THE 6th ICRMCE

International Conference on Rehabilitation and Maintenance in Civil Engineering

CONFERENCE PROCEEDING

POLICY, DESIGN, CONSTRUCTION, REHABILITATION, AND MAINTENANCE
FOR SUSTAINABLE BUILT ENVIRONMENT

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International Conference om Rehabilitation and Maintenance in Civil Engineering

Conference Preceeding

"Policy, Design, Construction, Rehabilitation, and Maintenance for Sustainable Built Environment" 4-5 July 2024

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FOREWORD

Rehabilitation and maintenance are just as crucial as planning and design in civil engineering. Infrastructure defects can arise from various factors, including excessive loads, natural disasters, poor construction practices, and material deterioration. Ad-dressing these issues through rehabilitation and maintenance efforts is essential for extending the useful lifespan of buildings and infrastructure. Rehabilitation refers to the process of restoring the functions of buildings and infrastructure that have been compromised due to defects or structural deterioration. This encompasses a wide range of activities, such as repair, strengthening, revitalization, renovation, and resto-ration. Maintenance, on the other hand, ensures that buildings and infrastructure continue to operate as intended, preventing the occurrence of further issues. By in-vesting in these crucial processes, civil engineers can safeguard the integrity and lon-gevity of the structures they design and build. Regular maintenance and timely reha-bilitation interventions can help mitigate the impact of various challenges, from envi-ronmental factors to human-induced damages, ultimately contributing to the overall sustainability and resilience of the built environment. Well-executed rehabilitation and maintenance strategies can also enhance the aesthetic appeal, functionality, and safety of buildings and infrastructure, meeting the evolving needs of the communities they serve.

The International Conference on Rehabilitation and Maintenance in Civil Engi-neering is a triennial event that provides a platform for researchers, academics, gov-ernment agencies, consultants, and contractors to share their experiences, technologi-cal advancements, and innovations in civil engineering rehabilitation and mainte-nance. The previous five ICRMCE conferences, held in 2009, 2012, 2015, 2018, and 2021, attracted hundreds of researchers from around the world to present their scien-tific papers in various civil engineering disciplines. These conferences have become a premier forum for civil engineering professionals to discuss the latest developments and challenges in the field of infrastructure rehabilitation and maintenance.

The 6th International Conference on Rehabilitation and Maintenance in Civil Engineering was organized by the Department of Civil Engineering at Sebelas Maret University in collaboration with the Department of Civil Engineering at Mataram University. The conference was held in Mataram, Nusa Tenggara Barat, Indonesia, from July 4 to 5, 2024. The conference's theme was "Policy, Design, Construction, Rehabilitation, and Maintenance for Sustainable Built Environment". Several repu-table universities and institutions participated as partners, including Nihon University, National Taiwan University, Curtin University, Universiti Teknologi Malaysia, Diponegoro University, Muhammadiyah University of Yogyakarta, Jenderal Soedir-man University, University of Jember, UPN Veteran East Java, Himpunan Ahli Kon-struksi Indonesia, Himpunan Ahli Teknik Tanah Indonesia, Masyarakat Transportasi Indonesia, Forum Studi Transportasi Antar Perguruan Tinggi, and Himpunan Ahli Tehnik Hidralik Indonesia.

The organizers of the conference received invaluable motivation, advice, and sup-port from various individuals and institutions during the planning process. The organ-izing committee members deserve sincere gratitude for their tireless efforts in prepar-ing for the event. Furthermore, the conference would not have been possible without the help, support, and guidance of the Head of the Civil Engineering Department, the Dean of the Engineering Faculty, and the Rector of Sebelas Maret University. The organizers also extend their special thanks to the conference sponsors, including PT Wijaya Karta, Tbk., PT Hutama Karya, PT Global Sakti P, PT WIKA Divisi Infra-struktur 1, PT Brantas Abhipraya, PT Adhi Karya Tbk., Jasamarga, Injorney Tourism Development Corp., Lab. Bahan Konstruksi UNS, Lab. Mekanika Tanah UNS, and Lab. Jalan Raya UNS, for their generous support. Finally, on behalf of the organizing committee, the organizers apologize for any shortcomings that may have occurred during the event and wish all attendees of the 6th ICRMCE an exceptional experi-ence. We look forward to the next ICRMCE conference.

Mataram, Indonesia

The 6th ICRMCE Chairman

Ir. Budi Yulianto, ST, M.Sc., Ph.D.

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REDESIGNING THE REINFORCED CONCRETE BEAM STRUCTURE SUPPORTING TWO STEEL TRUSS FRAMES TO INCREASE LOAD BEARING CAPACITY

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ABSTRACT

In general, the roof frame will support the columns. The only loads experienced by the beam are wall load, plate load, live load and dead load. If the frame rests on beams, unusual deformations will occur in the beams. In this article we will review the design of building structures at one of the universities in Surabaya which is experiencing this problem. From the results of the review, it was found that there was excess capacity in the cross-section of the concrete beams on the roof due to the frame resting on the beams. From the results of the review, it was concluded that additional strengthening was needed. In the support area, the initial strengthening top and bottom of 5D16 and 3D16 respectively turned into 7D22 and 5D19. Meanwhile, in the field reinforcement area, the initial upper and lower reinforcements 3D16 and 5D16 respectively were changed to 5D19 and 7D22. With this design modification it will be able to accommodate a moment capacity of 314.18 kN.m. This value is greater than the Ultimate Moment that occurs in the structure obtained from modeling results with SAP2000 of 284.74 kN.m.

Keywords: Beam Structure, Load Bearing Capacity, Reinforced Concrete.

1. Introduction

The roof is the part of a building that functions as a roof covering all the rooms below it against the effects of heat, rain, wind, dust and for protection purposes. The roof structure is the part of the building that supports or distributes loads from the roof [1]. Reinforced building structures that have roofs with steel truss frame types are a combination that is widely applied to high-rise buildings. Roof construction is a construction consisting of transverse beams that receive tensile forces, beams as supports or column that receive axial forces to support the curtains and rafters as well as the roof tiles [2]. An unusual deformation will occur in the beams if the roof frame rests on the beams. In this article we will review the design of building structures at one of the universities in Surabaya which is experiencing this problem. From the results of the review, it was found that there was excess capacity in the cross-section of the concrete beams on the roof due to the frame resting on the beams. With this unusual deformation behavior, it is necessary to strengthen the cross-sectional capacity of the beam, either by increasing the cross-sectional area or increasing the area of the installed reinforcement.

2. Methods

2.1 Building information

The taking after is the building structure information that will be examined and assessed with respect to its resistance to getting loads:

Number of floors	: 3 floors
Maksimum span between colums	: 9 meters.
Roof truss type	: double angled steel frame
Purlin	: CNP 125x50x20x3,2 [7]
Roof cover type	: Clay roof tiles
Building structure material	: reinforce concrete.
Concrete strength	: f'_c = 20 MPa
Yield strength of steel	: f_y = 240 MPa

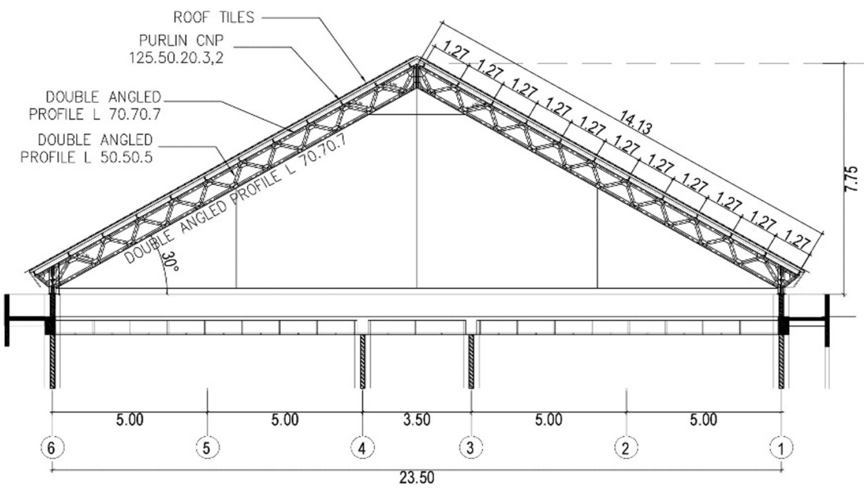


Fig. 1. Cross section of Roof steel frame of the structure

2.2 Load Analysis

The loads acting on this structure consist of dead loads (self-weight and additional dead load), live load, wind load, and earthquake load. Self-weight load refers to 2400 kg/m3 for concrete materials and 7850 kg/m3 for steel materials. Additional dead load consists of clay roof tiles, mechanical electrical, ceiling and frame with total weight 146,32 kg/m. The live load included in this load is the rainwater load which is calculated at 75,11 kg/m. The wind load calculation based on SNI 1727-2020 is 14,24 kg/m in horizontal direction and 12,23 kg/m at vertical direction. Parameter Calculation of earthquake load in the form of base shear refers to the provisions regulated in SNI 1726-2019 [3] and SNI 2847-2019 [4]. For combination loading refers to several regulations, namely SNI 1726-2019, SNI 1727-2020 [5], and SNI 1729-2020.

2.3 Beam Reinforcement Design

The following image shows the beam reinforcement design in the existing condition and after modification.

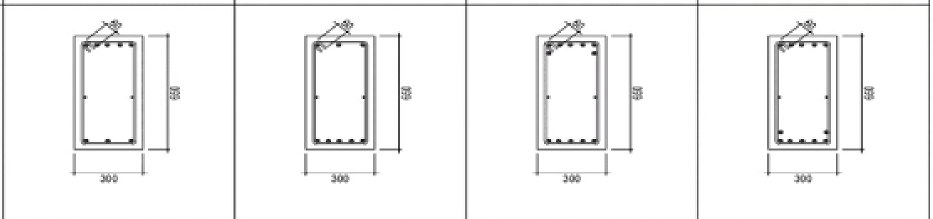
CODE	EXISTING BEAM REINFORCEMENT		MODIFIED BEAM REINFORCEMENT	
	SUPPORT	FIELD	SUPPORT	FIELD
				
DIMENTION	300 X 650	300 X 650	300 X 650	300 X 650
UPPER LONGITUDINAL REINF.	5 D16	3 D16	7 D22	5 D19
TORQUE LONGITUDINAL REINF.	2 ø 10	2 ø 10	2 ø 10	2 ø 10
BOTTOM LONGITUDINAL REINF.	3 D16	5 D16	5 D19	7 D22
TRANSVERSE REBAR	Ø10–100	Ø10–150	Ø12–100	Ø12–150

Fig. 2. Beam cross section design of reinforcement in existing condition and after modification.

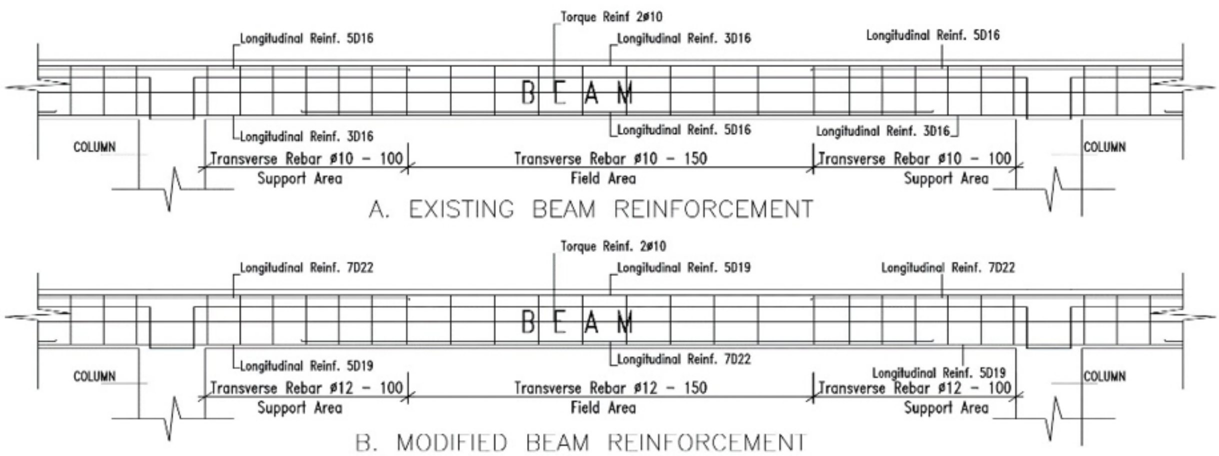


Fig. 3. Beam longitudinal section design of reinforcement in existing condition and after modification.

Table 1. Beam reinforcement rebar.

Area	Dimension (height x width)	Longitudinal Reinf.		Transverse Rebar
		Upper	Bottom	
Existing Beam Design:				
Support Area	650 x 300 mm	5D16	3D16	Ø12 – 100
Field Area		3D16	5D16	Ø12 – 150
Modified Beam Design:				
Support Area	650 x 300 mm	7D22	5D19	Ø12 – 100
Field Area		5D19	7D22	Ø12 – 150

3. Result and Discussion

3.1 Generating the ultimate moment from the modelling result

The SAP2000 program is used to model the structure of a building and generate ultimate moments caused by loads acting on the building [6]. Based on **Fig. 4**, there is a maximum moment in the support area and field in section B-C and section D-E because there are two concentrically load of two roof truss frames on the beam.

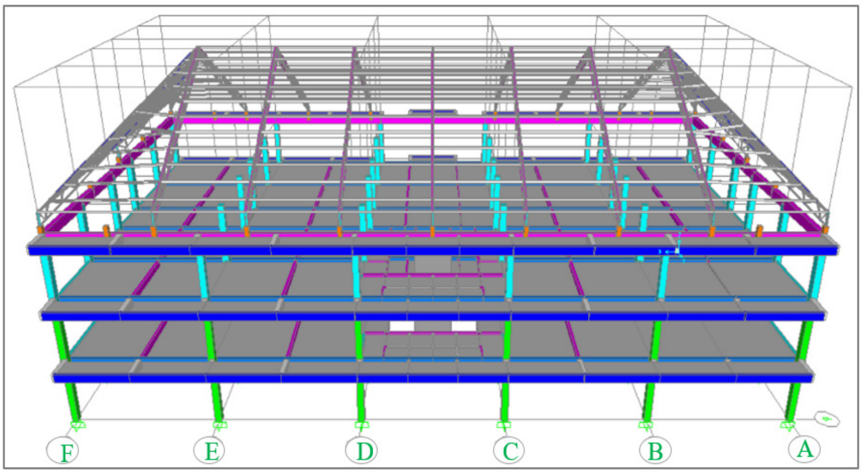


Fig. 4. Results of three-dimensional building structure modeling with SAP2000.

