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Analysis of the Effect of Factors on Hydraulic Engineering Software on Time Performance of Sewerage Design

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ABSTRACT

Almost all construction projects are almost certain to experience delays that occur at each stage of the project including the planning and design stages. In the implementation of infrastructure projects such as wastewater piping networks, there are still frequent delays in the planning and design stages. This is of course influenced by many factors, including the low use of Advanced Engineering Software. The use of conventional software such as Microsoft Excel is still an option in sewerage analyzing so that it takes more time to design or correct the design. Therefore, this study was conducted to determine the factors in the use of hydraulic engineering software that affect the design time performance of the sewerage. The results of multiple linear analysis show that with the simultaneous use of the factors of ease of analysis, clear visualization, design coverage, scenario management, automated design, integration with GIS, conversion and accuracy have a positive influence on the design time of the sewerage where the most influential factor is scenario management.

Keywords:

Sewerage Project, Engineering Software, Design Phase, Time Performance.

1. Introduction

There are still many countries in the world that face problems in handling sanitation and drinking water, one of which is what happened in Indonesia. Currently, Indonesia is ranked 125th in terms of handling sanitation and drinking water [1].

Table 1. Environmental Performance Index 2020 for Water and Sanitation.

No.	Rank	Country	Score	Region
1	1	Finland	100	1
2		Iceland	100	1
3		Netherland	100	1
4		Norway	100	1
5		Switzerland	100	1
6		England	100	1
7	50	Bosnia and Herzegovina	61.4	13
8	59	Malaysia	57.6	7
9	63	Thailand	55.8	8
10	74	Vietnam	52.7	9
11	100	Panama	43.5	20
12	110	Philippines	39	13
13	124	Myanmar	30.8	18
14	**125**	**Indonesia**	**28.4**	**19**
15	132	Timor Leste	25.9	21
16	150	Papua New Guinea	15.5	24

Source: (Yale Center for Environmental Law & Policy, 2020)[1]

Part of the sanitation that is a problem is wastewater management, especially in big cities in Indonesia, which contributes a lot of wastewater due to the high population. As an effort to deal with this problem, the Indonesian government through the Ministry of Public Works and Housing (MPWH) has set a development target in the form of a Vision of the MPWH which includes a program of 100% drinking water services, 0 ha of urban slums and 100% sanitation services [2]. This government program, of course, will be followed by programs that will increase the level of access to sanitation services, including planning for sewerage and wastewater treatment.

One of the challenges faced in the planning and design stages is the occurrence of delays [3]. In public works projects in Malaysia, it was found that around 88% of delays occurred in the planning and design stages [4]. This shows that time performance in the planning and design stages is still a problem that needs attention.

One of the factors that cause delays in the construction planning stage is the change in needs by the owner [5]. Changes by the owner in the sewerage network project such as changing the location of the service and different from what has been stated in the working terms of reference (TOR). This change greatly affects the design carried out by the engineer and will increasingly affect the time because it is still using conventional software. The same thing was also expressed by (Hafiz Usama Imad et al., 2018) [6] that the low use of more advanced software is one factor that has a significant impact on construction planning time. And in drinking water and wastewater projects, this factor is also one of the causes of delays [7].

The description of the problem above is the background for the preparation of this research with the title "Analysis of the Effect of Factors on Hydraulic Engineering Software on Time Performance of Sewerage Design".

2. Research Methodology

The stages of the research carried out began with formulating the problem as the research background, conducting theoretical studies, collecting data by distributing questionnaires, analyzing questionnaire data using the multiple linear regression analysis methods with SPSS version 25, interpreting the results of multiple linear regression analysis and concluding.

The following is a research framework in this paper.

