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The Effect of Addition Superplasticizer (Sikament-LN) with Variation of Percentage on Compressive Strength Foamed Mortar Lightweight Materials

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ABSTRACT

The foamed mortar (morbus) lightweight material consists of a mixture of sand, cement, water, and liquid foam (foam agent), which can improve the mechanical properties of clay soil and increase its bearing capacity. This research uses various variations of superplasticizer mixtures, namely by adding additional ingredients in the form of sikament-LN which will increase compressive strength by up to 40% at 28 days. This research needs to be carried out to determine the effect of sikament-LN on increasing the compressive strength of foamed mortar. The percentages of the sikament-LN mixture were 0.5%, 0.75%, 1%, and 1.25% with ages of 7, 14, and 28 days, each of which made 3 test objects in 4 variations of the mixture. The research results showed that the addition of sikament-LN to the 1.25% mixture did not meet the requirements because it produced a flowability of 23.5 cm and the mixture experienced a shrinkage of > 20% when placed in a cylindrical mold. All foamed mortar specimens experienced an average dry density increase of 1.994% at a curing age of 7 to 14 days and an average dry density increase of 4.044% at a curing age of 7 to 28 days. In a mixture of 0.5%, 0.75%, and 1%, at 28 days the maximum compressive strength value obtained was 841,667 kPa (more than the required 800 kPa). For the sikament-LN mixture, a maximum of 1% of the cement weight is recommended so that the hardening process occurs in the foamed mortar test object.

Keywords: *Med Mortar; Sikament-LN; Foam Agent; Compressive Strength.*

INTRODUCTION

Foamed mortar is a lightweight material technology for road construction as an effort to reduce land subsidence caused by low soil bearing capacity [1]. Foamed mortar is a concrete-like material consisting of a mixture of sand, cement, water, foam liquid/ foam agent [2] and other necessary additives. The addition of optimum cement water (FAS) of 0.6 meets the flow, dry density values and causes the compressive strength of foamed mortar lightweight material plan to increase significantly [3].

The water content in the foamed mortar lightweight material mixture can significantly reduce the compressive strength of the mortar where each addition of 1 liter of water to the foam agent mixture will reduce the compressive strength by 108 kg/cm^2 [4]. It is necessary to reduce the water content to obtain the maximum compressive strength value which can be done by adding various types of accelerators in the form of minerals and chemicals [5][6].

The addition of superplasticizers with the right dosage will give high compressive strength results [7]. Meanwhile, excessive use of superplasticizers in fresh concrete mix will reduce the compressive strength of concrete. Based on the test results that have been done, this research tries to add materials such as superplasticizer type (sikament-LN).

In this follow-up study, we have designed a research plan aimed at improving the bearing capacity of soil through chemical stabilization. We have used various variations of sikament-LN mixtures, including 0.5%, 0.75%, 1%, and 1.25%, with foamed mortar test objects. We conducted compressive strength testing at 7, 14, and 28 days of concrete age. Our objective is to determine the compressive strength values obtained from the different sikament-LN mixtures at the age of 7, 14, and 28 days of foamed mortar. Additionally, we hope to determine the percentage of the maximum sikament-LN mixture and how water content affects the performance of the mixture used.

MATERIALS AND METHODS

The method used in this research is the experimental research method as primary data. According to [8] is a research method used to seek the effect of certain treatments on others under controlled conditions. The manufacture of controlled foamed mortar test objects is intended to regulate (1). Composition, (2). Equipment and (3). The mix requirements on foamed mortar, can be met in accordance with the "Guidelines for Specifications of foamed mortar Lightweight Materials for Road Construction". Furthermore, secondary data is obtained from literature studies on related standards such as SNI and ASTM. The material testing includes testing Sieve Analysis, Solid and Loose Weight of Fine Aggregates, Water Content, and Mud Content of Fine Aggregates. Cement testing includes specific gravity, consistency, and bonding time. Foam testing includes specific gravity (PUPR, 2015a). The preparation of 40 foamed mortar specimens of various sikament-LN mix variations was molded on cylinders of dia. 100mm and 200mm height for further flow examination. During 24 hours the physical condition of the specimens was monitored to see if shrinkage occurred. After that, the molds were opened and cured for 7, 14, and 28 days and then tested for dry density and compressive strength.