The following are the ultimate moments (Mu) that occur at the most critical span because of the modeling, which can be seen in Fig 5.

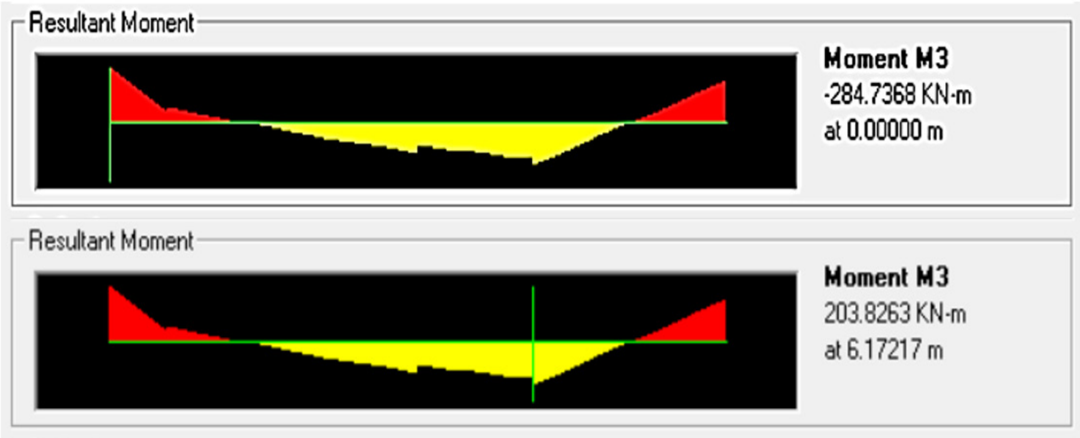


Fig. 5. The ultimate moment (Mu) of the modeling results that occurs in the most critical span.

3.2 Moment Capacity Analysis

Yield stress examination of the reinforcement. The purpose of this examination is to determine the types of stress diagrams that occur in beams. There are two types of stress diagrams that occur in double reinforced beams. The first case is when the compression reinforcement reaches the yield stage (fs' = fy). The ductile behavior of the RC beams can also be obtained if the flexural reinforcement was designed to be yielded first [8]. This concept can be represented by a stress diagram as follows in **Fig 6**. When calculating the moment capacity, assume that the beam is divided into Beam 1 (without concrete) and Beam 2 (with concrete and single layer reinforcement) [9]:

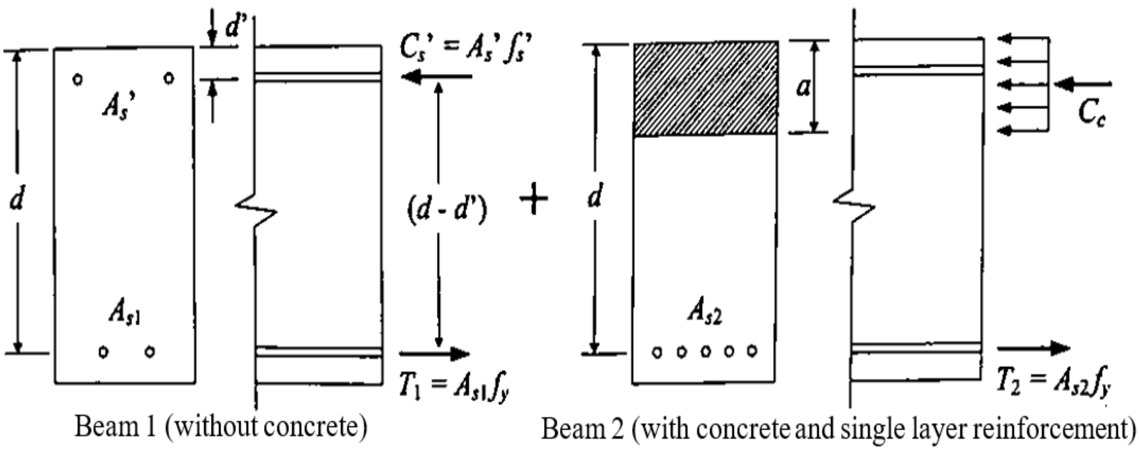


Fig. 6 Representation of couple moment and stress diagram of the first case concept.

And the second case is if the compression reinforcement does not yield or does not reach the yield stress (fs'≠fy) with the stress diagram as shown in **Fig. 7**. In calculating the capacity moment, assuming the beam is one unit by combining the moment due to the concrete compression force (Cc) with the moment due to the upper reinforcement compression force (Cs) [9].

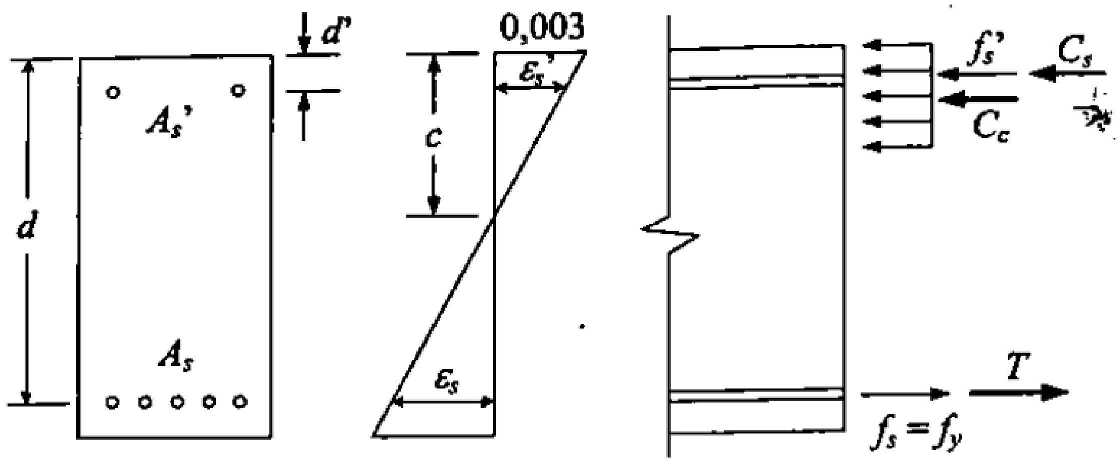


Fig. 7 Representation of couple moment and stress diagram of the second case concept.

For the initial work step, it is assumed that the compression reinforcement reaches the yield stage (fs' = fy) or the first case. In this case the beam is said to consists of 2 parts, namely Beam 1 and Beam 2 as explained:

Beam I (*without concrete*). The area of tensile reinforcement required in Beam 1 is calculated based on the balance condition $C_s=T_1$, so that:

$$A_s'=A_{s1} \quad (1)$$

The moment capacity of Beam 1 can be calculated by the following equation:

$$M_{n1}=A_s'f_y(d-d') \quad (2)$$

Beam 2 (with concrete and single layer reinforcement). Section area of remaining reinforcement:

$$A_{s2}=A_s-A_{s1} \quad (3)$$

If the tensile reinforcement reaches the yield stage, the tensile force that occurs is equal to:

$$T_2=(A_s-A_{s1})f_y \quad (4)$$

While the compression stress value is:

$$C_c=0,85f_c'ab \quad (5)$$

Because it was assumed initially that all the reinforcement reaches the yield stage, so that $A_{s1} = A_s$' and $A_{s2} = A_s$-A_{s1}. Height of the area affected by the compressive force (a) can be generated by the following formulation:

$$a=\frac{(A_s\text{-}A_{s1})f_y}{0{,}85f_c'b} \tag{6}$$

Then examine whether the compression reinforcement has yielded (fs'=fy) with the following equation:

$$\left(\frac{d'}{a}\right)<\left(\frac{d'}{a}\right)_{lim} \tag{7}$$

While

$$\left(\frac{d\prime}{a}\right)_{lim}=\frac{1}{\beta_1}\left(1-\frac{f_y}{600}\right) \tag{8}$$

From the results of the calculation analysis, it is known that the compression reinforcement has NOT yielded or fs' is not the same as fy. This can be interpreted as that compression reinforcement increases capacity and contributes to compression force like concrete and is included in the second type of case as depicted in **Fig. 7**. By adhering to this limit, a ductile failure mode, known as under-reinforced, will be achieved in the beam [10] [11]. Then examine whether the tensile reinforcement has yielded (fs=fy) using the following equation:

$$\left(\frac{a}{d}\right)<\left(\frac{a_b}{d}\right) \tag{9}$$

While

$$\left(\frac{a_b}{d}\right)=\beta_1\frac{600}{600+f_y} \tag{10}$$

Load bearing capacity examination. At this stage it will be checked whether the beam has sufficient load bearing capacity to withstand the ultimate load that occurs due to the weight of the steel truss frame and other structural load. Based on the yield stress examination, it is concluded that can be classified in case 2. Furthermore, the analysis steps are as follows:

The first step is to get the value of a using the new method by the following equation:

$$(A)a^2+(B)a-(C)=0 \tag{11}$$

with values A, B, and C can be found as follows:

$$A=0{,}85f_c'b \tag{12}$$

$$B=0{,}003E_sA_s'-A_sf_y \quad (13)$$

$$C=0{,}003E_sA_s'\beta_1d' \quad (14)$$

Then simplify the equation above with the following formula:

$$a_{1,2}=\frac{-B\pm\sqrt{B^2-4AC}}{2A} \quad (15)$$

Calculate the capacity of the beam by adding up the compressive force on the concrete (C_c) and the compressive force on the top reinforcement (C_s).

The value of C_c can be found using the following equation:

$$C_c=0{,}85f_c'ab \quad (16)$$

And the value C_s can be found using the following equation:

$$C_s=E_S\varepsilon_s'A_s' \quad (17)$$

While ε'_s is:

$$\varepsilon_s'=\left(1-\frac{\beta_1 d'}{a}\right)0{,}003 \quad (18)$$

And finally, the valueof Mn can be found using the following equation:

$$M_n=C_c\left(d-\frac{a}{2}\right)+C_s(d-d') \quad (19)$$

With the reduction factor is found 0,9 so if,

$$\phi M_n\geq M_u \quad (20)$$

then the cross section is meet the requirements or strong enough to withstand the load.

Table 2. Load bearing capacity examination.

Variable	Symbol	Existing Design	Modified Design	Unit
Upper Reinforcement	A_s'	603,18	1417,64	mm^2
Bottom Reinforcement	A_s	1005,30	2660,93	mm^2
Beam 2 Reinforcement	A_{s2}	402.12	1243,28	mm^2
Height of the compression area	a	18.92	58,51	mm
Check the compression reinforcement yield behavior ($f_s'=f_y$)	$\left(\frac{d'}{a}\right)<\left(\frac{d'}{a}\right)_{lim}$	3,06 > 0,71 ($f_s'\neq f_y$)	0,99 > 0,71 ($f_s'\neq f_y$)	-
Check the tension reinforcement yield behavior ($f_s=f_y$)	$\left(\frac{a}{d}\right)<\left(\frac{a_b}{d}\right)$	0.032 < 0.607 ($f_s=f_y$)	0.099 < 0.607 ($f_s=f_y$)	-
New height of the compression area	a	48,49	72,25	mm
Upper Reinforcement strain	ε_s'	0.00005	0.00095	
Compression force of concrete	C_c	247,31	368,46	kN
Compression force of upper reinforcement	C_s	6,03	270,16	kN
Moment Capacity	M_n	137,19	349,08	kN.m
Reduction factor	Ø	0,9	0,9	-
Effective moment capacity	ØM_n	123,47	314,18	kN.m

Variable	Symbol	Existing Design	Modified Design	Unit
Ultimate moment	M_u	287,74	287,74	kN.m
Conclution	$ØM_n>M_u$	Not Accomplished	Accomplished	-

4. Conclution

This research analyzes the structure of a 3-story reinforced concrete building with the problem of two frames that do not support the top of the column. There is a maximum moment in the support area and field in section B-C and section D-E because there are two concentrically load of two roof truss frames on the beam. So that the steel truss frame of the roof rests on the beams on the upper floor.

Number of floors : 3 floors

Maksimum span between colums : 9 meters.

Roof truss type : double angled steel frame

Purlin : CNP 125x50x20x3,2

Roof cover type : Clay roof tiles

Building structure material : reinforce concrete.

Based on the analysis results, it is necessary to review the design by increasing the amount of reinforcement on the beams on the top floor. From the results of the review, it was concluded that additional strengthening was needed. In the support area, the initial strengthening top and bottom of 5D16 and 3D16 respectively turned into 7D22 and 5D19. Meanwhile, in the field reinforcement area, the initial upper and lower reinforcements 3D16 and 5D16 respectively were changed to 5D19 and 7D22. With this design modification it will be able to accommodate a moment capacity of 314.18 kN.m. This value is greater than the Ultimate Moment that occurs in the structure obtained from modeling results with SAP2000 of 284.74 kN.m

5. References

1) Mulyadi, R., Wijaya, S., & Suwarjo, S. (2020). Analisa Struktur Rangka Atap Gedung Rektorat Universitas Muara Bungo (Rangka Kuda-Kuda Type Single Frame Beam). *Jurnal Komposits*, 1(1).

2) Iswanto, D. (2007). Kajian terhadap struktur rangka atap kayu rumah tahan gempa bantuan P2KP. *Jurnal Ilmiah Perancangan Kota dan Permukiman*, 6(1), 10-21.

3) Badan Standardisasi Nasional 2019 *Tata cara perencanaan ketahanan gempa untuk struktur bangunan gedung dan nongedung SNI 1726:2019* (Jakarta: Author)

4) Badan Standarisasi Nasional. 2019. *Tata Cara Perencanaan Struktur Beton untuk Bangunan Gedung. SNI 2847-2019.* Jakarta : Badan Standarisasi Nasional
5) Badan Standardisasi Nasional 2020 *Beban desain minimum dan Kriteria terkait untuk bangunan gedung dan struktur lain SNI 1727:2020* (Jakarta: Author)
6) Dewobroto, W. (2007). *Aplikasi Rekayasa Konstruksi dengan SAP2000*. Elex Media Komputindo.
7) Gunawan R, Morisco 1988 *Tabel Profil Konstruksi Baja* (Yogyakarta: Kanisius)
8) Piscesa, B., Alrasyid, H., & Prasetya, D. (2021). Numerical investigation of reinforced concrete beam due to shear failure. *IPTEK The Journal for Technology and Science*, 31(3), 373-382
9) Imran, I., & Hendrik, F. (2014). Perencanaan Lanjut Struktur Beton Bertulang. *Bandung: ITB.*
10) Puspitasari, N. D., & Aryaseta, B. (2022). Metode desain balok beton bertulangan tunggal di atas dua perletakan dengan cara grafis. *Jurnal Teknik Sipil*, 3(1), 313-322.
11) Puspitasari, N. D., & Alfiansyah, A. D. (2022). Single Reinforced Concrete Design of Simple Beam with Simple Formulation Method. *Nusantara Science and Technology Proceedings*, 162-169.