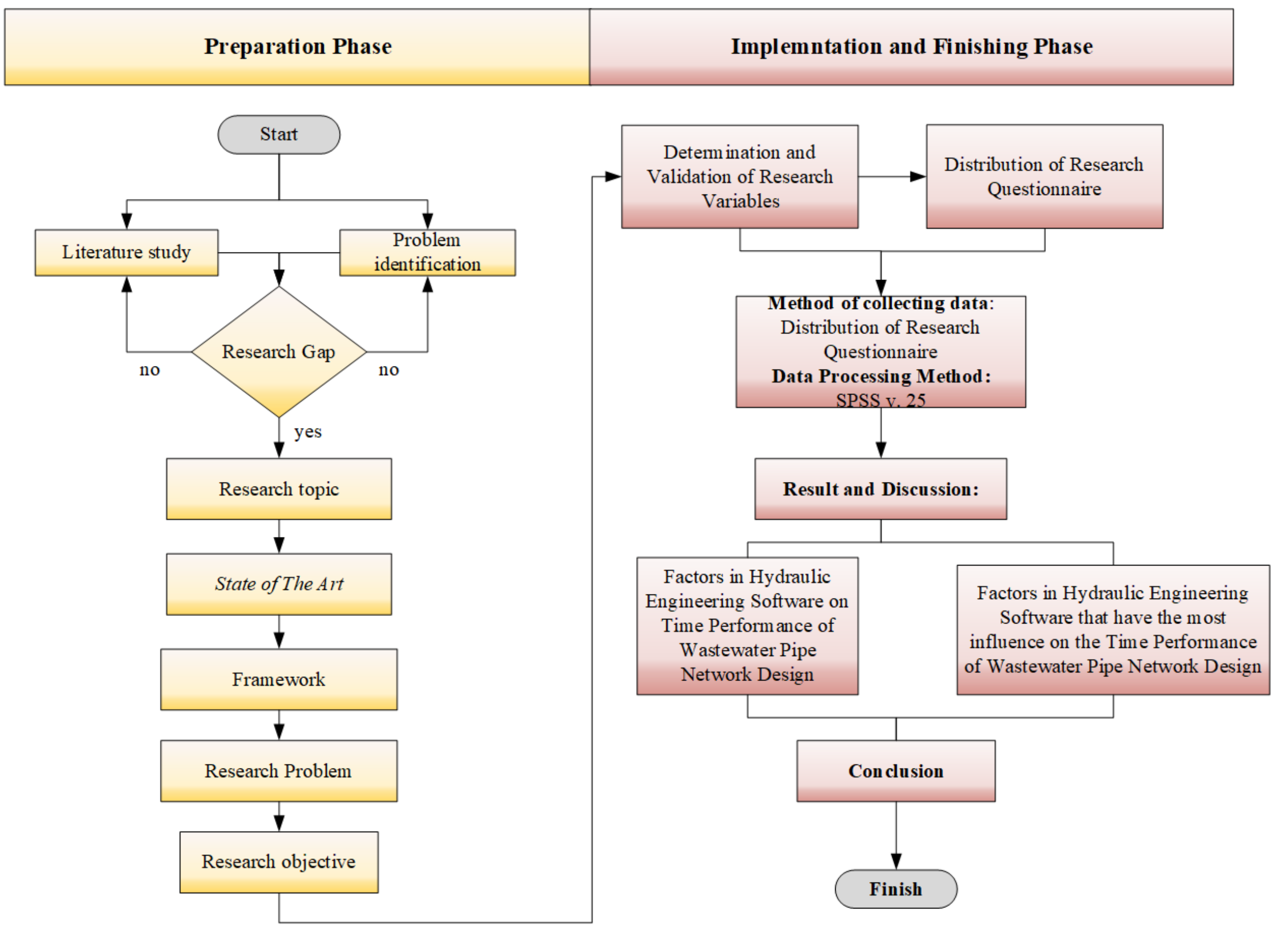

Figure 1. Research Framework.

3. Results and Discussion

3.1. Results

Research questionnaires were distributed to 32 respondents, referring to the minimum number of respondents for statistical analysis of at least 30 respondents [7]. The description of respondent data is as follows:

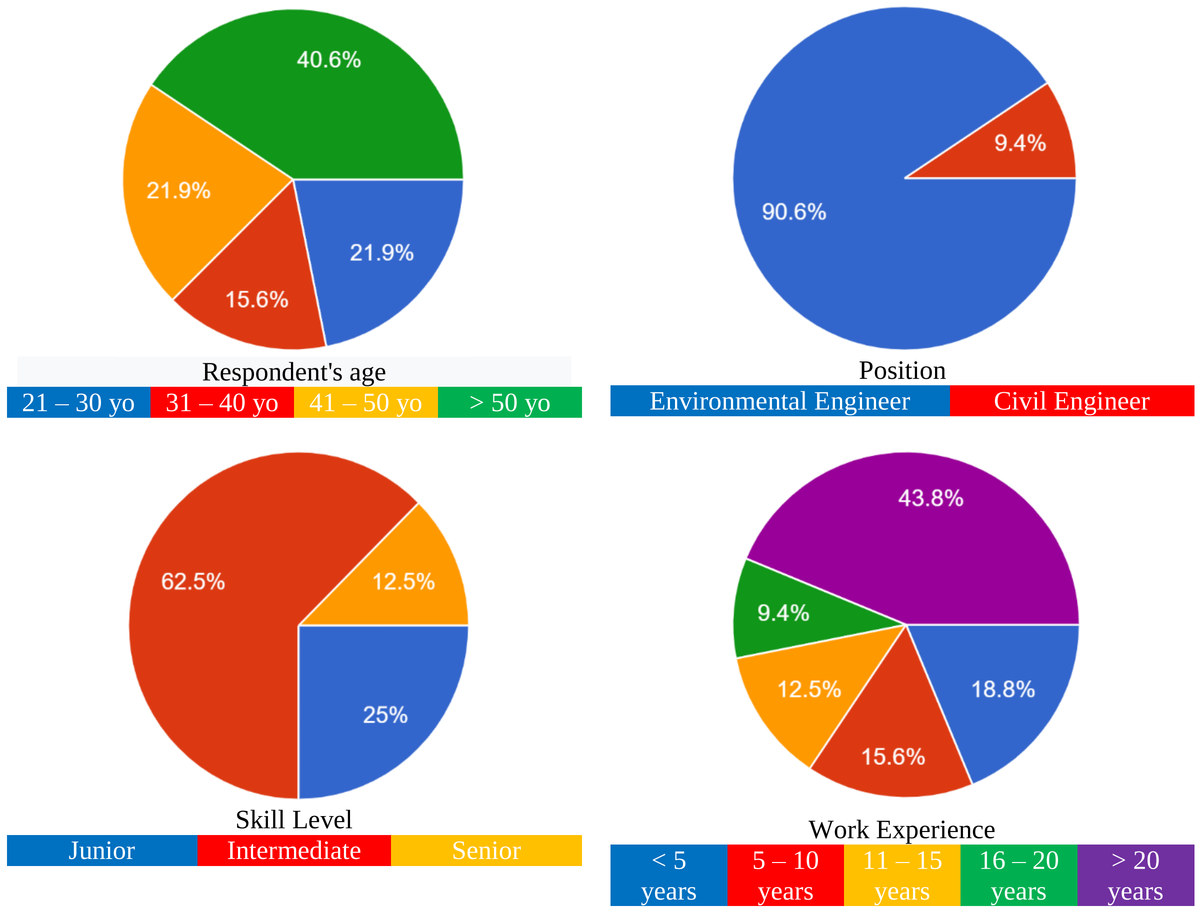

Figure 2. Description of Respondent Data.

The results of the identification of research variables from previous studies resulted in 8 (eight) research variables which were validated by experts and developed for questionnaires, namely ease of analysis (X1), clear visualization (X2) Design coverage (X3), Scenario management (X4), Automated design (X5), Data Integration with GIS (X6), Conversion to other formats (X7) and Accuracy (X8). Questionnaire data was carried out through statistical tests with the following levels: (i) validity and reliability tests, (ii) classical assumption tests including normality test, multicollinearity test, heteroscedasticity test, and autocorrelation test, (iii) multiple linear regression analysis with F-test simultaneous and partial t-test.

Table 2. Validity and Reliability Test.

No.	Research Variables	Validity Result	Reliability Result
1	Ease of analysis (X_1)	>0,349	> 0,6
2	Clear visualization (X_2)	>0,349	> 0,6
3	Design coverage (X_3)	>0,349	> 0,6
4	Scenario management (X_4)	>0,349	> 0,6
5	Automated design (X_5)	>0,349	> 0,6
6	Data Integration with GIS (X_6)	>0,349	> 0,6
7	Conversion to another format (X_7)	>0,349	> 0,6
8	Accuracy (X_8)	>0,349	> 0,6
9	Time Performance (Y)	>0,349	> 0,6

Notes: N = 32 respondents, r_{table} = 0,349 (sig 5%), Valid ($r_{count} > r_{table}$), Reliable (Cronbch alpha > 0,6)

Table 3. Classic Assumption Test.

