labor and labor supply [28].

Wang et al, revealed in his research that many construction practitioners and researchers have developed a four-dimensional (4D) model by connecting the three-dimensional (3D) component of the building information model (BIM) with the network activities of the project schedule. Operating simulations can consider the duration of work assignments that are uncertain, allow it to be able to consider resource requirements that compete among several work tasks, and to evaluate various resource allocation strategies, thus creating a match with the construction plan. Finally, the resulting project schedule is also linked to the 3D BIM component, resulting in an improved BIM based 4D model [29]. The similarity of this research with previous studies, among them are all agreed that the management of resources plays an important role in the success of construction projects, each type of construction project has different characteristics, the provision of inappropriate materials is an inhibiting factor in the completion of construction, the provision of improper labor can cause a decrease work productivity, existing implementation time scheduling methods are not integrated with the supply of materials and manpower needed and there are some similarities in the use of research methods to produce solutions. The difference between this research and the previous research is that the types of construction projects studied are different and the outputs generated from the research are also different.

The results offered by previous studies include, focus on the quantity of work, focus on work productivity, focus on the factors causing decreased work productivity and focus on the duration of the construction project implementation. While this study uses a combination of methods that have been used by previous researchers and aims to produce a very simple program for scheduling residential construction projects that is integrated between the duration of implementation time with the amount of material and manpower that must be prepared. So, this research can be stated important to do.

III. METHODOLOGY

To produce a model that becomes a formula in creating a construction project scheduling program, which is integrated with the duration of implementation time, the number of material requirements and the number of manpower needs, so that this research goes through several stages of the process and each process uses scientific methods. Broadly speaking, it can be summarized that the method used in this research is the BOW and SNI unit price analysis (AHSP) method, regression analysis method, S curve method and numerical mathematics. This study uses 60 random sampling data on housing projects including, complete construction drawings, bill of quantity, cost budget plans, the number of manpower for each project, the amount of materials used in each project and the schedule for implementing residential construction projects. The model that will be produced in this study is a model for calculating the quantity of work. Meanwhile, to calculate the material and manpower requirements in each period, using SNI analysis and BOW analysis. The research process is conveyed in this methodology sub-chapter.

A. Method of Creating a Job Quantity Model

To create a work quantity model, the steps are to make an average quantity of work from bill of quantity data, cost budget plan data and work quantity data from analysis of construction drawings. This process combines the BOW analysis method, SNI analysis and regression analysis [9-10]. This process is briefly illustrated in Figure 1.
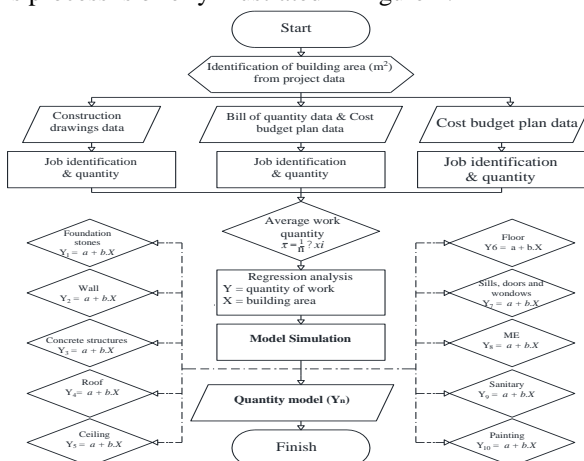

Fig 1. The process of producing a work quantity model

B. Method of Determining Construction Time Duration

The process of determining the duration of construction implementation, relying on data on the implementation of housing projects, by making an average weight of progress for each period and making the average length of time for project implementation, using mathematical methods. Make an average order of work based on time schedule data, which is combined using the Critical Path Method (CPM) [8]. Calculate the weight of the work progress in each time period and apply it to the S curve method. Apply the progress weights to the work quantity in each period to be a mathematical model.

C. Method of Calculating Material for Each Period

The process of calculating material for each period uses the BOW analysis method and SNI analysis, which already has a material coefficient for each work unit, so that after knowing the quantity of work for each period, the material needed can be calculated mathematically. The amount of material needed based on analysis is compared with the material data used factually, if a difference occurs then it is made average, so that the material needed in each progress period is the amount of material that has been confirmed between the amount of analysis and the amount based on fact data.

D. Method of Calculating Manpower for Each Period

The process of calculating manpower for each period, using the BOW analysis method and SNI analysis, is the same as calculating material requirements. Factual manpower data becomes a comparison with the results of the analysis. If a difference occurs then an average is made between the results of the analysis and the factual data, because manpower productivity is not necessarily the same in every project.