THE INFLUENCE OF LENGTH TO DIAMETER OF REBAR WIRE FIBER ON COMPRESSIVE AND SPLITTING TENSILE SELF-COMPACTING CONCRETE

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ABSTRACT

Some results of experimental studies on the influence of the length diameter ratio of rebar wire fiber to compressive and splitting test self-compacting concrete were investigated. SCC (self-compacting concrete) is a flowing concrete mixture which able to consolidate itself into formwork without vibration. Production of SCC can be achieved by optimization of aggregate size, proportion of the aggregates, and superplasticizer. In order to improve concrete tensile strength, rebar wire fiber can be added to the concrete mixture. Based on EFNARC, a trial and error method was employed in this study for mixed-design SCC. Rebar wire fiber of 0.7 mm diameter was considered with the proportion of 0.5% concrete volume. The length of rebar wire fiber were varied from 40 mm, 50 mm, 60 mm, and 70 mm, obtaining the length-diameter ratio of 58,71,86 and 100, respectively. The workability and mechanical qualities of SCC were found to be impacted by the length-diameter ratio of rebar wire fiber. Increasing the length-diameter ratio of rebar wire fiber will decrease the workability of the SCC. Evaluation of the result indicated that the length-diameter ratio of 71 was the optimum composition material with compressive strength and splitting tensile strength.

Keywords: Rebar wire, Compressive Strength, Fiber, SCC, Splitting Tensile.

1. Introduction

High-performance self-compacting concrete may flow under its own weight while preserving homogeneity, filling the formwork, and consolidating without compacting [1]. In 1986, Hajime Okamura introduced the idea of self-compacting concrete, or SCC [2]. In 1988, Ozawa developed a new prototype concrete in Japan [3]. Self-compacting materials improve filling, passing, and resistance segregation by reducing water powder ratio, utilizing superplasticizer, and increasing fines (i.e., particles < 0,125 mm) [4]. The advantages of SCC make this concrete particularly useful, plac-ing in heavily reinforced concrete members, filling every corner of the form using gravitational forces [5]. The tensile of concrete is relatively low, while strong compres-sive strength showed the concrete was brittle material. The creation of SCC represent-ed a significant step forward in terms of crack reduction efficiency under a variety of conditions. Many researchers have examined the effects of using different types of fibers in concrete, such as polypropylene, glass, and steel fiber [6]. Various fibers are utilized in concrete to boost its tensile capacity under tensile pressure [7].

Nonetheless, it is commonly understood that any sort of fiber would impair the workability [8], [9]. Because of their large surface area, fibers require more water. Fresh concrete needs greater potential energy to flow because of the friction between the aggregate and the fiber in the mixes [10]. In this paper focus only on harder prop-erties of the length of diameter fiber ratio on compressive and splitting tensile. The workability of fresh concrete is the primary distinction between conventional and self-compacting concrete. The workability was assessed based on flowability, viscosi-ty, and segregation resistance utilizing slump flow, slump T500 spread time, and sleeve segregation tests. The mechanical properties of self-compacting concrete (compressive strength and splitting tensile test) were also assessed.

2. Experimental Method

2.1 Materials

Locally produced Portland cement conforming to the requirements of SNI 2049;2015 was used. Prior to being mixed with concrete, the aggregate were created in saturated-surface-dry (SSD) conditions, as described in ASTM C127 [11] and ASTM C566 [12]. Find aggregates were made from river sand with a maximum par-ticle size of 4,75 mm. This study used Coase aggregates with a maximum size of 40 mm. Table 1 shows the physical parameters of fine and coarse aggregate.

Table 1. Physical properties of fine and coarse aggregate

Physical Property	Fine Aggregate	Coarse
Particle Size	4.75 mm to 0.075 mm	maximum 20 mm
Fineness Modulus	2,748	6,67
Bulk Density	2,546	2,684

*Sika Visconcrete*⑩, a superplasticizer that sold commercially was acquired from PT. SIKA Indonesia. It was applied to the mixture to reduce of water used and ensure the workability of SCC. According to the relevant health and safety requirements, the high range water reduction addition *Sika Visconcrete* ⑩ is a non-toxic and non-hazardous.This superplasticizer meets the requirement of ASTM C494 type F [13]. Table 2 shows the typical features of superplasticizers. The dose of superplasticizer was 1.68%.

Table 2. Properties of superplasticizer

Chemical base	Modified polycarboxylate
storage condition	dry ± 5 ° - 20 ° c
Density	1.06 kg/ I (at +20 °c)
Equivalent Sodium Oxide	< 0,4 %

2.2 Mix Proportion

The investigation of the impact of mixed proportions on the workability of fresh concrete and the hardened properties of SCC involved the creation of self-compacting concrete with different l/d (length to diameter) ratios. Rebar wire fiber of 0.7 mm diameter was considered with the proportion of 0.5% concrete volume. The length of rebar wire fibre were varied from 40 mm, 50 mm, 60 mm, and 70 mm, as shown in **Fig.1**, obtaining the length-diameter ratio of 58,71,86 and 100, respectively.

Fig. 1. Properties of Rebar Wire Fiber

After several trials, these ratios were established by adjusting the dosage of superplasticizer and the quantity of rebar wire fiber supplied. It's characteristics are given in Table 3 and Table 4. There is no comp acting during casting self-compacting concrete based on EFNARCH 2015 [14].

Table 3. Amount of rebar wire fiber added

Diameter	Length	l/d	Volume
0,7	40	57	61,75
0,7	50	71	59,8
0,7	60	86	56,22
0,7	70	100	59,43

Table 4. Mix design of self-compacting concrete

Material	Mass (kg/m³)
Coarse Aggregate	634
Fine Aggregate	951
Sika Visconcrete (1,68%) @10	7,83
Water	205

2.3 Test Method for Assessing the Workability of SCC

The flow ability of SCC and flow rate in the absence of obstacle are evaluated using the slump flow test. Fresh SCC is poured into a cone during the testing proce-dure, and the cone is then drawn higher. T500 time, as seen in **Fig.2**, is the amount of time that passes between the cone's upward movement and the point at which the concrete flows to a 500 mm diameter.

Fig. 2. Abarms Cone for Slump Flow Test

2.4 Test on Harned of SCC

Concrete's mechanical qualities were assessed using compressive strength in ac-cordance with astm C39. [15] and splitting tensile tests on ASTM C 496-96 [16]. 150 mm in diameter and 300 mm in height cylindrical molds were used to cast the fresh concrete. The concrete was demolded the day after it was cast, and it cured for 28 days in tap water as shown in **Fig 3**.

Fig. 3. Curing Concrete Specimen

3. Result and Discussion

The result of the workability of fresh self-compacting concrete shown in **Fig. 4, Fig 6**, and **Fig 7**, respectively. Flowability and viscosity of SCC were obtained by slump flow test with abarms cone. Segregation resultant also investigated by using sieve segregation method. The slump flow value represents the maximum speed of concrete. It has been observed that slump flow decreases and reduces the flowability with incorporating rebar wire fiber in SCC mixed because of the fiber and aggregate's increased interlocking and friction [10].

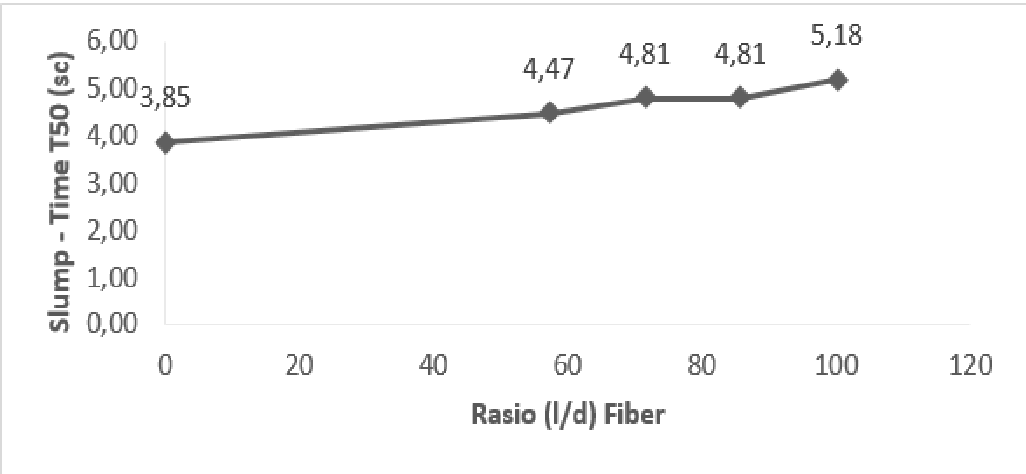

Fig. 4. Workability Test Result of Self-Compacting Concrete

T500 is the time it takes for concrete to flow to a diameter of 500 mm, as seen in **Fig. 5**. It shows the flow rate and thus, the SCC viscosity. The inclusion of rebar wire fiber to the SCC mixture increased the T500 values due to the increased in-ternal friction of the fiber in fresh concrete.

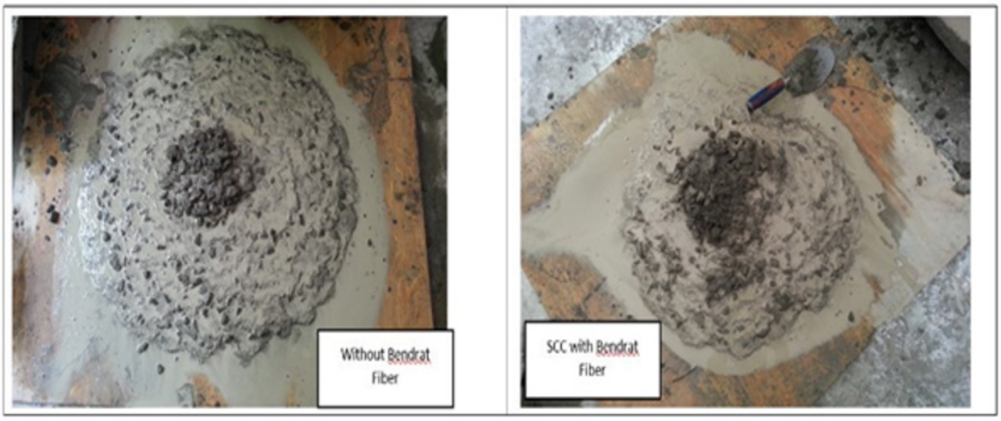

Fig. 5. Concrete Flow to Reach 500 mm Diameter

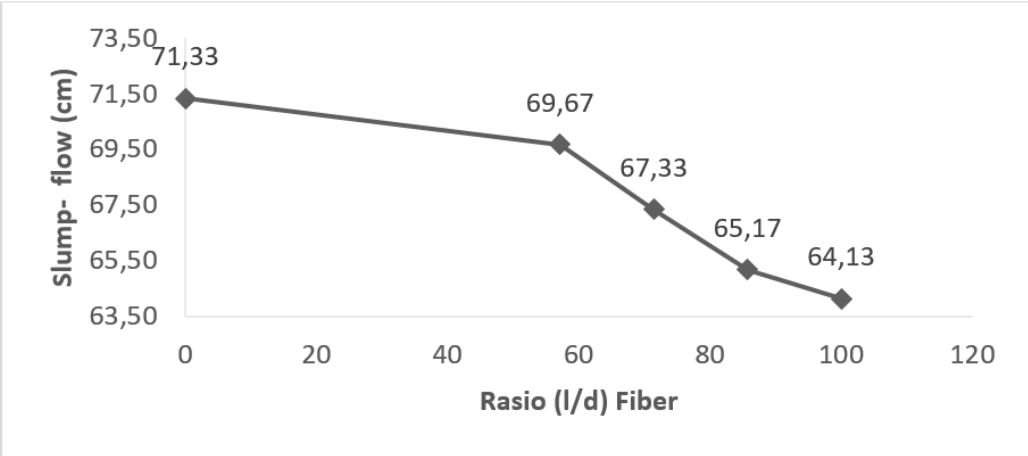

Fig. 6. Flowability Test Result of Self-Compacting Concrete

According to the test result, adding rebar wire fiber to the SCC mixture results in a rise in segregation resistance and a loss in filling and passing capacity. In addi-tion, the strength climbed to 71 with the addition of rebar wire fiber and then steadily decreased after that. When SCC's workability results fall within the per-mitted range specified by the technical specification EFNARCH for SCC at a great filling capacity [14]

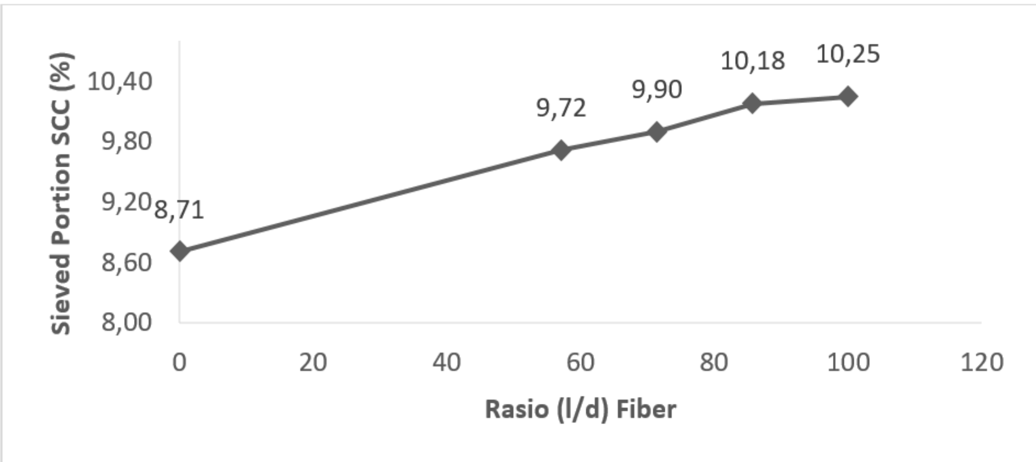

Fig. 7. Flowability Test Result of Self-Compacting Concrete

The hardened SCC compressive strength test results, which ranged from 58 to 100 in l/d ratio, are shown in **Fig.8**. Congcrete's compressive strength determines the greatest compressive load it can withstand. According to the result, the average com-pressive strength increased as the l/d ratio of rebar wire fiber added in SCC raised up to 71 and decrease as displayed in **Fig.8**. The highest compressive strength was ac-quire at l/d ratio of rebar wire fiber 71. However, beyond l/d ratio 71 the strength was reduced. This demonstrates that there is an optimal limit l/d ratio in fiber rebar wire for usage in SCC mixes.