Material preparation

The initial step in conducting this research is to prepare the test objects, including finding material sources, transporting, washing, and storing materials. The source materials used in this study are:

1. Cement
   The cement used in this study is Portland Composite Cement (PCC) Type I with the trademark Conch produced by PT. Conch Cement Indonesia which is packaged in a paper bag weighing 50 kg/sack.
2. Fine Aggregate
   The fine aggregate used in this study is Tanjung Raja sand originating from the Tanjung Raja District area, Ogan Ilir Regency, South Sumatra Province.
3. Water
   The water used in this study came from PDAM Tirta Musi Palembang City.
4. Foam Agent
   Foam Agent used in this research is ADT Foam Agent brand produced by CV. Citra Additive Mandiri.

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5. Sikament-LN Superplasticizer
   In this research, the Superplasticizer liquid uses type F with the Sikament-LN product brand produced by PT Sika Indonesia.

Material requirements

Material requirements are calculated based on the Guidelines for foamed mortar lightweight material mixtures for road construction [9]. Based on the calculation of the job mix plan, the number of material requirements is obtained as follows.

Table 1. Component Material

No.	Material	Material Label	Total Requirement	Unit
Requirement for 1 cylindrical specimen				
1.	Portland cement	Conch	1,431	kg
2.	Water	PDAM Tirta Musi Kota Palembang	0,715	ltr
3.	Sand	Tanjung Raja	1,727	kg
4.	Foam agent ADT	CV. Citra Additive Mandiri	0,263	ltr
5.	*Sikament-LN* Additive	PT. Sika Indonesia	0,0072	ltr
Requirement for total cylindrical specimens (36 cylindrical specimens + 4 backup specimens)				
1.	Portland cement	Conch	60	kg
2.	Water	PDAM Tirta Musi Kota Palembang	30	ltr
3.	Sand	Tanjung Raja	70	kg
4.	Foam Agent ADT	CV. Citra Additive Mandiri	11	ltr
5.	*Sikament-LN* Additive	PT. Sika Indonesia	0,3	ltr

So, based on the calculation table above, it takes:

1. Portland cement (50 kg/sack) : 2 sack
2. Water : 30 litre
3. Sand : 0,1 m^3
4. *Foam agent* ADT (5 ltr/jerry can) : 3 jerry cans
5. Additive *Superplasticizer Sikament-LN* (5 ltr/jerry can) : 1 jerry can

Mix design

The manufacture of test specimens based on the proportion of the material mixture refers to the Interim Special Specification Section 7.21 [11] foam-mortar on the guidelines for the preparation plan of a foamed mortar lightweight material. The test specimens were made in the form of cylinders with a diameter of 100 mm and a height of 200 mm. In this study, 36+4 specimens were planned.

The cylindrical specimens were made at the ages of 7, 14, and 28 days and with the following variations of sikament-LN superplasticizer additives.

1. Morbus 1 (Sikament-LN 0,5%) : 10 specimens (9 + 1 backup)
2. Morbus 2 (Sikament-LN 0,75%) : 10 specimens (9 + 1 backup)
3. Morbus 3 (Sikament-LN 1%) : 10 specimens (9 + 1 backup)
4. Morbus 4 (Sikament-LN 1,25%) : 10 specimens (9 + 1 backup)

The design of 800 KPa foamed mortar mix for each sikament-LN mix variation with 10 specimens per foamed mortar age can be seen in Table 2 below.