E. Method of Making a Program

Integrated housing construction project scheduling program, between the duration of time, the amount of material and the required manpower according to the duration of the construction period, using numerical mathematics. This program uses the Microsoft Excel application. In the data output page, input the time and progress mathematically, enter the quantity model, input the manpower needed mathematically, input the material needed mathematically, then summarize the sum of each mathematically. The preparation of this program uses a numerical method. The process of creating a program is illustrated in Figure 2.
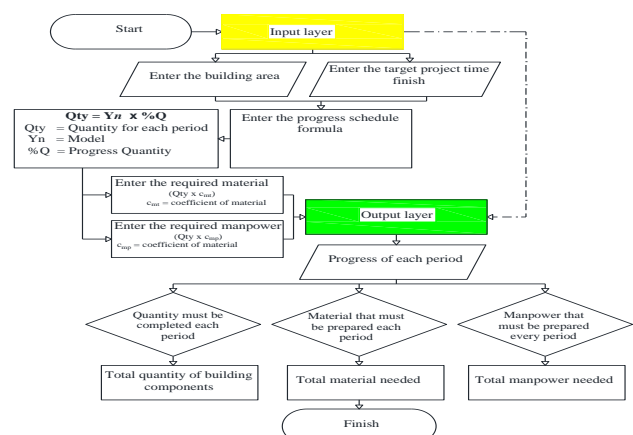

Fig 2. The process of making a program

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Through this stage of the process, a residential construction project scheduling program can be generated. Using the program that will be generated, simply enter the building area data and target construction finish time, then the work implementation period will be scheduled, detected the number of materials needed each period, detected the number of manpower needed each period according to his expertise, automatically.

IV. RESULT AND DISCUSSION

A. Housing Type

The type of housing referred to in this study is the type of minimalist housing that is trending in Indonesia today, with conventional construction methods. Examples of housing types as shown in Figure 3.

Fig 3. Examples of housing images studied

The area of the house under study is between 36 m^2 to 290 m^2, consisting of 1 level and 2 levels, with simple house categories, because the materials used are simple quality.

B. Job Quantity Identification

Home building consists of a quantity of building components, in each building component consists of the type of work. The quantity of work calculated is the quantity of building components including the type of work. Existing building components in house buildings in general, foundations, concrete structures, walls, sills (doors and windows), roofs, ceilings, mechanical electrical (ME), sanitary and painting [9-10]. The type of work in each building component is explained as follows:

- The foundation building component consists of the type of work, soil excavation, foundation sand, local concrete and stone foundation.
- Building components of concrete structures consist of types of work, foundation beam, main column, practical column, beam, ring beam, floor plate, concrete stairs, concrete canopy etc.
- Wall building components consist of types of work, masonry, plastering, and finishing.
- Components of building frames, consisting of types of work, door frames, window frames, doors, windows, and accessories.
- Roof building components consist of types of work, easel, roof truss, roof cover, ridge, and list plank.
- Ceiling building components consist of the type of work, install the ceiling frame and install the ceiling cover.

- Mechanical electrical building components (ME) consist of types of work, installation of electrical pipes, electrical installations, electrical sockets, switches, and lights.
- Sanitary building components consist of types of work, dirty water installations, clean water installations, toilets, water tanks, sinks, water taps.
- Painting is the finishing of all building components, the type of painting work consists of base paint, sandpaper, and painting work.

The quantity of building components calculated in this study is the quantity that has been confirmed for each type of building component work. To produce a model of building component quantity in this study using 60 sampling data consisting of, bill of quantity data, cost budget plan data and quantity of building components from the analysis of construction drawings. From the three data, the quantity of building components is made on average. Example of bill of quantity data as shown in Table I.

Table- I. Example of bill of quantity data for concrete structure work

N	Description	Specification	Unit	Quantity
1	Foundation beam	Concrete K-225	m^3	1.93
2	1st Floor Beam	Concrete K-225	m^3	2.77
3	Beam	Concrete K-225	m^3	1.31
4	Structure column	Concrete K-225	m^3	2.20
5	Stairs	Concrete K-225	m^3	1.28
6	Concrete floor plate	Concrete K-225	m^3	2.86
7	Canopy	Concrete K-225	m^3	2.27
8	The kitchen table	Concrete K-225	m^3	0.10
9	Sink table	Concrete K-225	m^3	0.05