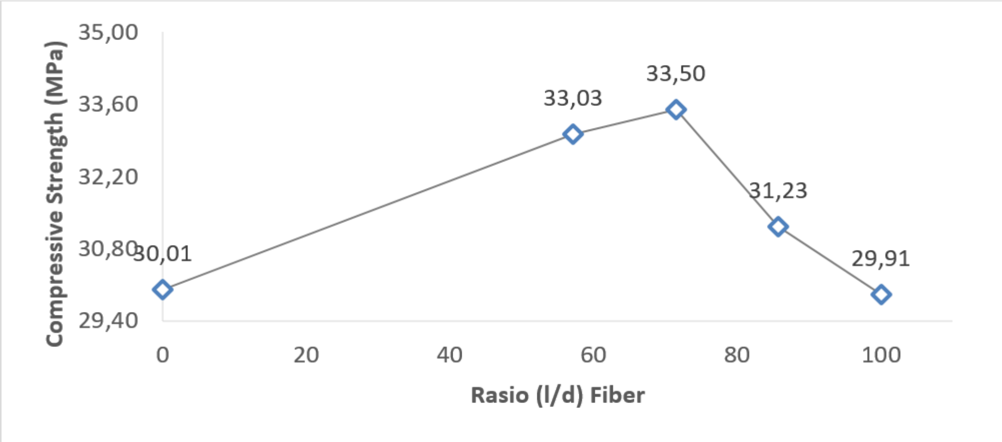

Fig. 8. Compressive Strength Test Result

In Addition, the crack pattern of hardened SCC after compressive strength test show different between SCC with rebar wire fiber and without rebar wire fiber as shown in **Fig 9**. This relate to rebar wire fibers mechanical characteristics and physical makeup, which allow it to withstand the emergence of microcracks and appropriately halt their propagation. [17]. The mechanical properties that could result from the composite's weakening within the cement matrix when more fiber-containing spaces are produced [4]. There was some similarity with the result of steel fiber reinforce-ment SCC [5], shows that steel fiber refers to the use of post-cracking ductility to control cracking and the mode of failure.

Fig. 9. Crack Pattern after Compressive Strength Test

The splitting tensile strength was increase as increasing of l/d ratio raise up to 71, as seen in **Fig.11**. The mechanism of SCC stopping crack growth is responsible for the strength improvement brought about by the fiber's presence [4]. When ratio l/d in rebar wire fiber climbed by more than 71, the improvement in SCC was less. The cylinder of SCC without rebar wire fiber was unexpectedly failure into two pieces shown in **Fig.10**. In contrast, the rebar wire fiber cylinder SCC broke ar failure without separating into two halves. The cause of this phenomenon is that the fiber in the con-crete inhibits the growth of internal microcracks, increasing the material's tensile strength.

Fig. 10. Crack Pattern after Splitting Tensile Test

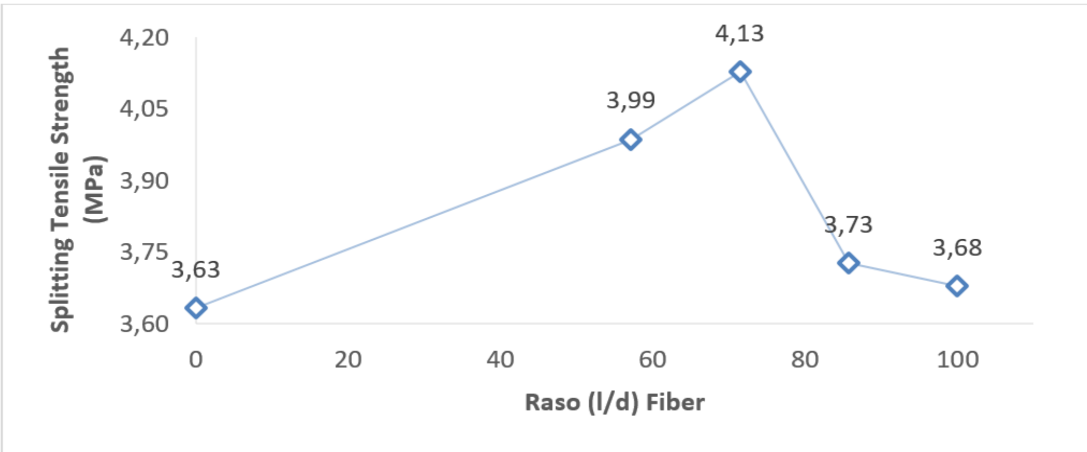

Fig. 11. Splitting Tensile Test Result

4. CONCLUSION

a. Workability decreases with an increase l/d ratio of rebar wire fiber in the con-crete mixture. However all mixes are fulfill the requirement of the EFNARCH standard for Self-compacting concrete.

b. The optimal l/d ratio of rebar wire fiber, which produce superior compressive strength of self-compacting concrete in 71, was observed during testing.

c. The optimum l/d ratio of rebar wire fiber was 71 to obtain appropriate worka-bility and a significant increase in splitting tensile strength.

4. References

1) S. Ahmad and A. Umar, "Characterization of Self-Compacting Concrete," Procedia Eng., vol. 173, no. February, pp. 814–821, 2017, doi: 10.1016/j.proeng.2016.12.108.

2) H. Okamura and K. Ozawa, "Self-Compacting High Performance Concrete," Struct. Eng. Int., vol. 6, no. 4, pp. 269–270, Nov. 1996, doi: 10.2749/101686696780496292.

3) K. Maekawa, "Development of High Performance Concrete n V ," no. January 1992, 2015.

4) J. Ahmad, F. Aslam, O. Zaid, R. Alyousef, H. Alabduljabbar, and A. Manan, "Self-fibers compacting concrete properties reinforced with propylene fibers," Sci. Eng. Compos. Mater., vol. 28, no. 1, pp. 64–72, 2021, doi: 10.1515/secm-2021-0006.

5) M. M. Kamal, M. A. Safan, Z. A. Etman, and B. M. Kasem, "Mechanical properties of self-compacted fiber concrete mixes," HBRC J., vol. 10, no. 1, pp. 25–34, 2014, doi: 10.1016/j.hbrcj.2013.05.012.

6) SRIDHARA S, KUMAR S, and SINARE MA, "Fibre reinforced concrete," Indian Concr J, vol. 45, no. 10, 1971.

7) A. AL-Ameeri, "The Effect of Steel Fiber on Some Mechanical Properties of Self Compacting Concrete," Am. J. Civ. Eng., vol. 1, no. 3, p. 102, 2013, doi: 10.11648/j.ajce.20130103.14.

8) A. H. Akca and N. Özyurt, "Effects of re-curing on residual mechanical properties of concrete after high temperature exposure," Constr. Build. Mater., vol. 159, pp. 540–552, 2018, doi: https://doi.org/10.1016/j.conbuildmat.2017.11.005.

9) V. Bindiganavile, N. Banthia, and B. Aarup, "Impact response of ultra-high-strength fiber-reinforced cement composite," ACI Mater. J., vol. 99, pp. 543–548, Nov. 2002.

10) S. Mahesh, "Self compacting concrete and its properties," J. Eng. Res. Appl. www.ijera.com, vol. 4, no. 8, pp. 72–80, 2014, [Online]. Available: www.ijera.com

11) American Society for Testing and Materials, "ASTM C127-15: Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate," ASTM Stand. B., no. C, pp. 1–6, 2013.

12) ASTM, "C-566-97: Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying (Método de prueba estandarizado por secado para el contenido de humedad total evaporable de agregados)," Annu. B. ASTM Stand., vol. i, no. Reapproved, pp. 3–5, 2004.

13) ASTM C494, "ASTM C494/C949M-19: Standard specification for chemical admixtures for concrete," Astm C494, no. January, pp. 1–10, 2005.

14) EFNARC, "The European Guidelines for Self-Compacting Concrete," Eur. Guidel. Self Compact. Concr., no. May, p. 63, 2005, [Online]. Available: http://www.efnarc.org/pdf/SCCGuidelinesMay2005.pdf

15) Astm C39/C39M, "Astm C39/C39M," Stand. Test Method Compressive Strength Cylind. Concr. Specimens, vol. 04, no. March, pp. 1–5, 2001.

16) ASTM C469, "Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens," ASTM Stand. B., pp. 545-545–3, 2008.

17) N. Hamah Sor et al., "The behavior of sustainable self-compacting concrete reinforced with low-density waste Polyethylene fiber," Mater. Res. Express, vol. 9, no. 3, 2022, doi: 10.1088/2053-1591/ac58e8.

ROAD SECTION PERFORMANCE AND LEVEL OF SERVICE (LOS) ANALYSIS ON YOS SUDARSO STREET IN SURAKARTA DURING WEEKDAYS AND WEEKENDS

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ABSTRACT

Improving urban planning and transportation efficiency in Surakarta is crucial for sustainable development. Assessing road sections' performance particularly along Yos Sudarso Street in Surakarta, is crucial for addressing these issues. This study aims to analyze road sections' performance and level of service (LOS) on weekdays and weekends. Data collection took place on weekend and weekday during morning and afternoon peak hours (06:30-08:30 AM and 03:00-05:00 PM). The data includes road geometrics, vehicle volume, side obstacles, and travel time. Analysis was conducted using the Indonesian Highway Capacity Manual 1997 (MKJI 1997). Results indicate that peak-hour traffic conditions are notably higher on weekdays than on weekends. Weekday traffic volume reached 1584.1 pcu/hour in the morning and 3240.05 pcu/hour in the afternoon, with a maximum degree of saturation value of 0.73 and a speed of 25.32 km/h. The road section's stable performance, as indicated by the degree of saturation (DS) values below 0.75, highlights effective traffic management. Future research could strengthen the study by expanding the analysis to encompass various variables and factors that impact road performance.

Keywords: Road Section, Performance, Traffic, Weekdays, Weekend.

1. Introduction

Transportation infrastructure, including railways, highways, waterways, and air transport, is essential for matching the needs of economic development and ensuring the smooth implementation of major national strategies [1] [2] [3]. The level of service (LOS) of road segments is a critical measure used to evaluate the operational efficiency and quality of road infrastructure [4]. Various studies have employed different methodologies to assess LOS, focusing on factors such as traffic flow, pavement condition, and the impact of parked vehicles on road capacity [5][6]. Moreover, the HCM's methodologies are adapted to local conditions, where local roadway design, vehicle size, and traffic mix necessitate customized capacity analysis. This adaptation is crucial for accurately reflecting the practical driving conditions and ensuring the safety and efficiency of roadways [7] [8][9]. The Highway Capacity Manual (HCM) and the Indonesian Road Capacity Manual (MKJI) are commonly used methodologies for analyzing road capacity and traffic flow. These manuals provide frameworks for evaluating the level of service (LOS) of road segments, which is a qualitative measure of traffic flow conditions ranging from free flow to congested flow [10] [11].

Improving urban planning and transportation efficiency in Surakarta is crucial for sustainable development. By implementing innovative strategies and infrastructure enhancements, such as optimized road networks and public transport systems, the city can reduce congestion, enhance accessibility, and promote environmental sustainability. Efficient urban planning fosters a more livable and resilient community, supporting economic growth and social well-being. Through collaborative efforts between stakeholders and policymakers, Surakarta can create a harmonious balance between urban development and environmental conservation, ensuring its residents' vibrant and sustainable future. The rising volume of vehicles and population in the city leads to delays in vehicle speed and congestion, especially during peak hours [12] [13]. Yos Sudarso Nonongan Road is a four-lane, two-way road with various trade shops and on-street parking. Side friction and narrow road geometry can impact the volume and capacity, resulting in congestion. This issue is particularly pronounced during peak hours, necessitating an analysis of the road section's performance.

By addressing the specific challenges and characteristics of Yos Sudarso Street in Surakarta, this research aims to provide valuable insights for urban planning and transportation management in the city. Furthermore, this study analyzes and discusses peak hours, road performance, and service levels. The results of this research are expected to serve as considerations for relevant authorities in determining policies and potential improvements for the road. Additionally, this research contributes to the field of transportation studies.

2. Research Methods

2.1 Data Collection

This research was conducted on Jalan Yos Sudarso Street, Surakarta. This location has high side obstacles and narrow geometric conditions affecting traffic flow. Primary data used are road geometric conditions, vehicle volume, side obstacles, and travel time. Secondary data used is population data obtained from the Central Bureau of Statistics Surakarta City. The survey was conducted during morning and afternoon peak hours on Saturday, October 22, 2022 (weekend) and Monday, October 24, 2022 (weekday) at 06:30-

08:30 AM and 03:00-05:00 PM. The data analyzed in this study are peak volume and road section performance based on the Indonesian Highway Capacity Manual 1997 (MKJI 1997). Data analysis based on MKJI 1997 [14] is divided into traffic volume, side friction, capacity, degree of saturation, speed and level of service of road section. The level of road service is a depiction of the operational conditions of traffic flow and the perception of drivers in terms of speed, travel time, comfort, freedom of movement, safety, and security. It serves to determine the quality of a specific road segment in serving the traffic flow passing through it. Levels are defined as follows: 0-0.25 Level A, 0.26-0.50 Level B, 0.51-0.75 Level C, 0.76-1.00 Level D, greater than or equal to 1 is considered Level E.

3. Result and Discussion

3.1 Geometrics and Environment

Based on observations and measurements, it can be seen that Yos Sudarso Street Surakarta 4/2 D (4-lane 2-way divided by the median) has a road width of 7.5 m, each lane width 3.25 m. This road has no shoulder, and there are curbs on each side, which have a width of 1.5 m. Based on visual observation, the environmental condition belongs to commercial areas with high roadside activities. The population used for analysis is based on Surakarta City data. The city size adjustment factor value is obtained at 0.94, referring to the population data from the Central Bureau of Statistics Surakarta City 2022.

3.2 Traffic volume

The number of vehicles obtained from the survey on weekends and weekdays is divided into two sides, namely the west side and the east side in units of pcu/hour. The results of traffic volumes for two days in the morning and afternoon are shown in Figure 1 and Figure 2.