Table 2. Material Composition for Each Specimen

Specimens	Densitas Rencana (kg/m^3)	Cement (kg)	Sand (kg)	Water (kg)	*Foam* (kg)	*Sikament -LN (kg)*
Morbus 1 (S-LN 0,50)	600	14,310	17,270	7,150	2,630	0,036
Morbus 2 (S-LN 0,75)	600	14,310	17,270	7,150	2,630	0,054
Morbus 3 (S-LN 1,00)	600	14,310	17,270	7,150	2,630	0,072
Morbus 4 (S-LN 1,25)	600	14,310	17,270	7,150	2,630	0,090

Based on Table 2, to make a foamed mortar mixture of 10 specimens per planned age in each sikament-LN mixture, 14.310 kg of cement, 17.270 kg of fine aggregate (Tanjung Raja sand), 7.150 kg of water, and 2.630 kg of foam and sikament-LN between 0.036-0.090 kg are needed according to the variations planned in the calculation of the foamed mortar composition design.

RESULTS AND DISCUSSION

This section discusses the results of the tests carried out, where testing of materials, cement, foam and was carried out in the form of examining the flow of foamed mortar, average dry density, the relationship between compressive strength.

Material testing

a) Fine aggregate
The test results of fine aggregates must meet the SNI standards.

Table 3. Test result of Fine Aggregate

Testing	Fine Aggregate	
Sieve analysis	2,831	%
Unit weight of solids	1,401	gram/cm^3
Unit weight of loose	1,296	gram/cm^3
Water content	7,319	%
Sludge content	1,480	%

Based on Table 3. fine aggregate test results (average), Tanjung Raja sand has a fine aggregate grain modulus value of 2.831% with gradation zone II (slightly coarse sand) and the test results show that Tanjung Raja sand has met the standard requirements.

b) Cement
The cement test results can be seen in full in Table 4 below.

Table 4. Test result of Portland Cement

Testing	Cement	
Specific gravity	3,128	gram/cm^3
Initial setting time	84,783	minute
Finish setting time	150	minute
Consistency	24,750	%

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From the test results of PCC Conch Type I cement as outlined in the table above, the test data shows that the cement has met the requirements.

c) *Foam*

The design of the foam agent mixture in the foamed mortar of this study refers to for the subbase layer in Table 5. and the minimum compressive strength value in Table 6.

Table 5. Test result of Foam

Testing	**Foam**	
Specific gravity	0,075	t/m^3

The foam-specific gravity values listed are the required values for the manufacture of foamed mortar mixtures as described in the guidelines. The test specimens with each age of (7, 14 and 28 days) which must meet values set as the lower foundation layer in road construction [10]

Table 6. Minimum Compressive Strength (age 14 days) Foamed mortar

Max. dry density (gr/cm^3)	**Min unconfined compressive strength (UCS)**	
	kPa	**Kg/cm^2**
0,6	800	80

Source : (PUPR, 2015c)

Flow check

Foamed mortar flow inspection is a method to measure the flowability and consistency of foamed mortar. This check is carried out in fresh condition. The results of the flow check in each variation can be seen in the following figure and Table 7 :

Figure. 1. Flow examination

Table 7. Flow Examination in Foamed mortar Variations

No.	**Variation**	**Flow Results**	**Recommended**	**Decision**
1	S.LN 0,5%	17,4 cm	18 cm ± 2 cm	Accepted

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No.	Variation	Flow Results	Recommended	Decision
2	S.LN 0,75%	18,5 cm		Accepted
3	S.LN 1,0%	20 cm		Accepted
4	S.LN 1,25%	23,5 cm		Rejected

The results of the flow examination are 0.5% sikament-LN variation, 0.75% sikament-LN variation, 1% sikament-LN variation, and 1.25% sikament-LN variation, where the lowest flowability is in the 0.5% sikament-LN variation and the highest flowability is in the 1.25% sikament-LN variation. The inspection results in the table can be seen in the following figure:

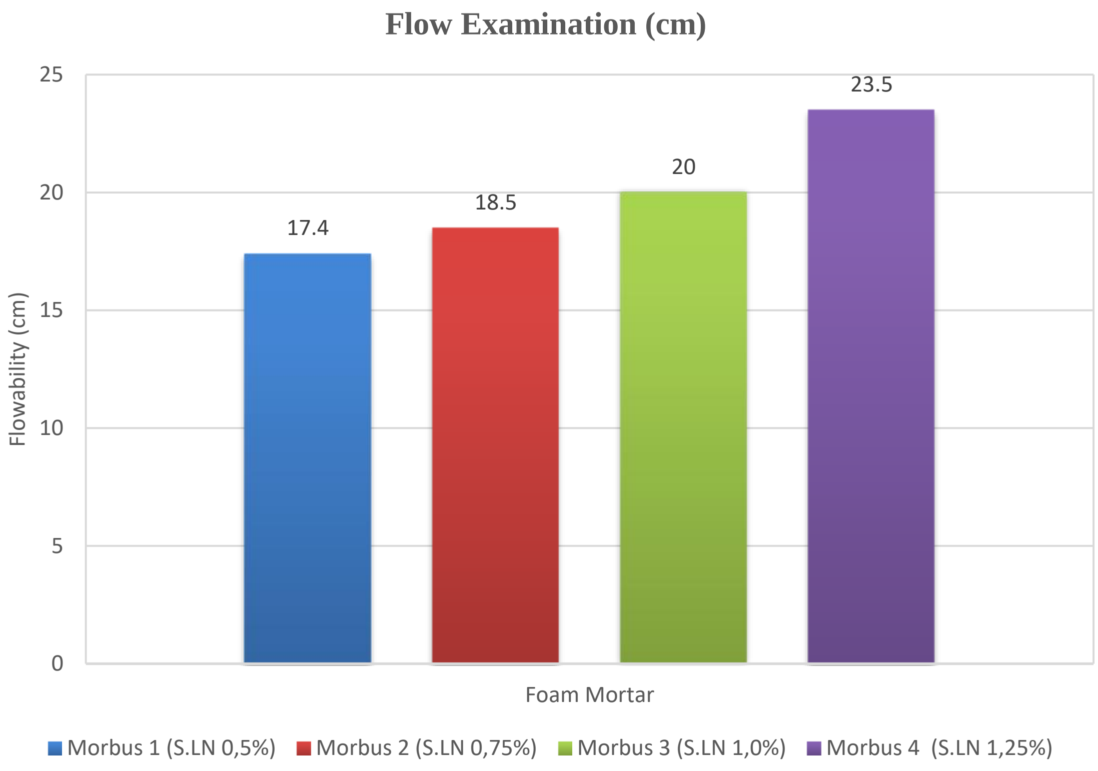

Figure 2. Flow examination graphs for each variation

From Figure 2, it can be concluded that the higher the percentage of sikament-LN used, the higher the flow obtained. Where the minimum flow with a flowability of 17.4 cm is in the 0.5% sikament-LN variation and the highest flow with a flowability of 23.5 cm is in the 1.25% sikament-LN variation.

Foamed mortar mixes 1, 2, 3, and 4 were inserted in the 80 mm diameter, 80 mm high flow ring that had been prepared where it was inserted gradually to be filled according to volume. The value of the flow results must reach the required value of 180 mm ± 20 mm, in foamed mortar mixtures 1, 2, and 3 which can meet the test requirements based on (PUPR, 2015c).

Whereas when the foamed mortar mixture 4 where the effect of adding sikament-LN is 1.25% produces a flowability of 235 mm which exceeds the requirements and when the foamed mortar 4 is inserted into the cylinder mold there is a shrinkage of > 20% so that the volume of the cylindrical specimen is not fully filled. Foamed mortar 4 did not meet the criteria for further testing.