The cost budget plan data has the same description as the bill of quantity data but has been equipped with unit prices and total costs, so the sample bill of quantity data can illustrate the cost budget plan data. Data on housing construction images were analyzed in order to identify the quantity of work. The analysis process is examining drawings, identifying building components, types of work and their quantities. As an illustration of the analysis shown construction drawings such as Figure 3 - 4.
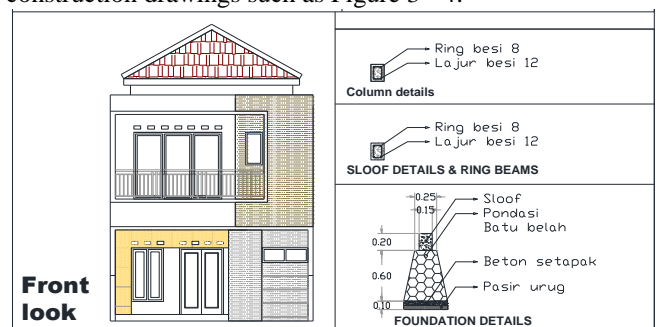

Fig 3. Example of construction drawings

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Figure 3 to identify the quantity of building components there needs to be other complementary drawings such as Figure 4.
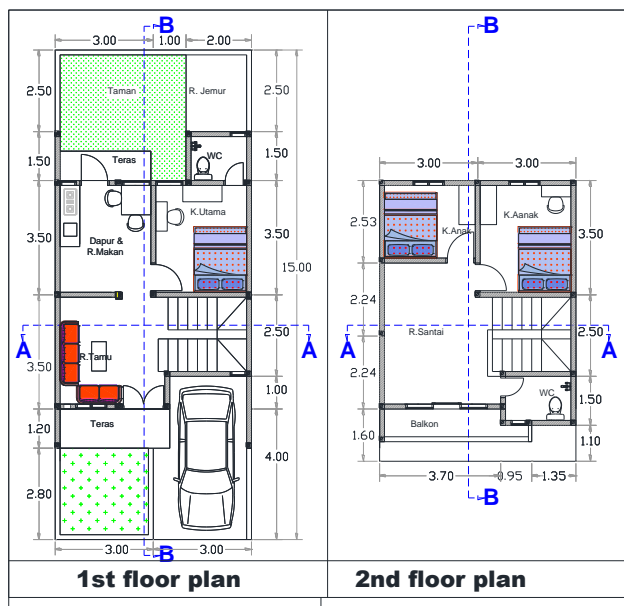

Fig 4. Example of construction drawings

Based on Figures 3 and 4, it can be calculated that the area of the house building is 90 m². Wall quantity can be calculated by identifying the wall length and identification of the wall height. The quantity of the wall is the length of the entire wall multiplied by the height of the wall. The results of identifying the quantity of wall area and type of wall work are shown in Table II

Table- II. Example wall quantity data analysis results from construction drawings

N	DESCRIPTION	UNIT	QUANTITY
	Wall		
A	1st floor		
1	Brick wall	m²	109.76
2	Plaster wall finishing	m²	219.52
3	Plaster stair finishing	m²	6.36
4	Plaster list plank finishing	m²	2.25
5	Plaster finishing, concrete canopy	m²	6.00
6	Wall height of 120 cm	m²	19.92
7	Finishing the parapet wall plaster	m²	39.84
B	2nd Floor		-
1	Brick wall	m²	213.51
2	Plaster wall finishing	m²	427.03
3	Plaster finishing, concrete canopy	m²	12.15
	Total wall quantity:		**323.27**

The entire quantity of building components is calculated based on the analysis of construction drawings, so there is a quantity of building components in accordance with the area of the building, which consists of the quantity of image analysis results, quantity data based on bill of quantity data and quantity data based on the cost budget plan. Quantity data obtained from the bill of quantity data tend to be the same as the quantity data from the budget plan, which often occurs the difference between the quantity usually between the bill of

quantity and the quantity of results of image analysis, this occurs because the expertise and accuracy in image analysis of each individual is different, therefore the quantity data is made on average from 3 data sources. Data on quantity of building components as an illustration are exemplified in Table III.

Table- III. Example of building component quantity data

y_1	y_2	Y_3	y_4	y_5	Y_6	y_7	y_8	y_9	y_{10}	X
48	862	41	379	46	118	18	144	1,852	271	290
69	391	23	289	13	73	2	234	1,466	312	286
51	386	17	273	13	74	11	88	1,114	273	273
49	368	30	260	19	86	10	84	1,061	260	260
48	360	30	255	19	86	10	82	1,041	255	255
47	353	17	250	19	74	10	81	1,020	250	250
30	800	39	228	30	127	37	222	1,495	244	234
30	541	29	215	19	41	18	102	1,370	214	222
36	516	28	214	23	91	120	33	1,073	210	211
24	395	26	109	23	61	51	91	593	117	109