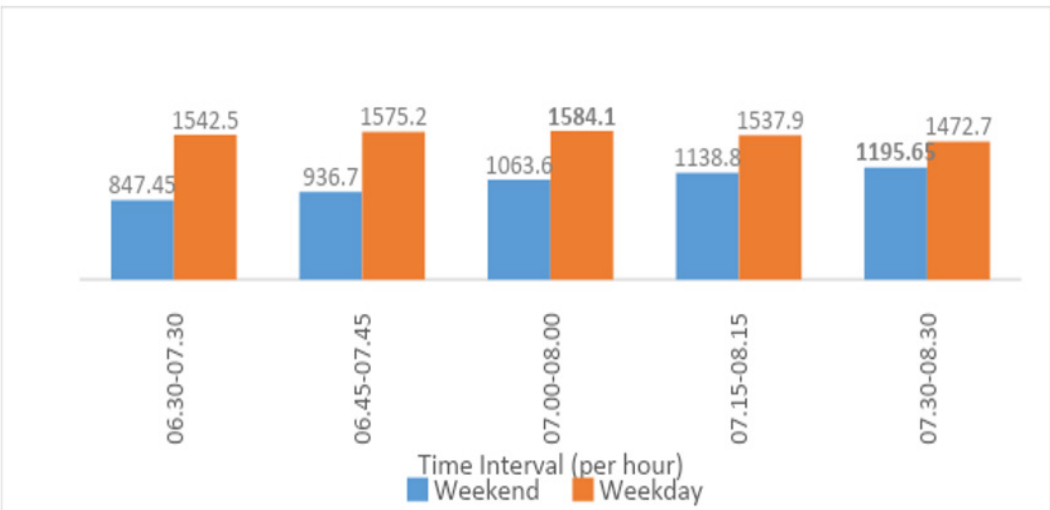

Fig. 1. Traffic volume condition in the morning

Based on Figure 2 and Figure 3, the traffic volume of weekday conditions is greater than weekend. Morning conditions on holidays obtained the highest volume of 1195.65 smp / hour and in the afternoon the largest volume of 1549.35 pcu/hour, while weekday conditions in the morning obtained a peak volume of 1584.1 pcu/hour and in the afternoon obtained a peak volume of 3240.05 pcu/hour. This situation is caused by the increased activity on workdays on the road, it serves as access for work, school, and shopping purposes. As a result, the volume of vehicles also increases.

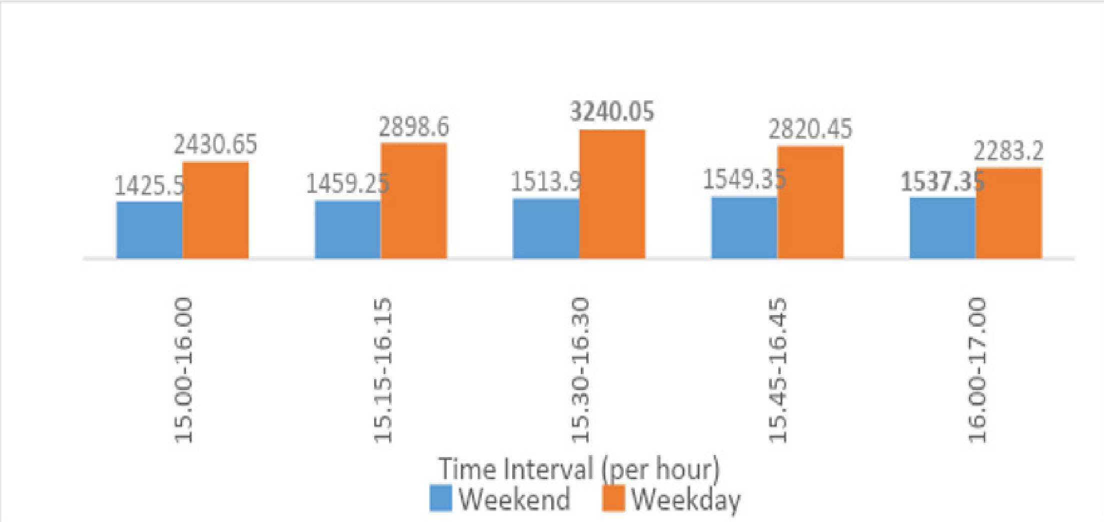

Fig. 2. Traffic volume condition in the afternoon

The data displayed previously in Figure 2 and 3 represents an hourly volume analysis, making it difficult to accurately determine the highest traffic flow during this period. Therefore, a more extensive data collection and analysis are needed to obtain a clearer understanding of traffic patterns in the mornings and evenings of the weekend.

3.3 Side Friction

The analysis results of side friction are divided into the east side and west side. The values of side friction on Yos Sudarso road on the east and west sides are different. The side friction during weekend mornings from 07:30-08:30 AM on the east side is 683.6 weighted frequency/hour (High), while on the west side it is 425 weighted frequency/hour (Medium). In the afternoon from 15:45-16:45 PM, the side friction on the east side is 609.3 weighted frequency/hour (High), while on the west side it is 488.1 weighted frequency/hour (Medium). On weekdays, during morning hours from 07:00-08:00 AM, the side friction on the east side is 707.6 weighted frequency/hour (High), while on the west side it is 481.5 weighted frequency/hour (Medium). In the afternoon from 15:30-16:30 PM, the side friction on the east side is 717 weighted frequency/hour (High), while on the west side it is 590.2 weighted frequency/hour (High).

3.4 Capacity

Based on the road geometric data obtained, the basic capacity value and influencing factors can be determined. Referring to the equations and tables in MKJI 1997, the values as shown in Table 1 are obtained.

Table 1. Capacity analysis

Day/ Date	Time	Side	Correction factor					Capacity (pcu/ hour)
			Co	FCw	FCsp	FCsf	FCcs	
Saturday 22-10-2022	Morning	E	3300	0.96	1	0.92	0.94	2739.69
		W	3300	0.96	1	0.95	0.94	2829.02
	Afternoon	E	3300	0.96	1	0.92	0.94	2739.69
		W	3300	0.96	1	0.95	0.94	2829.02
Monday 24-10-2022	Morning	E	3300	0.96	1	0.92	0.94	2739.69
		W	3300	0.96	1	0.95	0.94	2829.02
	Afternoon	E	3300	0.96	1	0.92	0.94	2739.69
		W	3300	0.96	1	0.92	0.94	2739.69

The capacity results in Table 1 indicate that the capacity values on each side of the road, whether east or west, are the same in the morning and afternoon during weekends and weekday. The highest capacity value is found on the west side, which is 2829.02 pcu/ hour.

3.5 Degree of Saturation

Based on the obtained volume and capacity results, and referring to the equations in MKJI 1997, the degree of saturation can be calculated, and the results are displayed in Table 2. It shows that the east side and west side have different DS (degree of saturation) values due to the difference in vehicle volume on the east and west sections. The highest value is on Yos Sudarso road on Saturday, which is 0.34 (afternoon), and on Monday, it is 0.73 (afternoon). The condition on weekdays is higher compared to weekends, which is caused by the fact that on weekdays, many people engage in activities such as commuting from work, shopping, and frequent vehicle entry and exit. Additionally, there are bus stops, which narrow the road and contribute to higher saturation levels.

Table 2. Degree of saturation analysis

Day/Date	**Time**	**Side**	**Degree of saturation parameter**		
			Q (pcu/hour)	**C (pcu/hour)**	**DS**
Saturday 22-10-2022	Morning	E	628,6	2739,69	0,23
		W	567,05	2829,02	0,20
	Afternoon	E	928,1	2739,69	0,34
		W	621,25	2829,02	0,22

Monday 24-10-2022	Morning	E	873,25	2739,69	0,32
		W	710,85	2829,02	0,25
	Afternoon	E	2005,35	2739,69	0,73
		W	1234,7	2739,69	0,45

3.6 Speed

The analysis results show that the vehicle speeds vary. The factors influencing this vaiation are the different side friction values on each side. The highest vehicle speed on Saturday, October 22, 2022, is 31.18 km/h (morning), and the lowest vehicle speed is 22.37 km/h (afternoon). On Monday, October 24, 2022, the highest vehicle speed is 34.83 km/h (morning), and the lowest speed is 22.08 km/h (afternoon). The vehicle speed on the west side tends to be lower than on the east side due to the influence of side friction; the quantity of parked vehicles is higher on the west side compared to the east side, thus slowing down the speed of cars passing through that road section.

3.7 Level of Service

The results of the degree of saturation can be classified into service levels, as presented in Table 3. Generally, the condition on Yos Sudarso Road section exhibits a stable traffic flow with a service level of B. The analysis results indicate a Good service level during weekends. However, on weekdays, particularly in the afternoon, a service level of C is obtained. This difference is caused by the varying volume and side friction values on each side. On weekdays, there are activities such as the evening commute and school dismissal, with a higher volume of vehicles heading south compared to those heading north. Additionally, many vehicles park on the roadside for shopping purposes, which can narrow the road. On weekends, some shops are closed, resulting in improved traffic conditions.

Table 3. Level of service

Day/Date	Time	Side	Level of Service	
			DS	LOS
Saturday 22-10-2022	Morning	E	0.23	A
		W	0.20	A
	Afternoon	E	0.34	B
		W	0.22	A
Monday 24-10-2022	Morning	E	0.32	B
		W	0.25	B
	Afternoon	E	0.73	C
		W	0.45	C

The previous analysis results also indicate that the capacity on the west side has a higher value than the east side. In contrast, the volume calculation results show a higher volume on the east side than on the west. This is the reason why the Level of Service (LOS) is higher on the west side than on the east side.

4. Conclusion

Based on the analysis results, it can be concluded that the peak hour on Yos Sudarso Road section during weekends is in the morning from 07:30-08:30 AM with a volume of 1195.65 passenger car units per hour (smp/jam), and in the afternoon from 15:45-16:45 PM with a volume of 1549.35 smp/jam. On weekdays, the morning peak hour from 07:00-08:00 AM has a volume of 1584.1 smp/jam, while the afternoon peak hour from 15:30-16:30 PM has a volume of 3240.05 smp/jam. The road section's stable performance, as indicated by the degree of saturation (DS) values below 0.75, highlights effective traffic management. The highest DS value is 0.73 on Monday afternoon on the east side, with a speed of 25.32 km/h. The road service level on holidays is classified as good, while on weekdays, especially in the afternoon, it is classified as Level C. The analysis findings offer valuable insights into the traffic behavior and efficiency of the Yos Sudarso Road segment on weekdays and weekends. Nevertheless, it's essential to recognize the study's limitations. Future research could strengthen the study by expanding the analysis to encompass various variables and factors that impact road performance.

5. References

1) B. Zou and S. Madanat, "Incorporating delay effects into airport runway pavement management systems," *J. Infrastruct. Syst.*, vol. 18, no. 3, pp. 183–193, 2012.

2) J. Zhan, S. Yang, X. Wang, and T. Fan, "Measurement Method of Comprehensive Transportation Development Quality Based on Transportation Efficiency," *J. Adv. Transp.*, vol. 2023, pp. 1–15, 2023, doi: 10.1155/2023/3238777.

3) E. Korsakova, "Development of transportation as a condition for improvement of economic ties between the regions," vol. 2389, no. 1, p. 20008, 2021, doi: 10.1063/5.0063672.

4) S. M. Hafram and A. R. Asrib, "Traffic Conditions and Characteristics: Investigation of Road Segment Performance," *Int. J. Environ. Eng. Educ.*, vol. 4, no. 3, pp. 108–114, 2022, doi: 10.55151/ijeedu.v4i3.77.

5) M. A. Rizal, M. Darwis, and N. Nagu, "Analysis of Road Capacity Due to Parking on Road Agency on The Jati Perumnas Segment of Ternate City," *MATEC web Conf.*, vol. 372, p. 7005, 2022, doi: 10.1051/matecconf/202237207005.

6) E. Amini, D. Xu, N. M. Rouphail, L. Elefteriadou, and B. Aghdashi, "Capacity Analysis Framework for Freeway Ramp Weaves," vol. 147, no. 12, p. 4021085, 2021, doi: 10.1061/JTEPBS.0000594.

7) I. Mahdalova, J. Petru, and V. Krivda, "Assessment of the Capacity of Roads Weaving Segments," vol. 18, no. 2, pp. 101–106, 2017, doi: 10.1515/TTJ-2017-0009.

8) J. C. García-Palomares, J. Gutiérrez, J. C. Martín, and B. Moya-Gómez, "An analysis of the Spanish high capacity road network criticality," *Transportation (Amst).*, vol. 45, no. 4, pp. 1139–1159, 2018, doi: 10.1007/S11116-018-9877-4.

9) D. Nian, Q. Jiang, and J. Ma, "Developing Highway Capacity Manual Capacity Adjustment Factors for Connected and Automated Traffic at Two-Way Stop-Controlled Intersections," *J. Transp. Eng.,* vol. 149, no. 2, 2023, doi: 10.1061/jtepbs.teeng-7082.

10) F. Sasahara, L. Elefteriadou, and S. Dong, "Lane-by-Lane Analysis Framework for Conducting Highway Capacity Analyses at Freeway Segments:," *Transp. Res. Rec.*, vol. 2673, no. 8, pp. 523–535, 2019, doi: 10.1177/0361198119840609.

11) A. D. Wardani and W. A. Ilonka, "Analisis Lalu Lintas Terhadap Kapasitas Jalan Jolotundo Kota Semarang," vol. 24, no. 2, p. 47, 2023, doi: 10.20961/enviro.v24i2.70719.

12) A. Magfirona, N. Hidayati, I. Setiyaningsih, and G. Slamet, "The delays for signalized intersection using ATCS Data and Field Survey Method at Kerten-Intersection of Surakarta," *Procedia Eng.*, vol. 125, pp. 526–533, 2015, doi: 10.1016/j.proeng.2015.11.055.

13) N. Hidayati, A. Magfirona, and A. Riyanto, "Network-based traffic managementat Kerten Areain Surakarta (Case study: Manahan-Purwosari-Kerten-UNIBA-Jongke intersections)," *AIP Conf. Proc.*, vol. 1977, no. 2018, 2018, doi: 10.1063/1.5043004.

14) MKJI, "Manual Kapasitas Jalan Indonesia," Jakarta, 1997.

ALTERNATIVE DESIGN REHABILITATION OF LALUNG DAM JAWA TENGAH PROVINCE

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ABSTRACT

Dams are one of the most important infrastructure buildings in the field of water resources and provide benefits to the local community. Currently, the community is faced with the fact that the availability of water resources is very critical due to fluctuating climatic conditions between heavy rain discharges and water that is decreasing day by day. To increase water storage capacity, it is necessary to rehabilitate existing dams. The Lalung Dam is located at Karanganyar, Jawa Tengah Province, which was built in 1943 with a homogeneous landfill type, is currently experiencing moderate damage. This is indicated by the occurrence of landslides at tree points on the downstream dam slope. In addition to the positive aspects of the benefits of the dam, the safety factor must be considered against the influence of the slope stability of the dam. This should be of particular concern in order to minimize the negative impact and human casualties. Dams and reservoirs provide numerous benefits but they also represent a risk to public safety and the nation's infrastructure if not properly maintained. The first step in rehabilitation is to develop an investigation program to define the extent of rehabilitation, and the methods to be used.