Dry density

Foamed mortar test specimens that have hardened for 24 hours are removed from the 100 mm x 200 mm cylinder mold, then wrapped in plastic for 3 days to prevent contamination with the outside environment and then soaking the test specimens, then the dry density and compressive strength of the foamed mortar will be tested at the age of 7, 14, and 28 days with the planned dry density and compressive strength (see Table 5).

Average of Dry Density (Kg/m³)

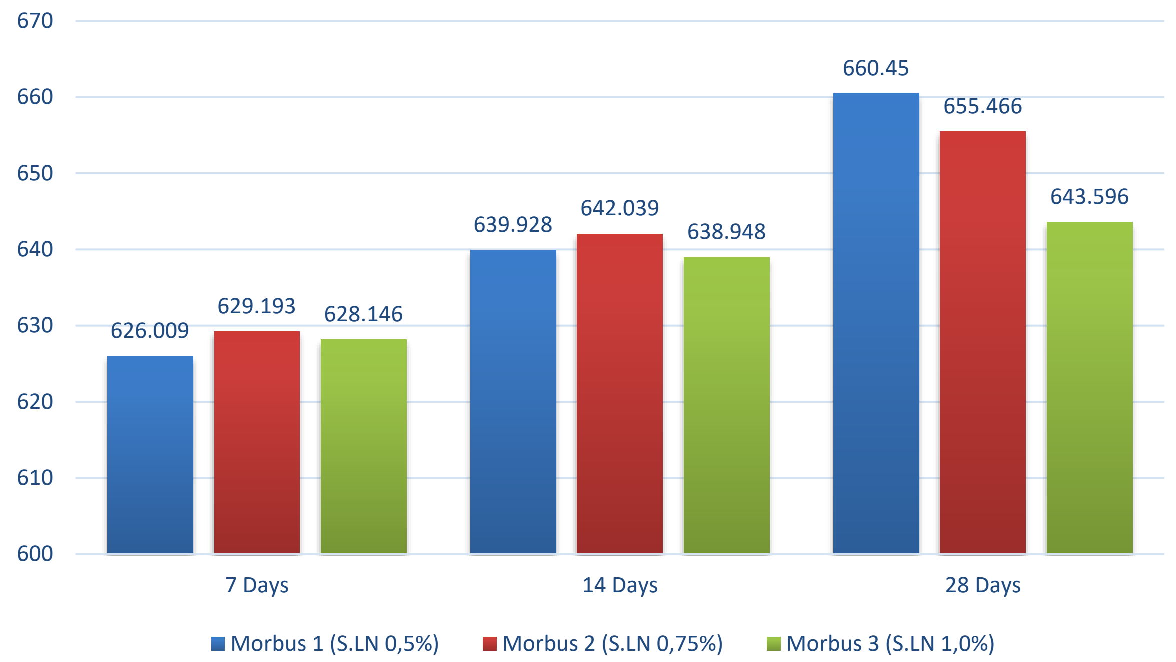

Figure. 3. Dry Density Results on Foamed Mortar Variations

The dry density results of the 28-day-old foamed mortar showed an increase when compared to the density of the test specimens with a treatment age of 7 days of 34.441 kg/m^3 (morbus 1), 26.273 kg/m^3 (morbus 2), and 15.450 kg/m^3 (morbus 3) for the same sikament-LN mixture variation. All foamed mortar specimens experienced an increase in average dry density of 1.994% from 7 to 14 days and an increase in average dry density of 4.044% from 7 to 28 days.

Figure. 4. Weight Testing Dry Density Foamed mortar

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Unconfined Compressive Strength (UCS)

From the compressive strength tests that have been carried out for each foamed mortar specimen at 7, 14, and 28 days of treatment, the following test data show that the average compressive strength for foamed mortar specimens has met the plan specification standard of 800 kPa.