In Table III, what is meant by; y_1 (concrete structure), y_2 (wall), y_3 (sill, door & window), y_4 (floor), y_5 (sanitary), y_6 (mechanical electrical), y_7 (foundation), y_8 (roof), y_9 (painting), y_{10} (ceiling) and X (building area). Data on building component quantity with a building area of 290 m², consisting of building components with quantity, concrete structure 48 m³, wall 862 m², sills, doors and windows 41 units, 379 m² floor, sanitary 46 units, mechanical electrical 118 points, foundation 18 m³, 144 m² roof, painting 1,852 m², and ceiling of 271 m². Data on building component quantity contained 60 sampling data with the largest building area of 290 m² and the smallest of 36 m². The data is then performed regression analysis to produce a model. The purpose of making a model is to practically calculate the quantity of building components using the building area as an input variable, so that a program can be made.

B. Regression Analysis

Regression analysis aims to produce a model quantity of building components using input variable building area, therefore the definition of a decision variable is expressed as the independent variable (X) of building area, the dependent variable (Y) of building components, because there are many building components, it is determined, y_1 (concrete structure), y_2 (wall), y_3 (sill, door & window), y_4 (floor), y_5 (sanitary), y_6 (mechanical electrical), y_7 (foundation), y_8 (roof), y_9 (painting), y_{10} (ceiling).

Stages of analysis include test data normality, R square test, significance test and coefficient test. Data normality test uses probability plot technique with decision making basis, if the data spreads along the diagonal line then the data functions normally, and if the data spreads do not follow the diagonal line then the data does not function normally [9-10].

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Data normality test is performed on the analysis of all building components Y_1 - Y_{10}. Examples of data normality tests such as the probability plot test results Figure 3-4.
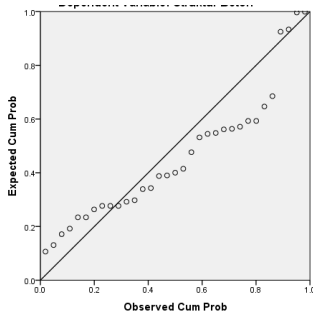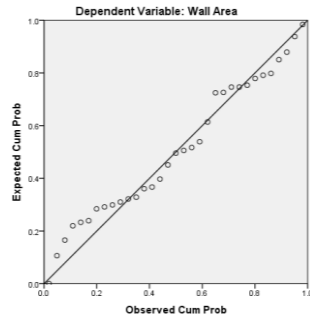

Fig. 3. Normatlity test y_1   **Fig. 4. Normality test y_2**

The results of normality test data conducted on the model Y_1 - Y_{10} in general show that the data can be normally distributed, then the analysis can be continued to the next stage, namely the significance test.

The significance test aims to find out whether the independent variable (X, building area) can significantly influence the dependent variable (Y, the building component). The determined probability is 0.05, so if the significance test value < 0.05 can be stated that the variable X (building area) significantly affects Y (the quantity of building components), if the significance test value > 0.05 then it is declared insignificant. Significance test can be performed using the statistical model summary method. The output of the summary model analysis can explain the results of the significance test and the R square test. R square test aims to explain how large the variable X (building area) can explain the variable Y (quantity of building components). Examples of the results of the significance test and R square on the output of the statistical model summary method are explained in Table IV.

Table- IV. R square test and significance test

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df₁	df₂	Sig. F Change	
1	.855ᵃ	.730	.721	93.951	.730	83.899	1	31	.000	1.869

a. Predictors: (Constant), Building Area
b. Dependent Variable: Wall Area

Significance test results such as the example in Table IV were performed on all models Y_1-Y_{10}. Significance test results all show a significance value < 0.05, so it can be stated that the variable X (building area) significantly influences the variable Y (Y_1 - Y_{10}). R square test results can be stated that the variable X (building area) is very influential to express the variable Y (quantity of building components) between 72.6% - 97.5%, it is stated in the R square test results between 0.726 - 0.975, but the model Y7 (quantity of foundation) the results of the analysis state the value of R square 0.424 so that it can only explain the foundation quantity of 42.4%.

After going through the data normality test, the significance test and the R square test are then carried out a coefficient analysis to produce a model. The model that will be produced in this study is explained in equation 1.

$$Y = a + b. X \qquad (1)$$

With understanding:
Y = dependent variable

a = a constant
b = parameter value
X = building area

The coefficient test aims to produce constant values (a) and parameter values (b). Examples of the results of the statistical analysis of the coefficient models are shown in Table V.