Keywords: Landslides, investigations, rehabilitation

1. Introduction

Lalung Dam is located in Lalung village, Karanganyar District, Karanganyar Regency, Jawa Tengah Province. Lalung Dam which was built in 1943 with a homogeneous fill type with a height of 12.40 m from the base of the foundation; The length of the dam is 2.9 km and is currently experiencing moderate damage. This is indicated by the occurrence of landslides at three points on the downstream embankment slope (Agus Paryanto, 2019).

In 2017, the Lalung Reservoir was only able to accommodate a water volume of around 2 million cubic meters, from its normal capacity of 4.40 million cubic meters. This dam has a function for irrigation with a service area of 7,394 ha, with normal conditions of the water level at an elevation of +152.0 m. Therefore, the Ministry of Public Works in 2022 through the Bengawan Solo Water Resources Operations and Maintenance Work Unit conducted the Lalung Dam Rehabilitation work to restore the performance of the Dam.

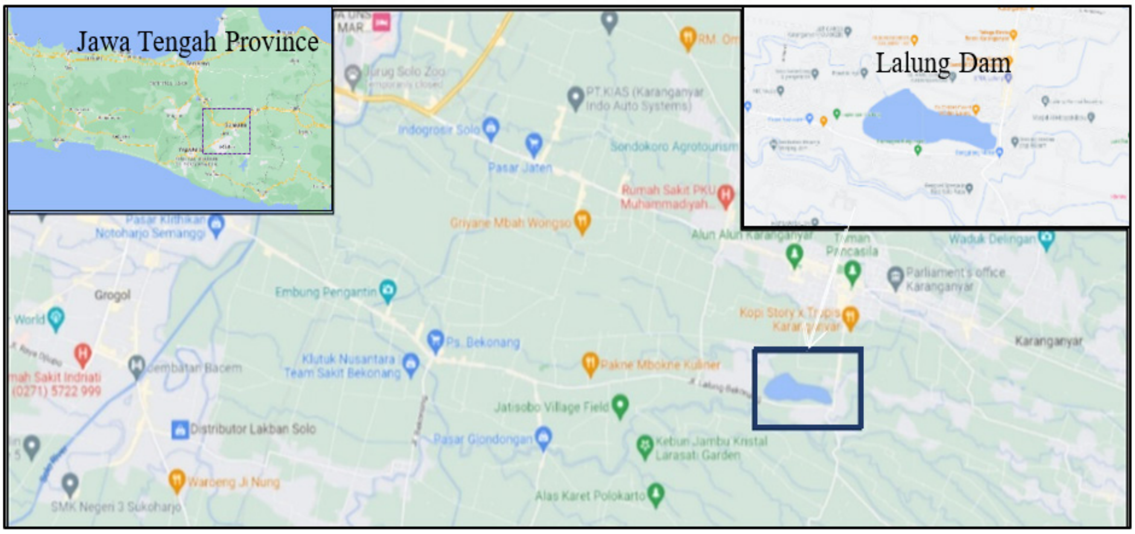


Fig. 1. Location Map of Lalung Dam

Rehabilitation of a dam is the act of restoring the distressed dam not only to its original state but improvement to meet added requirements caused by changes in the safety criteria from time to time.

Rehabilitation needs vary for each dam and the approach is different for diverse types of dams. Field investigations, engineering analysis, and material selection are vital for planning and finalizing rehabilitation and improvement programme.

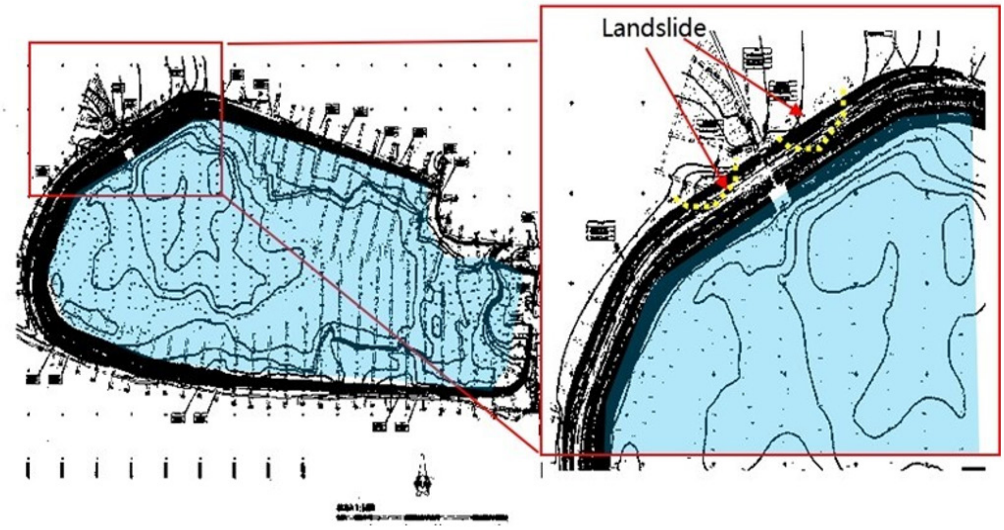


Fig. 2. Layout of Lalung Dam and Location of Downstream Slope Landslide
(Source: Documents of the Lalung Dam Rehabilitation Project Supervision Consultant)

Lalung Dam is a homogeneous type of dam with clay as its constituent material. The technical data is used for the basis of technical studies which will be discussed in the following sub-chapters. There are 3 landslide points on the downstream slope of the Dam with the width of the landslides as follows: landslide (A) 28 m wide, located 62 m to the left of the stairs, landslide (B) with a width of 23 m, is located right beside the left of the stairs to the outlet, and landslide (C) with a width of 38 m, located right beside the stairs.

The technical data of the dam are as follows,

The geotechnical investigation of landslide area are consists of test pit, core drilling, Dutch Cone Penetration Test (DCPT), ground penetrating radar (GPR), and geoelectrical sounding divided into 3 (three) segments. With each segment consists of 3 (three) measurement paths consisting of downstream to upstream on the dam body. Soil samples are taken to laboratory for testing of physical and mechanical property. To carry out the initial analysis, the consultant team used topographical data on the sliding area to get the sliding angle. From this data, the consultant team did a Back Analysis to get estimation of existing soil parameters when a landslide occurs. The results of the Back Analysis are then compared with the existing soil parameters exist from geotechnical analysis work in prior studies.

Then modeling analysis using Geo studio 2012 software.

Fig. 3. The landslides at downstream slope of dam body
(Source: Measurement results of the Lalung Dam Rehabilitation consultant supervision team)

2. Method

This research was conducted at the Lalung Dam, Karanganyar Regency, Jawa Tengah Province Indonesia. The map of research locations can be seen in Figure 1.

The first step in rehabilitation is to develop an investigation program to define the extent of rehabilitation, and the methods to be used. This allows better decisions to be made concerning the rehabilitation of ageing structures (Lalung dam constructed at 1943, about 80 years old dam), should consider both the value of the asset and the safety of the public's at downstream villages. The difficulties of investigation of an old dam that data are limited event no data. Study should include assessment of the safety of the general public. Several approaches to risk analysis have been proposed to supplement the direct and effective method of inspection, analysis and reporting which suffer from the limitation that they principally identify defects that have already developed. The stages of work are field observation stage, data collection stage, data processing stage, data analysis stage, and evaluation stage. In the data collection stage, the authors used primary data from the results of an investigation drilling including in-situ test, construction material and laboratory test result.

Based on the data have been collected and processing and continuing with design alternative for remedial and rehabilitation of Lalung dam, monitoring of seepage investigations and rehabilitation, earthquake deformation analysis, and forensic investigations of dam and embankment failures, that can be suited to safety and construction cost.

3. Investigation Results

The results of geoelectric sounding shows that weak layer, consisting of softened soil and sandy loam, this point is a continuation of the landslide found on the southwest side. The weak layer shows continuity from left side to right side of the stairs. Depth around 5 meters from the top of the dam crest. Based on the results of the GPR data, zone is located at the landslide area that occurs, the zone is dominated by the blue color response indicates that in the zone it is suspected that there are cavities or water seepage. The cavity in the body of the dam is thought to have been formed as a result of this landslides, so that the existence of these cavities is very vulnerable to be traverse by water. The movement of water through the cavity can affect the size of the cavity so that it can causing the dam body to be weaken.

Based on the site surveillance survey and investigation result, the caused of landslide at down slope of dam body are as follows:

- The depth of landslide at down slope about 3-5 m, with various wide.
- Insufficient drainage in the context that the external and internal drainage systems of the dam body are not capable of diverting excess rainfall and can disrupt slope stability.
- The level of soil density varies.
- The possibility of internal erosion on the dam body continuously causes slope instability.
- Soil creep where the load carried by the soil mass does not change but the deformation of the soil mass will increase over time.
- The behavior of strain softening, in which the soil material loses its strength after reaching its maximum strength, is commonly found in progressive failure where the slip will start from the surface of the slope and spread to the inside of the dam body up to a certain distance.
- Saturation of the soil may result in high value of pore-pressure and reduction in shear strength of the downstream slope which create disorders in and the form of downstream slips degradation etc.

4. Alternative Design Rehabilitation

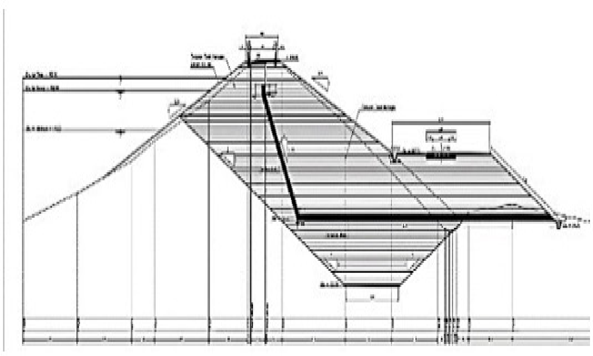
Several considerations in carrying out alternative designs for the rehabilitation of the Lalung dam body include as follows: the age of the dam body is about 80 years, it is possible that there is no internal drain structure; The depth of the landslide varies from 3 to 5 m; the borrow area source of construction material located from outside the dam area; The calculation of downstream slope safety stability must meet predetermined standards, because that in the downstream part of the dam there are densely populated villages.

There are 4 alternative designs rehabilitation of Lalung dam with some various excavation depth. The excavation depth of existing dam body to consider of removal soft or loosened materials due to landslides. In design alternatives 1 and 2 plan to be excavated most of the old dam body and make a cut off trench under the foundation. Both designs will be completed with chimney and horizontal drain, and the alternative 2 there is added a rock toe.

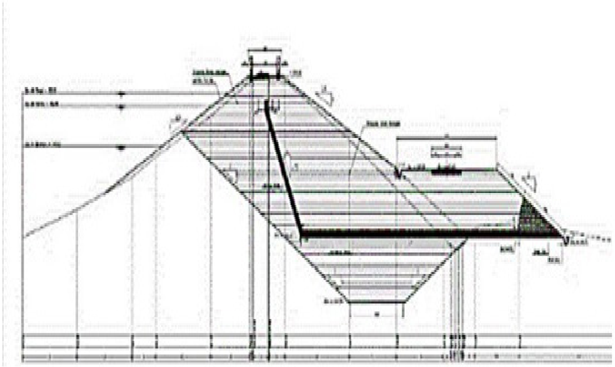
In design alternative 3, the plan is to excavate most of the old dam body but without making a cut trench below the foundation. Then added the bored pile structure and counterweight embankment. In design alternative 4, the plan is to excavate in limited depth old dam body but without making a cut trench below the foundation.

Then a new embankment with slope of 1:3 and added horizontal drain with rock toe at the end of slope.

Alternative Design 1

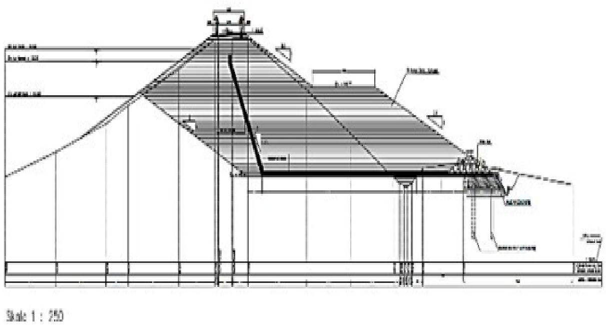


Alternative Design 2

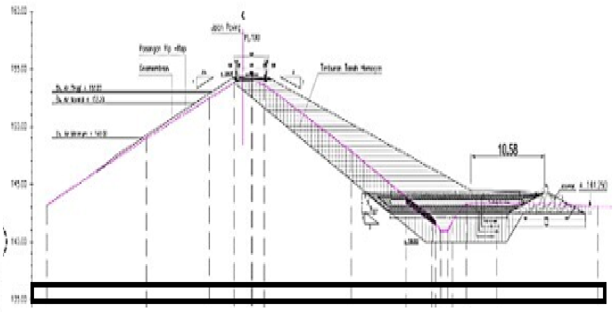


The Main Design Comparison	
Excavation of existing embankment materials, total excavation volume: 265,825 m^3, cut off.	Excavation of existing embankment materials, total excavation volume: 265,825 m^3
Embankment of new materials, slope 1:2,5; total embankment material: 327,826 m^3	Embankment of new materials, slope 1:2,5; total embankment material: 327,826 m^3
Chimney and Horizontal Drain: 4750,6 m^3	Chimney and Horizontal Drain: 4750,6 m^3
No Toe Rock Toe	Embankment of Rock Toe: 7085,4 m^3

Alternative Design 3



Alternative Design 4



The Main Design Comparison	
Excavation of existing embankment materials Total Excavation volume: 173.928,49 m^3, without cut – off.	Excavation of existing soft embankment materials within limited excavation depth, total excavation volume: 64,521,5 m^3
Embankment of new materials and counter weight, slope 1:2,5, total embankment materials: 242.549,82 m3	Embankment of new materials, slope 1:3; total embankment material: 164,647 m^3
Chimney and Horizontal Drain: 4750,6 m^3	Horizontal Drain: 7574,2 m^3
Embankment Rock Toe : 7085,4 m^3	Embankment of Rock Toe: 3575,8 m^3
Two rows bor pile with concrete cap: 3.790,08 m^3 + 915,10 m^3	No bor pile

Fig. 4. Alternative Design and Comparison

5. Alternative Design Calculation

The soil properties consisting of existing embankment materials and the new embankment materials taken from the borrow area. Investigation of construction materials is intended to determine the location of suitable borrow area and knowing the quantity and quality of dam embankment material. The soil parameter of existing embankment materials at several depths of 3,0 m to 8,0 m, cohesion (C): 0,25 kg/cm^2 and internal friction angle (Ø): 13°, Unit weight (γn): 1,7 gr/cm3; this parameter will be used as foundation of a new embankment materials.