No.	Classic Assumption Test	Result	Notes
1	Normality test	Asymp Value. Sig. (2-tailed) 0.200 (>0.05)	Data is normally distributed
2	Multicollinearity test	Tolerance value>0.1 and VIF value <10	No multicollinearity symptoms
3	Heteroscedasticity test	There is no clear pattern from the dots	No heteroscedasticity symptom
4	Autocorrelation test	Asymp Value. Sig. (2-tailed) of 0.369 (>0.05)	No autocorrelation symptoms

The rules in the simultaneous F-test analysis are:

- if the value of sig. <0.05 then the independent variable (X) simultaneously affects the dependent variable (Y)
- If $F_{count} > F_{table}$, where it is known that Ftable = (k; n-k) = (8; 32-8) = (8; 24) = 2.36

Table 4. Result of F-Test

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	130.666	8	16.333	4.308	.003[b]
	Residual	87.209	23	3.792		
	Total	217.875	31			
a. Dependent Variable: Time Performance						
b. Predictors: (Constant), Accuracy, Design coverage, Scenario management, Integration with GIS, Automated design, Conversion Data, Ease of analysis, Clear visualization						

In the table above, it can be seen that the significance value is 0.003 which is smaller than 0.05, and F_{count} = 4.308 which is greater than F_{table} = 2.36. This means that all variables measured at the same time or together have a significant influence on the acceleration of the planning time of the sewerage network.

To find out the most influential factors individually, a partial t-test was carried out with the following rules:

- If the value of sig. <0.05 then the independent variable (X) partially affects the dependent variable (Y).
- If $t_{count} > t_{table}$, where it is known that $t_{table} = (\alpha/2; n\text{-}k\text{-}1) = (0.05/2; 32\text{-}8\text{-}1) = (0.025; 23) = 2.069$.

Table 5. Result of t-Test.

Model		t	Sig.
1	(Constant)	0.385	0.703
	Ease of analysis	1.370	0.184
	Clear visualization	0.236	0.816
	Design coverage	-0.051	0.959
	Scenario management	2.225	0.036
	Automated design	0.411	0.685
	Integration with GIS	0.653	0.520
	Conversion Data	-.066	0.948
	Accuracy	0.563	0.579

From the table above, it can be seen that partially only the Scenario management variable has a significant effect on the time performance of the sewerage project, which is indicated by a significance value of <0.05 (0.036) and $t_{count} > t_{table}$ (2.225 > 2.069).

3.2. Discussion

3.2.1. Factors in Hydraulic Engineering Software That Affect Time Performance

Based on the results of the simultaneous F test described in the previous sub-chapter, it can be seen that the factors possessed by hydraulic engineering software are: (i) ease of analysis, (ii) clear visualization, (iii) design coverage, (iv) scenario management, (v) automatic design, (vi) GIS data integration, (vii) data conversion, and (viii) accuracy, have a positive influence simultaneously on the acceleration of the time performance of the sewerage network planning project. This has been proven from the results of the F test which shows the value of F_{count} (4.308) > F_{table} (2.36). By using the regression equation, the influence of these factors can be written as follows:

$$Y = 2.725 + 0.308\,X_1 + 0.038\,X_2 - 0.020\,X_3 + 0.657\,X_4 + 0.247\,X_5 + 0.205\,X_6 - 0.017\,X_7 + 0.150\,X_8 \quad (1)$$

Factors that have a positive effect on time performance are ease of analysis (X_1), clear visualization (X2), scenario management (X4), automatic design (X5), integration with GIS data (X6), and accuracy (X8). This means: "If the hydraulic engineering software has these factors to analyze the wastewater pipeline network, then it has a positive influence on the time (accelerates time) for sewerage planning."

The ease of analysis (X_1) factor has a positive effect on the results of this study and supports the results of Minaya's research [8] that it is possible to use the sewerCAD program to minimize the time required for planning because the input of data and parameters is fast and easy. For the clear visualization factor (X_2), this study found a positive effect on time performance, as in the study of Amiri, et al [9] stating that sewerCAD has a better understanding of the conditions and parameters of wastewater development.

According to a study conducted by Ojha [10], it was concluded that sewerCAD is very efficient because it allows the creation of designs with different criteria and scenarios. This finding is also supported by the results of this study which found that the scenario management factor (X_4) in the software has a positive and significant effect on the planning time performance of City Scale SPALD-T. The automated design factor (X_5) has a positive impact on time performance, this finding supports the results of a previous study by Katti and B. M. which states that SewerGEMS takes less time to describe the pipeline with existing tolls and labeling and can update the data automatically [11].

According to Bentley [12] that this software can automatically display elevation based on GIS data, this study shows that data integration with GIS (X_6) has a positive impact on time performance. According to Amiri, et al (Amiri et al., 2016) that sewerCAD can shorten the analysis time and obtain a more accurate design, it is supported by the results of this study that the accuracy factor (X_8) in the software has a positive influence on the time performance of sewerage planning.