Table- V. The Example of coefficients test y2

Model	Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
1 (Constant)	100.968	27.04		3.73	.001					
Building Area	2.126	.232	.855	9.16	.000	.855	.855	.855	1.000	.000

a. Dependent Variable: Wall Area

The results of the coefficient analysis on the model Y_2 (wall quantity) as in Table V can be taken the decision that the constant value (a) 100.968 and the parameter value (b) 2.126, so that the wall quantity model has been produced, namely:

$$Y_2 = 100.968 + 2.126. X \qquad (2)$$

Based on a model such as Equation 2, if the planned area of a house is known, the wall quantity can be calculated. For example, it is known that the area of the building to be built is 100 m^2, then the quantity of walls can be calculated: 100.962 + 2.126 x 100, then the quantity of walls is 313.562 m^2. The results of the overall regression analysis are summarized in Table VI.

Table- VI. Summary of Analysis Results

N	Model	R Square	Sig.	Independent variable (X)
1	$Y_1 = 3.927 + 0.171X$	0.726	0.000	Building area
2	$Y_2 = 100.968 + 2.126X$	0.855	0.000	Building area
3	$Y_3 = 10.518 + 0.090X$	0.785	0.000	Building area
4	$Y_4 = 0.449 + 1.074X$	0.969	0.000	Building area
5	$Y_5 = 9.879 + 0.072X$	0.605	0.000	Building area
6	$Y_6 = 12.869 + 0.323X$	0.804	0.000	Building area
7	$Y_7 = 2.416 + 0.125X$	0.424	0.012	Building area
8	$Y_8 = 37.322 + 0.463X$	0.735	0.000	Building area
9	$Y_9 = 126.447 + 5.334X$	0.958	0.000	Building area
10	$Y_{10} = 13.388 + 0.953X$	0.975	0.000	Building area

The ten models of building component quantities as summarized in Table VI are then used as formulas in making programs. To find out the quantity of building components in each period, the percentage of progress weights per period is multiplied by the quantity of building components.

C. Identification of Materials Needed

Process data to determine the material required using the BOW (*Burgerlijke Openbare Werken*) method and SNI analysis [9-10, 30]. It was explained beforehand that the BOW analysis was a general provision, which was set on February 28, 1921 Number 5372 A during the Dutch Government era which was currently adopted and updated by the Indonesian government to be an Analysis of the Indonesian National Standard (SNI) [30]. The method of analysis is to multiply the coefficients determined by BOW and SNI with the volume of work.

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For example, in a building area of 250 m², it is known that the volume of concrete structures is 47 m³, so the material can be calculated: cement = 47 × 323, sand = 47 × 0.52, and concrete coral = 47 × 0.78. Examples of calculations as shown in Table VII.

Table- VII. Identification of material needs on concrete structure

Material description	Unit	Coefficient	Volume of concrete structure	Amount of material
Cement	Kg	323	47	15,181
Sand	m³	0.52		24
Gravel	m³	0.78		37

Based on the BOW analysis on the concrete structure volume of 47 m³, the material needed is cement = 15,181 kg, sand = 24 m³, and gravel = 37 m³. All types of work on building components of a house can be calculated as needed, as exemplified in Table VII. This SNI coefficient is used as a formula to calculate material in each period of a construction project, by multiplying the quantity according to the progress period with the material coefficient. The specifications of construction materials used in this study are, SNI standard size bricks are 5 × 20 × 10 cm, roof tiles measuring 22 × 25 cm, reinforced concrete, and other materials, SNI standards, so that if a project uses different material dimensions, need to be multiplied by the reduction factor, with the material dimensions specified in this study.

C. Identification of Total Manpower Needs

To find out the manpower needed according to his expertise using the BOW method and SNI Analysis [9-10, 30]. The method of analysis is, using the labor coefficient determined by BOW and SNI, multiplied by the quantity of building components.

Suppose that it is known that the quantity of reinforced concrete structures on a building area of 290 m² is 48 m³. According to the coefficient of manpower BOW and SNI are, workers = 4.85, carpenters = 0.35, masons = 1.56, blacksmiths = 1.4 and foreman = 0.17. Based on these data it can be calculated: workers = 4.85 × 48, carpenters = 0.35 × 48, masons = 1.56 × 48, blacksmiths = 1.4 × 48 and foremen = 0.17 × 48. More details are shown in Table VIII.

Table- VIII. Manpower identification data process

1	2	3	2 * 3
Manpower expertise	Coefficient	Quantity of concrete structures	Total manpower
The worker	4.85	48	232.8
Carpenter	0.35		16.8
Bricklayer	1.56		74.88
Blacksmith	1.4		67.2
Foreman	0.17		8.16

Using BOW and SNI unit price analysis methods, it can be seen the number of workers, as explained in Table VIII, that the quantity of concrete structures 48 m³ is done by, workers = 232.8 days, carpenters = 16.8 days, masons = 74.88 days, blacksmiths = 67.2 days and foreman = 8.16 days. The manpower coefficient becomes a fixed number in the project scheduling program, which can be multiplied by the percentage progress in the type of building component work in each period.