Table 1. Soil Parameter of existing embankment dam body

Depth (m)	Soil Description	Nspt	Consistency	C (kg/cm^2)	γ (gr/cm^3)	ϕ (deg)
3.5 - 4.0	Embankment soil with brown colour, sandy clay	0 - 8	Soft - Medium	0.418	1.702	13.083
5.5 - 6.0	Embankment soil with brown colour, sandy clay	0 - 8	Soft - Medium	0.252	1.732	17.307
7.5 - 8.0	Silty clay with brown colour, moist, medium plastic	9 - 30	Stiff - Very Stiff	0.425	1.614	16.741

The soil parameter of new embankment materials from borrow area, cohesion (C): 0,13 kg/cm2 and internal friction angle (Ø): 17°, Unit weight (γn): 1,28 gr/cm3; this parameter will be used as a new embankment materials.

To carry out the initial analysis, the consultant team used topographical data on the sliding area to get the sliding angle. From this data, the consultant team did a Back Analysis to get estimation of existing soil parameters when a landslide occurs.

The results of the Back Analysis are then compared with the existing soil parameters exist from geotechnical analysis work in prior studies.

Landslide reconstruction is intended to determine the magnitude of the actual material shear when there is a landslide.

There is no cohesion value in the landslide sector at the time after landslides. The weight of the soil that burdens the slope is held by friction that is relied on from the value of the material shear angle.

The stability analysis by Geo Studio 2012 version software of each alternative with various conditions, such as empty reservoir, normal water level, high water level, rapid drawdown, without and with an earthquake.

Some samples of calculating results are as follows: In an alternative design, 1 shows a safety factor without an earthquake of 3.5 and with an earthquake of 1.7. In an alternative design, 2 shows a safety factor without an earthquake of 3.3 and with an earthquake of 1.8. In an alternative design, 3 shows a safety factor without an earthquake of 3.6 and 1.6.

Of all alternative rehabilitation designs, showing that it is still above the safety factor requirements, an evaluation of the most efficient design can still be carried out for dam rehabilitation.

6. Value Engineering

This rehabilitation uses value engineering methods to find the most effective design alternatives. In making decisions, value engineering considers four criteria: cost, quality, materials, and time.

Cost models, cost breakdown Analyses, and Pareto diagrams are used to determine the work to be carried out in value engineering.

The application of value engineering can bring up alternatives to the replacement of work items so that the costs and efforts that are not needed or not supported can be eliminated so that the value or price of the project can be reduced, which will provide benefits in the form of cost savings.

Based on the results of the analysis, it was found that the percentage of significant work weight in earthwork was 63.10 %, followed by bore pile work with a percentage of work weight of 18.08 % in the second place, and the third place was occupied by horizontal & vertical drain work with weight amounting to 8.94 %.

In the creativity phase, in overcoming problems in this project, the researcher creates an alternative concept mentioned in the information phase where earthwork has the highest work weight and a considerable cost, followed by bore pile and horizontal & vertical drain work in the second and third places.

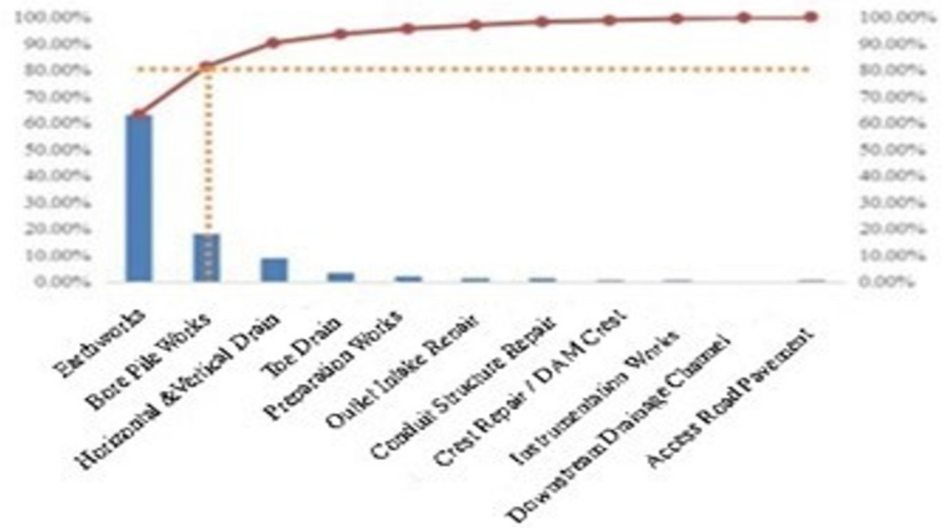


Fig. 5. Pareto diagram of the Lalung Dam Rehabilitation Project

Therefore, the alternative that will be taken is centered on changes in the design of the dam's body. An alternative design four or review design shows a safety factor without an earthquake of 1,9 and with an earthquake of 1.2 bigger than the standard safety factor.

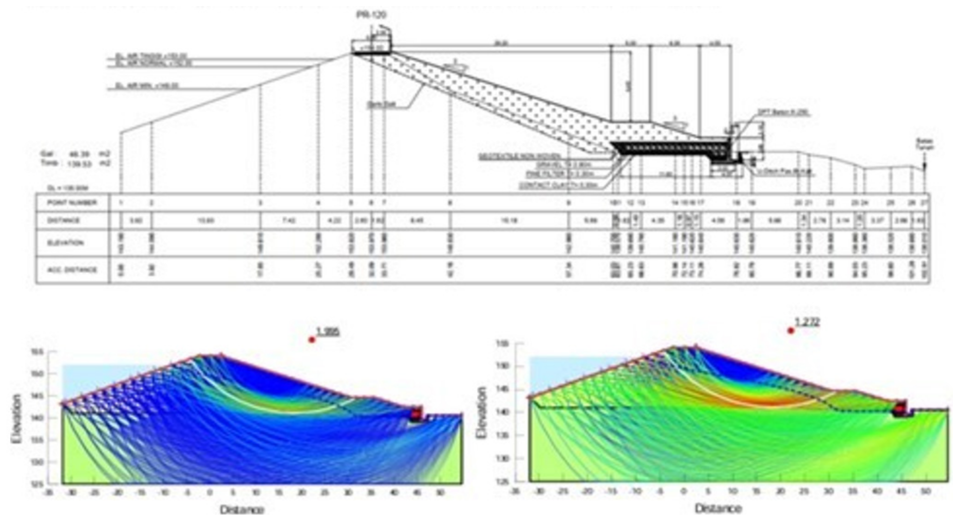


Fig. 6. Design and Stability Analysis of Lalung Dam Rehabilitation Project

7. Construction Rehabilitation

Based on the review design, Lalung Dam rehabilitation construction work can be done faster because the excavation and embankment material volume is less than planned.

Fig. 7. Excavation of Dam Slope and Embankment nof New Material of Lalung Dam Rehabilitation Project.

8. Conclusion

Value engineering can be applied during the Lalung dam rehabilitation construction stage. By applying six stages, namely the information phase, function analysis phase, creativity phase, evaluation phase, development phase, and recommendation phase. The top four high-weight work items, such as earthwork, bore pile and pile cap, horizontal and chimney drain, and rock toe with value engineering, can reduce the total cost and schedule.

9. References

1) Azdan M. D. & Samekto, C. (2008). Kritisnya Kondisi Bendungan di Indonesia. Seminar Nasional Bendungan Besar Indonesia.
2) Aitchison, G.D., and Wood, C.C., (1965) "Some Interactions of Compaction, Permeability and Post-Construction Deflocculation Affecting the Probability of Piping Failure in Small Earth
3) Dams." Proc. 6th Int. Conf. Soil Mechanics and Found. Eng., Vol 2, pp. 442-6.
4) Casagrande, A., "Seepage through Dams" Jnl. New England Water Works Assn., Vol. 51, No. 2, June 1937, also published in "Contributions to Soil Mechanics, 1925 - 1940", Boston Society of Civil Engineers, pp. 295 - 336, 1940.
5) Moore, P.J., (1970) "Some Aspects of the Use of Stability Analyses in Earth Dam Design", Proc.Tenth Congress on Large Dams, Montreal, pp. 151-167.
6) The Rehabilitation of Dams and Reservoirs. Geoffrey P Sims, Brown & Root Services, UK

GREEN BUILDING IMPLEMENTATION USING GREENSHIP NEW BUILDING V1.2 AT POLYTECHNIC OF PUBLIC WORKS

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ABSTRACT

Recent concern for construction professionals are the sustainability of their building projects, therefore several buildings are trying to assess their green performance. The assessment helps to make sure that building projects are designed and built using strategies intended to minimize environmental impacts. Polytechnic of Public Works construct their new building at Semarang. The construction is around 30 hectares and has five main buildings: administration building, auditorium, student activity building, workshop, and lecture building. This research aims to assess the implementation of the green building concept at the Polytechnic of Public Works. Six aspects are evaluated using Greenship New Building V1.2 covers appropriate site development, energy efficiency and conservation, water conservation, material resource and cycle, indoor health and comfort, and building and environment management. Actually, educational buildings have a special requirement and different aspects from conventional buildings. This research tries to combine the assessment criteria from Greenship with recommendations based on the Green School Standard from the Ministry of Education. Each of the aspects has been evaluated by several data, field assessments, technical calculations and also expert judgment. Finally, the greenship rating for Polytechnic of Public Works is 74 poin with Platinum predicate. This research has several recommendations to improve the rating: providing glass coating to reduce the OTTV value in the building and reduce room heat, carrying out waste processing independently, and conducting regular evaluations to improve the building services.

Keywords: Green building assessment, Sustainability, Environmental impact, Greenship New Building V1.2, Energy efficiency

1. Introduction

Construction project definitely has an impact on the environment. The issue of global warming is a trending topic discussed at the end of this decade. Started with the Protocol Kyoto in 1997, when industrial countries committed to reducing collective greenhouse gas emissions were 5.2% compared to 1990. The UN report in a publication titled "Buildings and Climate Change" states that 30%-40% of energy is used in buildings (Adji, 2016). The construction sector also contributes more than 40% of carbon emissions, uses quite large amounts of natural materials, contributes to waste, and reduces water catchment areas and green areas (Sucipto, 2014). The Green Buildings concept is designed by considering environmental aspects so that the impact of development is minimal and in line with energy-saving goals. The building assessment guide using the Greenship method is divided based on its application, which includes neighborhoods, Homes, New buildings, Existing buildings, and Interior Space with different assessment criteria. The Public Works Polytechnic as an educational institution under the Ministry of Public Works and Public Housing is completing the construction of the campus 2 building complex on Jalan Soekarno-Hatta, Semarang City. Planning documents state that the building is designed to green building standards. However, in its implementation, adjustments are needed related to the building's function as an educational building. In order to support the creation of environmental balance, this research was conducted by evaluating the application of the green building concept in the Campus 2 Polytechnic of Public Works buildings.

Previous research generally discusses the evaluation of green building criteria for existing buildings. Research (Nabilla, et al, 2018) was conducted to evaluate the application of green building criteria in office buildings in Semarang. Meanwhile, other research (Putri, et al, 2012) tried to evaluate the application of green building criteria in the ITS Civil Engineering Building. The research object has similarities with current research, namely educational buildings. However, in its evaluation, previous research used the basic criteria of existing buildings, while the current research is new buildings. Apart from that, this research tries to compare the standards from the GBCI and also the Green School standards from the Ministry of Education.

2. Methodology

This research was carried out in the Public Works Polytechnic Campus 2 Building which was just operational in 2023. The Greenship New Building (NB) V1.2 method was used to assess new buildings that have been in use for less than 1 year. Data collection in this research was carried out using primary and secondary surveys.

Fig. 1. Case Study Location

1. Primary Survey

    Primary data is data taken directly by researchers, in the form of data from direct observation surveys in the field concerning the Greenship NB V1.2 form and direct interviews with the person in charge of the building and building users.

2. Secondary Survey

    Secondary data is data taken from documents or other secondary sources, in the form of Detailed Engineering Design (DED), material technical specifications, and other supporting documents.

    The research tool used is the rating tool in the Greenship criteria for New Buildings. GREENSHIP NB Version 1.2 is an extension of the GREENSHIP NB assessment tool version 1.0 and GREENSHIP NB benchmark summary version 1.1.

Table 1. Criteria and Benchmarks of Greenship NB

Category	**Total Value of Design Recognition**			**Total Value of Final Assessment**		
	Requirement	**Credit**	**Bonus**	**Requirement**	**Credit**	**Bonus**
ASD	-	17		-	17	
EEC	-	26	5	-	26	5
WAC	-	21		-	21	
MRC	-	2		-	14	
IHC	-	5		-	10	
BEM	-	6		-	13	
Number of Criteria and Benchmarks	-	77	5		101	5

3. Analysis of Greenship New Building Criteria

Assessment of prerequisite criteria is the initial stage in evaluating green buildings. Each category has prerequisite criteria that must be fulfilled. If the prerequisite criteria have been fulfilled, a credit criteria assessment can be carried out. The evaluation results are divided into 6 (six) criteria including, Land Use, Energy Efficiency and Conservation, Water Conservation, Material Sources and Cycles, Indoor Health and Comfort, and Building Environmental Management.

3.1 Appropriate Site Development

The minimum area for new buildings is 10% of the total land area. The total land area of the 2nd Campus Polytechnic of Public Works is 54,781 m2 so 10% of the land area is 547,1 m2. The type of vegetation used follows Minister of Public Works Regulation No. 5/PRT/M/2008 concerning Green Open Space (RTH) Article 2.3.1 concerning Vegetation Criteria for Yards. Based on on-site processing and circulation data, it is known that the green area is 12,292 m2 with a Green Area Coefficient (KDH) of around 22.4%. So, from the KDH value, the 2nd Campus Polytechnic of Public Works meets the prerequisite criteria for Land Use Management.

3.2 Energy Efficiency and Conservation

The assessment of energy efficiency and conservation has 2 (two) criteria, namely sub-meter installation and OTTV calculation. The benchmark for installing a kWh meter is to install a kWh meter to measure electricity consumption for each load group and equipment system, which includes, the air conditioning system, lighting system, and contact box as well as other load systems. The second benchmark is to carry out OTTV calculations based on SNI 03-6389-2011 concerning Energy Conservation of Building Envelopes in Buildings. The overall thermal transfer value must not exceed or be a maximum of 35 W/m2. Based on the results of interviews and direct observations in the field, the 2nd Campus Polytechnic of Public Works Building has a kWh meter used to measure electricity consumption. Meanwhile, the results of the OTTV calculation show that only the Directorate Building has an OTTV value of less than 35 W/m2, namely 30 W/m2. Meanwhile, other buildings exceed it. So it can be concluded that the Building does not meet the prerequisite criteria for Energy Efficiency and Conservation.