The Design coverage (X_3) and Conversion (X_7) factors have a negative impact on time performance, as shown in the regression equation above. This means that "The greater the design coverage and data that must be implemented by hydraulic engineering software, the negative effect on time performance (slowing down time performance) for City-Scale SPALD-T Planning". According to research by Kothai, et al [13] that the use of sewerCAD in a wider service area is considered more optimal, it should also be explained that the use of hydraulic engineering software also depends on how large the service area will be designed. Because the larger the service area designed, the longer it will take. As stated by Tonde, et al [14] that the design results can be converted into dwg format, it should be emphasized that although there are factors for the conversion of the design results, the more results or images that are converted, the more time needed for sewerage planning because the conversion results still need to be tidied up according to the format agreed upon by the owner during the implementation of certain projects.

3.2.2. Factors in Hydraulic Engineering Software That Have the Most Influence on Time Performance

All factors have a positive or negative influence on time performance, but only the scenario management factor (X4) has a significant effect on time performance. This is indicated by a significance value of 0.036 (< 0.05) and a t_{count} of 2.225 (> t_{table}). This factor has a significant effect due to:

a. Can provide tools to manage analysis scenarios (100% served conditions, 50%, etc.) based on user requirements.

b. The results of the scenario can be used as a reference for decision making and corrections in the presence of hydraulic conditions at certain times of the scenario management

c. Displays comparison results between scenarios with comparison items requested by users

Scenario management in SewerCAD can be configured by:

a. Alternative management on "Alternative" option

b. Configure calculation options to configure flow conditions at specific hours (peak, average, minimum, maximum)

c. Scenario management in Options " Scenario"

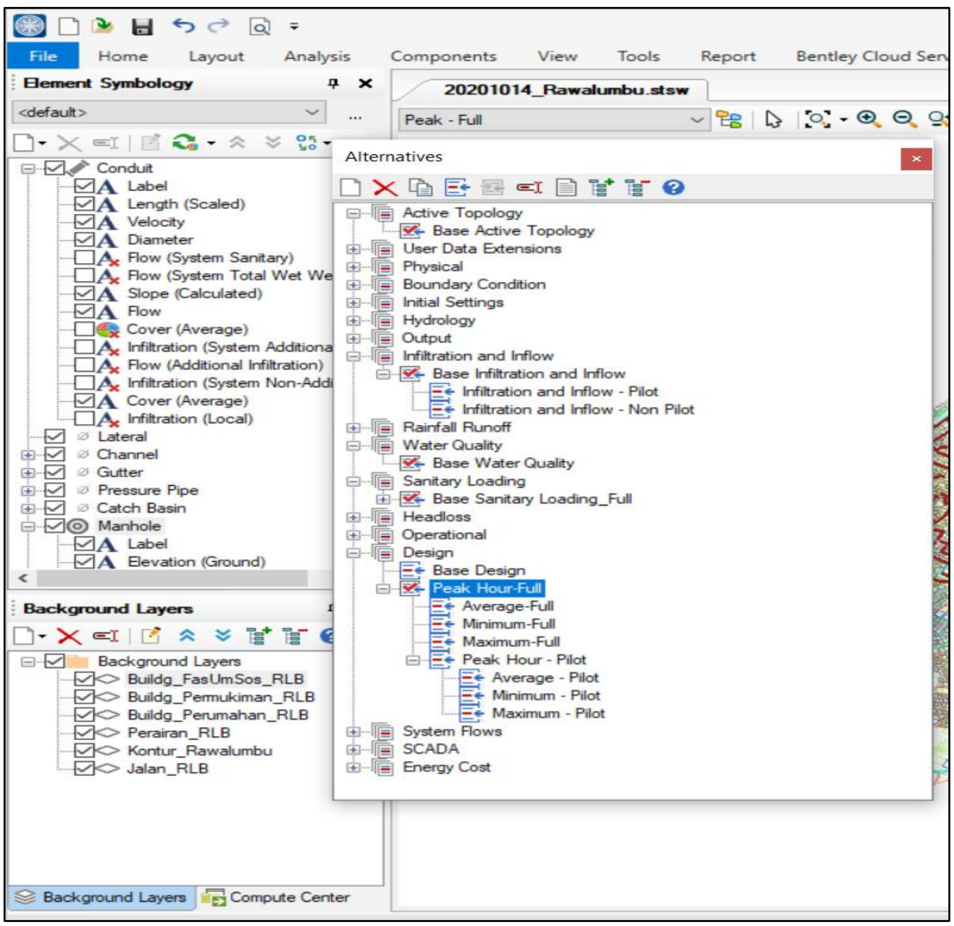

Figure 3. Alternative Management for Scenario Analysis.