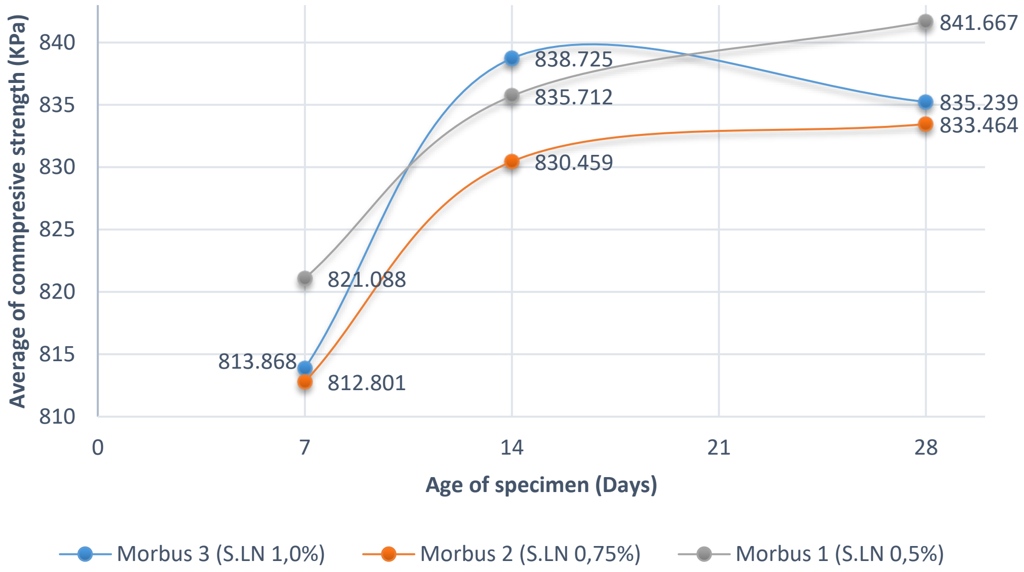

Figure. 5. Graphic compressive strength (Average) for all specimens

Based on Figure 5, the trend of adding sikament-LN causes the foamed mortar to experience an increase in its average compressive strength value, where morbus 1 (S.LN 0.5%) experienced an increase in average compressive strength of 1.781% at the treatment age of 7 to 14 days and an increase in average compressive strength of 2.506% at the treatment age of 7 to 28 days. Furthermore, foamed mortar specimen 2 (S-LN 0.75%) also experienced an increase in average compressive strength of 2.172% at 7 to 14 days of treatment and an increase in average compressive strength of 2.542% at 7 to 28 days of treatment. Another case with foamed mortar specimen 3 (S-LN 1.0%) also experienced an increase in average compressive strength of 3.054% at the age of 7 to 14 days of treatment and a decrease in average compressive strength of - 0.416% at the age of 14 to 28 days of treatment.

Figure. 6. Compressive Strength of Foamed mortar

It can be concluded that the addition of sikament-LN helps in increasing the strength of foamed mortar where the compressive strength results exceed the required (800 kPa). The addition of sikament-LN between 0.5-1% will increase the compressive strength value of foamed mortar where the results showed (Figure 5) while the addition of sikament-LN > 1% will reduce the compressive strength at the end of the treatment life (28 days) of foamed mortar this is due to sikment-LN reducing bubbles in the foam resulting in shrinkage of foamed mortar. The strength gain in foamed mortar is not very significant 1.781-3.054% is still far from 40% at 28 days of concrete age.

CONCLUSION

This research discusses the effect of variations in the addition of sikament-LN on the compressive strength of foamed mortar. Based on the results of the research conducted are as follows.