F. Time Schedule and Percentage of Work Progress

Based on 60 housing project time schedule data, an average of the percentage of progress per period is made. The average project schedule is simulated in a time schedule, the S curve method is shown in Figure 5.
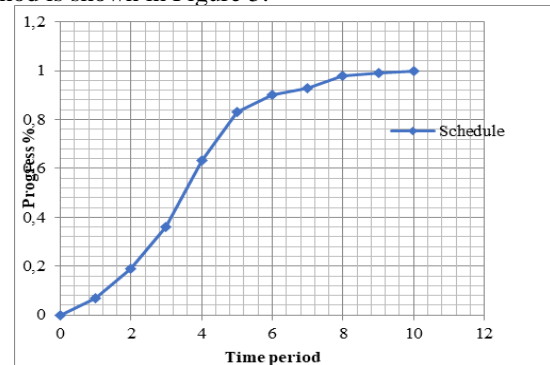

Fig. 5. Average project time schedule

From the average residential project time schedule analyzed using the CPM (Critical Path Method) method to determine the order of work to be done first, second and so on, as well as work that can be done simultaneously. The time to complete a housing construction project, is recorded from the fastest time to the longest time. From the fastest and longest time data is made on average, so that the implementation period is the same, but the length of time for each period can be different. For example, the project implementation period is determined for 10 periods, but the length of time for each period can consist of 5 days, 6 days, 7 days even up to 20 days, depending on the length of time the target is determined. Suppose the target time is determined within 100 days must finish, then 100 days in 10 periods there are 10 days per period. This is made so that each project implementation can determine the time as desired, the difference is the amount of quantity that must be completed each period that affects the amount of manpower needed and the amount of material that must be prepared.

Based on the time schedule data process illustrated in Figure 5, it can be identified that each period of progress consists of quantities of building components that must be completed. The building components that must be completed can be explained in the schedule bar chart method, as shown in Table IX

Table- IX. Time schedule bar chart method

Schedule Progress		1	2	3	4	5	6
Foundation	10.18 %	5.09%	5.09%				
Concrete structure	9.17%	1.83%	2.75%	2.75%	1.83%		
Wall	23.25 %		4.65%	9.30%	4.65%	2.33%	2.33%
Door frames	11.14 %			5.57%	5.57%		
Sanitary	11.15 %	1.11%	1.11%	1.11%	1.11%	1.11%	1.11%
ME	4.63%					0.46%	0.93%
Roof	13.41 %				4.02%	4.02%	4.02%

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Floor	6.68%						
Ceiling	5.20%					1.56%	2.08%
Painting	5.19%						0.52%
Total Progress	100%	8.0%	13.6%	18.7%	17.2%	9.5%	11.0%
Schedule	0	8%	22%	40%	58%	67%	78%

From the bar chart method schedule data, it can be seen the progress value of the building component quantity that must be completed in each period. For example, in period 1 the foundation work must be completed 5.09%, while the total weight of the foundation progress is 10.18%, then the quantity of foundation can be calculated in the equation:

$$Foundation\ progress = \frac{B_n}{A_n} \times \sum A \qquad (2)$$

B_n = progress period
A_n = percentage value of building components
$\sum A$ = total project percentage 100%

A progress value of 5% from 10.18% can be calculated:

$$\frac{5.09\%}{10.18\%} \times 100\% = 50\%$$

If the total foundation quantity is 38.67 m^3, then in period 1 must be completed: $38.67 \times 50\% = 19.33$ m^3

D. Home construction project scheduling program

This home construction scheduling program uses Microsoft Excel, so that it can be used by society in general. The program consists of 2 layers, namely the input layer and the output layer. In the input layer consists of input variables that must be entered, namely the area of the building and the duration of the construction project implementation must finish. The input layer in the Microsoft excel program is shown in Figure 6.
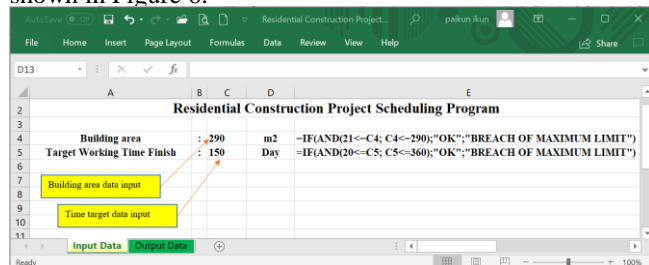

Fig. 6. Display data input layer

The input layer has a reminder, which can detect that the variable entered is outside the conditions specified in the program. Because this research program is specifically for housing construction projects, with a minimum building area of 36 m^2, and a maximum building area of 290 m^2, so if the input layer enters data < 36 or > 290, a warning appears that the variable entered violates the maximum limit. Likewise, when inputting the target variable of the project's finish time, there is a reminder if the time entered is too fast or too long. Because if time is too fast then, too much manpower is needed, so work productivity decreases. The purpose of the reminder in the system is, so that a housing project can be done realistically.