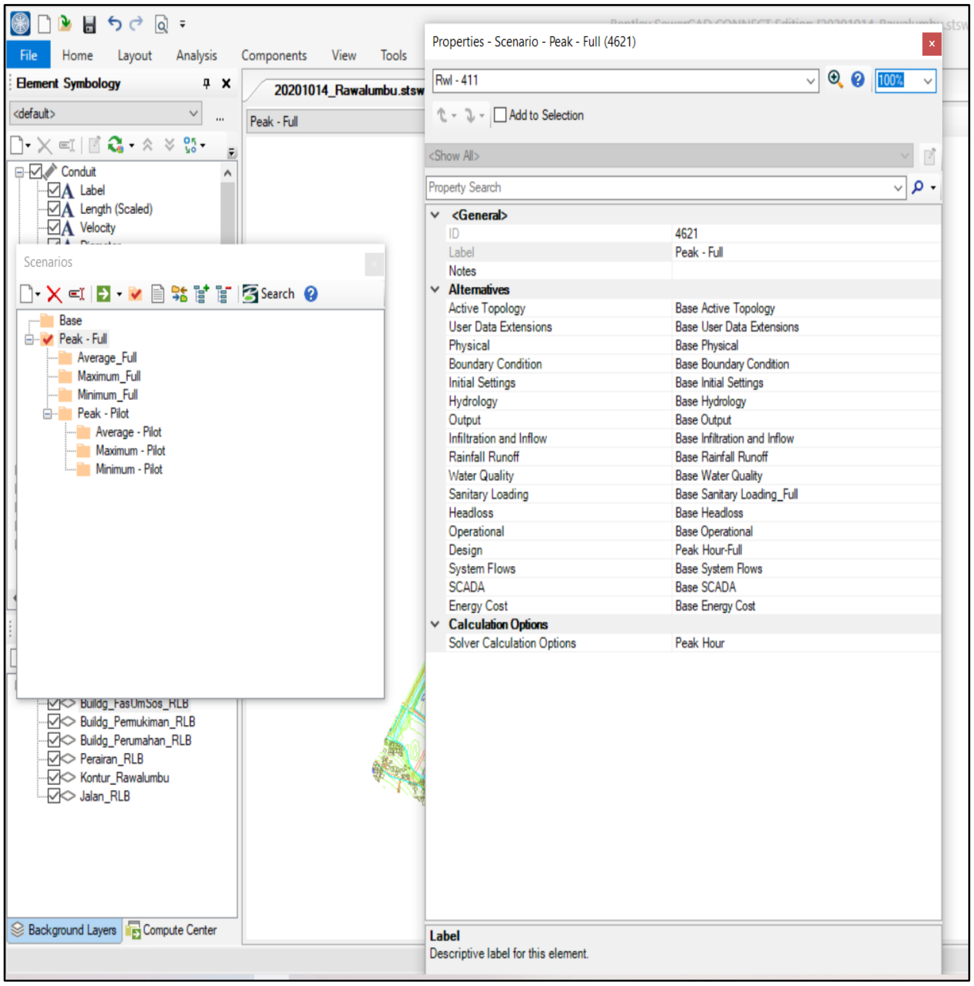

Figure 4. Scenario Management.

With scenario management, users can compare one scenario to another. For example, comparing flow rate conditions in the same pipe segment, but under different flow conditions (compare peak and minimum conditions).

4. Conclusion

Factors in hydraulic engineering software that affect the time required for the sewerage planning, are (i) ease of analysis, (ii) clear visualization, (iii) design coverage, (iv) scenario management, (v) automated design, (vi) GIS data integration, (vii) data conversion and (viii) accuracy. There are 6 (six) factors that have a positive effect, namely ease of analysis, clear visualization, scenario management, automated design, GIS data integration, and accuracy. Meanwhile, design coverage and conversion factors have a negative impact on time performance; "The more designs and data coverage that hydraulic engineering software has to convert, the longer it will take." The most influential factor is the scenario management factor because the village provides tools to manage hydraulic analysis scenarios, the results of which can be used as a reference for decision making and correction by software users.

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