1. Each variation of sikament-LN addition (0.5-1%) increased the average compressive strength value of foamed mortar differently at each age of foamed mortar. The average compressive strength of foamed mortar at the age of 14 days increased significantly by 1.781-3.054% compared to the age of 7 days, while at the age of 28 days, the increase in the strength of foamed mortar was not very significant, only <1%.
2. The maximum dry compressive strength and density values were achieved at 28 days of curing and were successfully achieved by the foamed mortar at 841.667 kPa or 0.842 MPa (meeting the minimum compressive strength requirement at 14 days of age of 0.8 MPa). The highest compressive strength value of this foamed mortar is from the addition of 0.5% sikament-LN. Meanwhile, the average dry density of sikament-LN foamed mortar increased by 1.994% from 7 to 14 days of treatment and the average dry density increased by 4.044% from 7 to 28 days of treatment.
3. The addition of sikament-LN to foamed mortar is the most effective and optimum to be applied at a maximum rate of 0.5-1% by weight of cement because the average compressive strength of foamed mortar is higher than other sikament-LN variations. The addition of sikament-LN more than 1% causes the bubbles in the foam to burst, resulting in shrinkage of the foamed mortar.

REFERENCE

[1] Hidayat, D., Purwana, Y. M., & Pramesti, F. P. (2016). Analisis Material Ringan dengan Mortar Busa pada Konstruksi Timbunan Jalan. In *Seminar Nasional Sains dan Teknologi Universitas Muhammadiyah Jakarta 2016*.

[2] PU, K. (2011). Spesifikasi Material Ringan dengan Mortar Busa untuk Konstruksi Jalan.

[3] Susilowati, A., & Nabhan, F. (2021). Pengaruh Variasi Faktor Air Semen Terhadap Mortar Busa. *Journal of Applied Civil and Environmental Engineering*, *1*(2), 9. https://doi.org/10.31963/jacee.v2i1.2797

[4] Nudia, N., & Beladin, S. (2019). *Pengaruh Kadar Air Terhadap Kuat Tekan Mortar Busa Sebagai Material Konstruksi Jalan*. Politeknik Negeri Sriwijaya.

[5] Andika, Y., & Dimalouw, J. D. (2021). Pengaruh penggunaan sikament Ln terhadap pengurangan jumlah kadar air dan kuat tekan beton. *Jurnal Karkasa*, *7*(2), 54–61. https://www.poltekstpaul.ac.id/jurnal/index.php/jkar/article/view/422

[6] Hidayat, T. (2018). *Pengaruh Penambahan Zat Admixture Accelerator Beton Mix Terhadap Sifat-Sifat Mekanis Mortar Busa*. Universitas Majalengka.

[7] El Gamal, S. M., & Bin Salman, H. M. (2012). Effect of addition of Sikament-R superplasticizer on the hydration characteristics of portland cement pastes. *HBRC Journal*, *8*(2), 75–80. https://doi.org/10.1016/j.hbrcj.2012.09.001

[8] Sugiyono. (2018). Metode Penelitian Manajemen, Pendekatan: Kuantitatif, Kualitatif, Kombinasi, Penelitian Tindakan Kelas, Penelitian Evaluasi. In *CV. ALFABETA* (Vol. 6).

[9] PUPR, K. (2015a). *Pedoman Pelaksanaan Timbunan Material Ringan Mortar Busa untuk Konstruksi Jalan*.

[10] PUPR, K. (2015b). *Pedoman Perancangan Campuran Material Ringan dengan Mortar Busa untuk Konstruksi Jalan*.

[11] Bina Marga, D. J. (2017). *Spesifikasi Khusus Interim Material Ringan Mortar-Busa* (SKh-1.7.21).

[12] PUPR, K. (2015c). *Pedoman Spesifikasi Material Ringan dengan Mortar Busa untuk Konstruksi Jalan*.

[13] Iqbal, M. (2012). Kajian Penanganan Tanah Lunak Dengan Timbunan Jalan Mortar Busa. In *Pusat Penelitian dan Pengembangan Jalan dan Jemabatan, Kementrian Pekerjaan Umum. Bandung*.