After inputting the data in the input layer, the model, and the mathematical formula that has been entered in the output layer, will process as follows:

- The process of determining the number of days in each period. Because in the program the specified number of periods is 10 periods, the number of days per period depends on the input data of the target time of the construction of the finish construction at the input data layer. If the target time is entered 150 days, the number of days in each period is 150 divided by 10, or the number of days in each period is 15 days. If the target time is set to 100 days, the number of days in each period is 10 days, therefore the mathematical model included in the output layer is the target time divided by 10 (periods).

- The process of determining the quantity of building components is, by including a model that has been produced in this study. Because the model uses independent variables (X, building area), so if the input layer has entered the building area variable, then in the output layer automatically the building quantity can be detected. For example, the model for calculating the quantity of building wall components, is:

$$Y_2 = 100.968 + 2.126.\ X \qquad (3)$$

If the area of the building in the input layer, entered 290, then the quantity of building wall components is: 100.962 + 2,126 x 290, or = 717.50 m^2.

- The process of determining the percentage of progress into the quantity of building components. The percentage of progress in the time schedule is the percentage of progress of the total progress of 100%, to determine the percentage of progress for each type of building component work, it is necessary to calculate the percentage value of each building component. For example, in period 1 the percentage of progress of the foundation building components, in the schedule is 5% of the total 100%, it is known that the percentage of foundation work is 10%, so it can be calculated that the progress of the foundation 5%, equivalent to 50% of 10%, meaning that in the period 1, foundation work must be done 50%. If the foundation volume is 39 m^3, in period 1 the foundation quantity can be calculated: $39 \times 50\%$ or 19.5 m^3. That is the way to change the percentage of progress into the quantity of building components, on foundation work, as well as other building components.

- The process of determining the number of manpower needed in each period is by, the quantity of building components per period multiplied by the coefficient of SNI divided by the number of days per period. For example, the percentage of progress of wall work in the second period is 4.6%, the weight of the percentage of wall work is 23%, then 4.6% of 23% is 20%, so it can be calculated with a mathematical model, $23\% \times 20\% = 4.6\%$, the quantity of building components walls, with a building area of 290 m^2 is 718 m^2, then 20% of 718 is = 143.6 m^2, so the required mason is 143.6×0.1 (SNI coefficient) = 14.36 days. The number of days per period is 15 days, so that the masons needed are 14.3 / 15 = 1 person every day.

- The process of determining the amount of material needed in each technical period is the same as determining the required manpower, the difference is the SNI coefficient value.

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The output from the program will produce S curve method schedule, bar chart method schedule, bill of quantity, total required manpower, manpower needed in each period, total material needed, material needed in each period, as shown in Figure 7, and Table X – XI
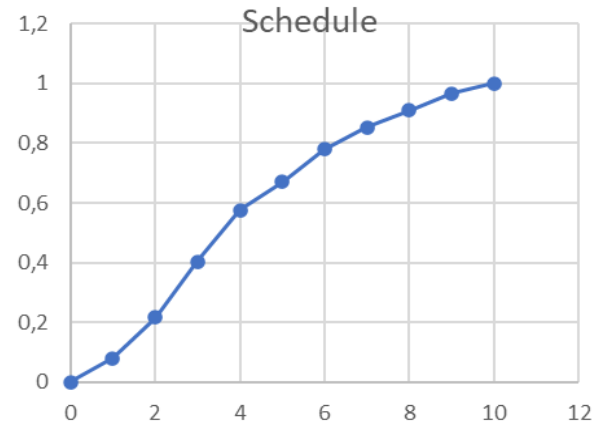