3.3 Water Conservation

The prerequisite criteria for Water Conservation have 2 (two) benchmarks. The first benchmark is the installation of a water meter (volume meter) in the water distribution system. The second benchmark is filling in the water worksheet provided by GBCI. Based on the results of the interview with the person in charge of the building, in the

2nd Campus Polytechnic of Public Works building there is a water meter to control the distribution of clean water. Therefore, the building meets the prerequisite criteria for Water Conservation.

3.4 Material Sources and Cycles

The prerequisite criteria for Material Sources and Cycles have one benchmark. The benchmark is not to use chlorofluorocarbon (CFC) as a refrigerant and halon as a fire-extinguishing agent. Based on Mechanical Electrical Plumbing (MEP) technical specification data, the air conditioning (AC) used in the 2nd Campus Polytechnic of Public Works Building is a Variable Refrigerant Volume System. This type of refrigerant does not use chlorofluorocarbon (CFC) as the main ingredient but uses Hydro Fluro Carbon (HFC). Therefore, the Building meets the prerequisite criteria for Material Sources and Cycles.

3.5 Indoor Health and Comfort

The criteria for creating Indoor Health and Comfort have one benchmark. The benchmark is room design by ASHRAE Standard 62.1-2007 regarding the potential for outside air introduction. Based on observations in the field, the room design in the 2nd Campus Polytechnic of Public Works building has been adjusted to ASHRAE Standard 62.1-2007. This is demonstrated by the presence of air ventilation, ventilation, and the use of air conditioning in the building so that it can maintain indoor air circulation. Therefore, the Building meets the criteria for fulfilling Indoor Health and Comfort.

3.6 Building Environmental Management

The prerequisite criteria for Building Environmental Management have one benchmark. The benchmark is the existence of an installation to sort and collect waste based on organic, inorganic, and Toxic Hazardous Waste. Based on observations, the 2nd Campus Polytechnic of Public Works building provides waste installations that are differentiated based on organic and inorganic types. Therefore, the building meets the prerequisite criteria for Building Environmental Management.

4. Evaluation of Greenship New Building Credits

4.1 Appropriate Site Development

The Land Use category has 7 credit criteria. Each criterion has assessment points. These criteria include site selection, community accessibility, public transportation, bicycle user facilities, land landscaping, microclimate, and rainwater runoff management.

Table 2. Recapitulation of Appropriate Site Development Assessment4

ASD	Appropriate		Point
	Yes	No	
Basic Green Area	√		-
Site Selection	√		2
Community Accesibility	√		2
Public Transportation	√		2
Bicycle Facility	√		2
Site Landscaping	√		1
Micro Climate	√		1
Stormwater Management	√		2
Total Point of ASD			**12**

Based on the building landscape plan, it is known that the area of the landscape area that is free from buildings and is located above ground level is less than 40%. However, the use of local cultivated plants and large canopy areas is already available in Campus 2 of the Public Works Polytechnic.

4.2 Energy Efficiency and Conservation

Energy Efficiency and Conservation Criteria have 5 credit criteria. Each criterion has assessment points. These criteria include energy-saving measures, natural lighting, ventilation, the influence of climate change, and renewable energy on the site. Assessment in the Energy Efficiency and Conservation category cannot be continued because the prerequisite criteria are not met.

Table 3. Recapitulation of Energy Efficiency and Conservation Assessment

	EEC	Appropriate		Point
		Yes	No	
P1	Electrical Sub Metering	√		-
P2	OTTV Calculation		√	-
1	Energy Efficiency Measures	√		15
2	Natural Lighting	√		2
3	Ventilation		√	
4	Climate Change Impact		√	
5	On-Site Renewable Energy	√		5
	Total Point of EEC			**17**

4.3 Water Conservation

Water Conservation Criteria has 6 credit criteria. Each criterion has assessment points. These criteria include Reducing Water Use, Water Features, Water Recycling, Alternative Water Sources, Rainwater Harvesting, and Landscape Water Use Efficiency. Assessment in the Water Conservation category can continue because the prerequisite criteria have been met.

Table 4. Recapitulation of Water Conservation Assessment

WAC		Appropriate		Point
		Yes	No	
P1	Water Metering	√		-
P2	Water Calculation	√	√	-
1	Water Use Reduction			15
2	Water Fixtures	√		2
3	Water Recycling	√	√	
4	Alternative Water Resources	√	√	
5	Rainwater Harvesting	√		5
6	Water Efficiency Landscaping			
	Total Point of WAC			9

Water Recycling has 1 benchmark. The benchmark is the use of used water which is recycled for flushing and/or cooling water needs. Based on the results of interviews with the person in charge of the building, Campus 2 Building of the Public Works Polytechnic recycles water used for ablutions. The results of recycling used ablution water are used as flushing. Another benchmark is to provide the installation of a rainwater storage tank with a capacity of 20%, 35% or 50% of the amount of rainwater that falls on the roof of the building. Calculations are carried out using a rainfall intensity value of 50 mm/day. Based on the results of interviews with the person in charge of the building, the Public Works Polytechnic Campus 2 building has a rainwater collection installation with a capacity of 35%.

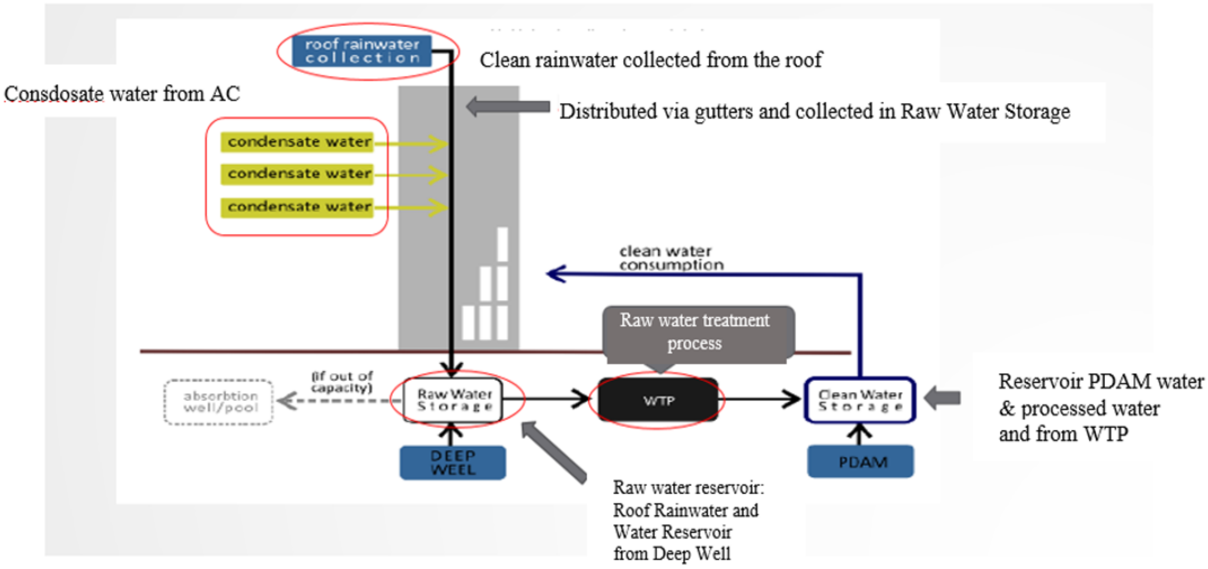

Fig. 2. Water Recycling Concept for the 2nd Campus Polytechnic of Public Works

4.4 Material Sources and Cycles

Source Criteria and Material Cycles have 6 credit criteria. Each criterion has assessment points. These criteria include the use of buildings and materials, environmentally friendly materials, use of refrigerants without OPD, certified wood, fabricated materials, and regional materials. Assessment in the Material Source and Cycle category can continue because the prerequisite criteria have been met.

Table 5. Recapitulation of Material Source and Cycle Assessment

MRC		Appropriate		Point
		Yes	No	
P	Fundamental Refrigerant	√		-
1	Building and Material Reuse		√	0
2	Environmentaly Friendly Mterial	√		3
3	Non ODS Usage	√		2
4	Certified Wood	√		1
5	Prefab Material	√		3
6	Regional Material	√		2
Total Point of MRC				**11**

4.5 Indoor Health and Comfort

Health and Comfort Criteria The room has 7 credit criteria. Each criterion has assessment points. These criteria include monitoring CO2 levels, controlling cigarette smoke and the environment, chemical pollutants, views outside the building, visual comfort, thermal comfort and noise levels. Assessment in the Room Health and Comfort category can continue because the prerequisite criteria have been met.

Table 6. Recapitulation of Indoor Health and Comfort Assessments

	IHC	Appropriate		Point
		Yes	**No**	
P	Outdoor Air Introduction	√		
1	CO_2 Monitoring	√		1
2	Envronmental Tobaco Smoke Control	√		2
3	Chemical Pollutant	√		3
4	Outside View	√		1
5	Visual Comfort	√		1
6	Thermal Comfort	√		1
7	Acoustic Level	√		1
	Total Point of IHC			**10**

Fig.3. View out of the building

4.6 Building Environmental Management

Building Environmental Management Criteria has 7 credit criteria. Each criterion has assessment points. These criteria include GP as a Project Team Member, Pollution from Construction Activities, Advanced Waste Management, Good and Correct Commissioning System, Submission of Green Building Data, Agreement on Carrying Out Activities, and Building User Survey. Assessment in the Building Environmental Management category can continue because the prerequisite criteria have been met.

Table 7. Recapitulation of Building Environmental Management Assessment

BEM		Appropiate		Point
		Yes	No	
P	Basic Waste Management	√		-
1	GP as a Member of Project Team	√		1
2	Pollution of Construction Activity	√		2
3	Advanced Waste Management	√		1
4	Proper Commisioning	√		3
5	Green Building Submission Data		√	0
6	Fit Out Agreement	√		1
7	Occupant Survey	√		2
Total Point of BEM				**10**

Fig. 4. Waste Water Treatment

Based on the analysis results of the 2nd Campus Polytechnic of Public Works Building assessment using Greenship New Building Version 1.2, the total points obtained for each category are shown in Table 4.26. The minimum points to obtain green building certification using the Greenship New Building Version 1.2 method is 35 points or 35% of 101 points. Campus 2 Building of the Public Works Polytechnic received 74 points out of a total of 101 points. From the points obtained, the 2nd Campus Polytechnic of Public Works Building can receive a Platinum title.

Table 8. Green Building Category Assessment Results

No.	Assessment Criteria	Total Point
1	ASD	12
2	EEC	22
3	WAC	9
4	MRC	11
5	IHC	10
6	BEM	10
	Total Point	**74**

The research results can be input for building managers to increase credit scores before certification is carried out. In addition, based on the Green School standards from the Ministry of Education, research results can be collaborated to create sustainable educational buildings. The initial steps that can be taken are saving energy, managing waste, and developing an environmentally caring character for students and the academic community.

5. Conclusion

Recommendations that can be made to increase the chances of obtaining Greenship New Building assessment points are:

1. Apply glass coating to reduce the OTTV value in the building and reduce room heat;
2. Carry out waste processing independently or in collaboration with third parties (GBCI, 2013). The building collaborates with third parties to re-manage inorganic waste. This collaboration adds 1 point to the building's greenship assessment;
3. Conduct regular surveys of building users to improve building services.

6. References

1) Adji, Hadjar Seti. (2016). Green Building and Green Construction. Jakarta: Engineer Weekly.

2) Armstrong, B. (2008). Green building strategies. Manitoba Business, 30 (2), ABI/INFORM Complete pg.14.

3) Green Building Council Indonesia. (2016). Greenship Existing Building.

4) Nabila, Soraya, dkk. (2018). Penerapan Green Building di Perkantoran Menara Suara Merdeka, Semarang. Nature: National Academic Journal of Architecture. Vol.5, Nomor 2, hlm 124-134.

5) Putri, Aristia, dkk. (2012). Penilaian Kriteria Green Building pada Gedung Teknik Sipil ITS. Surabaya: Jurnal Teknik ITS Vol.1, No.1.

6) Sucipto, Taufiq, dkk. (2014). Kajian Penerapan Green Building pada Gedung Bank Indonesia Surakarta. Surakarta: Jurnal Ilmiah Pendidikan Teknik dan Kejuruan Vol.7, No.2.

7) Triwidiastuti, Sri. (2017). Model Green Building di Indonesia Berbasis Konsep Kualitas DMAIC SIX SIGMA. http://repository.ut.ac.id/7075/1/UTFMIPA2017-06-sri.pdf

8) Utomo, Christiono. (2012). Penilaian Kriteria Green Building pada Gedung Teknik Sipil ITS. Surabaya: Jurnal Teknik ITS Vol.1, No.1 ISSN 2301-9271.

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Rehabilitation and maintenance are just as crucial as planning and design in civil engineering. Infrastructure defects can arise from various factors, including excessive loads, natural disasters, poor construction practices, and material deterioration. Ad-dressing these issues through rehabilitation and maintenance efforts is essential for extending the useful lifespan of buildings and infrastructure. Rehabilitation refers to the process of restoring the functions of buildings and infrastructure that have been compromised due to defects or structural deterioration. This encompasses a wide range of activities, such as repair, strengthening, revitalization, renovation, and resto-ration. Maintenance, on the other hand, ensures that buildings and infrastructure continue to operate as intended, preventing the occurrence of further issues. By investing in these crucial processes, civil engineers can safeguard the integrity and longevity of the structures they design and build. Regular maintenance and timely rehabilitation interventions can help mitigate the impact of various challenges, from environmental factors to human-induced damages, ultimately contributing to the overall sustainability and resilience of the built environment. Well-executed rehabilitation and maintenance strategies can also enhance the aesthetic appeal, functionality, and safety of buildings and infrastructure, meeting the evolving needs of the communities they serve.The International Conference on Rehabilitation and Maintenance in Civil Engineering is a triennial event that provides a platform for researchers, academics, government agencies, consultants, and contractors to share their experiences, technological advancements, and innovations in civil engineering rehabilitation and maintenance. ICRMCE conferences attracted hundreds of researchers from around the world to present their scientific papers in various civil engineering disciplines. These conferences have become a premier forum for civil engineering professionals to discuss the latest developments and challenges in the field of infrastructure rehabilitation and maintenance.

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