Fig. 7. Time schedule S curve method

Table- X. Time schedule barchart method

Schedule Progress		1	2	3	4	5	6	7	8	9	10
Building Component Description	Bobot %	15	15	15	15	15	15	15	15	15	15
Foundation	10.18%	5.09%	5.09%								
Concrete structure	9%	1.83%	2.75%	2.75%	1.83%						
Wall	23%	0.00%	4.65%	9.30%	4.65%	2.33%	2.33%				
Door, windows frames	11%			5.57%	5.57%						
Sanitary	11%	1.11%	1.11%	1.11%	1.11%	1.11%	1.11%	1.11%	1.11%	1.11%	1.11%
ME	5%					0.46%	0.93%	0.93%	0.93%	0.93%	0.46%
Roof	13%			4.02%	4.02%	4.02%	1.34%				
Floor	7%							1.34%	2.00%	2.00%	1.34%
Ceiling	5%				1.56%	2.08%	1.56%				
Painting	5%					0.52%	1.04%	1.56%	1.56%	0.52%	
Total Progress	100%	8.0%	13.6%	18.7%	17.2%	9.5%	11.0%	7.3%	5.6%	5.6%	3.4%
Period	0	1	2	3	4	5	6	7	8	9	10
Schedule	0	8%	22%	40%	58%	67%	78%	85%	91%	97%	100%

Table- XI. Bill of quantity and resources needed

I	Bill of Quantity	Total	1	2	3	4	5	6	etc.
1	Foundation	38.67	19.3	19.3	-	-	-	-	-
2	Concrete structure	53.52	10.7	16.1	16.1	10.7	-	-	-
3	Wall	717.51	-	143.5	287.0	143.5	71.8	71.8	-
4	Door, windows frames	36.62	-	-	18.3	18.3	-	-	-
5	Sanitary	30.76	3.1	3.1	3.1	3.1	3.1	3.1	-
6	ME	106.54	-	-	-	-	10.7	21.3	-
7	Roof	171.59	-	-	-	51.5	51.5	51.5	-
8	Floor	311.91	-	-	-	-	-	-	-
9	Ceiling	289.76	-	-	-	-	86.9	115.9	-
10	Painting	1,673.31	-	-	-	-	-	167.3	-
II	Manpower every period								
1	Foreman	1	0.1	0.1	0.1	0.1	0.1	0.1	-
2	Blacksmith	0	0.0	0.0	0.0	0.0	0.0	0.0	-
3	Bricklayer	4	1.3	2.1	2.9	2.7	1.5	1.7	-
4	Electrician	0	0.0	0.0	0.0	0.0	0.0	0.0	-
5	Painter	2	0.3	0.5	0.7	0.6	0.3	0.4	-
6	Carpenter	1	0.1	0.1	0.1	0.1	0.0	0.0	-
7	The worker	10	7.6	12.9	17.7	16.3	9.0	10.4	-
III	Materials								
1	Sand (m³)	126	17	34	37	20	7	7	-
2	Gravel (m³)	44	9	13	13	9	-	-	-
3	cement (kg)	52,303	6,911	13,780	15,879	9,010	2,364	2,364	-
4	Steel bar 12 mm (kg)	112	56	11	17	17	11	-	-
5	Steel bar 8 mm (kg)	112	56	11	17	17	11	-	-
6	Brick (pcs)	87,568	163	17,383	34,603	17,383	8,773	8,773	-
7	Sills, door (unit)	44	-	-	22	22	-	-	-
8	Sills, window (unit)	44	-	-	22	22	-	-	-
9	C light steel (rod)	357	-	-	-	51	138	167	-
10	Mild steel lath (rod)	232	-	-	-	77	77	77	-
11	Roof tiles (pcs)	3,861	-	-	-	1,287	1,287	1,287	-
12	etc.	…..	….	….	….	….	….	….	….

This program can be used specifically for scheduling home construction projects, with minimalist type of house 1 level and 2 levels, with the largest building area of 290 m^2 and the smallest of 36 m^2 The quantity of building components used in the program uses a model but can be input manually if, it is known the quantity of building components. This program can create a time schedule, bar chart method, S curve method, determine the manpower needed, and determine the material needed, automatically.

V. CONCLUSION

This research has produced a solution to the problem of the length of time in scheduling construction projects, the complexity of calculating the manpower and materials needed for construction projects, the complexity of determining the amount of material needed in each period, all of which can be detrimental to the project owner and project implementer. Now a solution has been found for this problem, namely using a program, which was created using the Excel Microsoft application. This program produces bar chart time schedule, S curve, total needed manpower, manpower for each period, total material needed, material for each period, automatically, just by entering the building area variable and target implementation time at the input layer.

This program is integrated between the implementation time schedule, the materials needed, and the manpower needed, periodically, as well as the total manpower and material needs in the housing construction project. This program can be used specifically for resource scheduling planning in minimalist type of residential construction projects, 1 floor and 2 floors, with a building area of at least 36 m^2 and a maximum of 290 m^2.

This program can be used in other types of housing projects by manually entering the quantity of building components. This program is feasible to be developed so that it can be used in construction projects other than housing. This program can also be a reference in determining the quantity of building components and resources needed in the Building Information Modeling (BIM) application.

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