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Estimation of Single Crop Co-Efficient for Wheat Crop Using Spectral Indices

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Abstract

The majority of the time, real crop water requirements are determined by combining references evaporation with crop coefficients. The crop coefficient accounts for plant transpiration and soil evaporation. The Kc values calculated with the lysimeter setup are point valued with no spatial fluctuation. Remotely detected spectral indices were used to estimate the crop coefficient in both space and time. As a result, this research was carried out to show that crop coefficients may be estimated using satellite data. The corrected satellite data for the research region were obtained/downloaded from the USGS website for the winter growing season (November to March). A hand-held GPS device was used to acquire ground truth valued. Plant heights of randomly selected plants were measured at 15 days intervals at the same time. The downloaded satellite data yielded two spectral indices: the Normalized Difference Vegetation Index (NDVI), and Soil Adjusted Vegetation Index (SAVI).to build relationships between Kc values and spectral indices, basic linear and multiple linear regression approaches were used kc and NDVI had a great individual relationship (R^2=0.92) and SAVI (R^2=0.79) while the combined association of NDVI and SAVI (R^2=0.94) was shown to be superior than each index's standalone relationship. These relationships should be used to determine Kc values for wheat grown in dry areas with plenty of water.

Keywords :
Actual Evapotranspiration, Crop Coefficient, Remote Sensing, Vegetation Index.

1. Introduction

The significance of water assets management is because of the increase of the population and water demand particularly in arid and semi-arid regions. These areas are under threat and will be under threat due to scarcity of water watershed in the future. Pakistan falls among the areas that are confronting intense water deficiencies. This is mainly due to the combination of determined less availability of water in the system, increase in water demand in irrigated agriculture sector and improper management of the water.Information on crop water prerequisites is a significant down to earth thought for structuring and overseeing water system frameworks (Dhotre et al., 2015). The water prerequisite fluctuates broadly from harvest to trim and furthermore during the time of development of individual yields. Consequently, estimation of yield water prerequisite considering the trimming design is a region of study, which needs the consideration of water assets organizers and repeating engineers.

Conservation and measurements of requirements for a specific usage are essential for effective utilizing of existing water sources. It is critical to assess the water requirements of the crop under investigation using a trustworthy appoarch in order to make the greates use of available water resources in the irrigated agricultural sector.

Several methodologies for measuring ETc based on combination of yield demonstrating and remotely detected data have been developed in recent decades. These methods range from simple onces like the vegetation index/ temperature trapezoid to more complicated land surface models (Haboudane, 2004). However, the infrequent recurrence of the required high- goals satellite information combined with the discontinuous nearness of cloud renders these techniques unappreciated for operational application (Er-Raki et al., 2010).

Crop coefficients kc were mostly determined by canopy dynamics (cover fraction, LAI, greenness). Remote sensing data may be used to assess various key-factors associated with vegetation phonology (Kiptala et al., 2018), which open up possibilities for determining the truth variation of kc. At field and regional sized, the use of remotely sensed vegetation records such as the Normalized Difference Vegetation Index (NDVI) and the soil Adjusted Vegetation Index (SAVI) has been used to anticipate crop related information

2. Methodology

2.1. Study Area

The study was conducted in the Khairpur district in northeastern Sindh province, surrounded by Shikarpur and Sukkur in the north, India in the east, Sanghar and Shaheed Benazeerabad in the south, and Larkana and Noshero Feroz in the west. The area is located at 68◦.741 longititude to 27.558 latitude. Most of the agricultural

land in the area is in the Indus Plain, which is irrigated by the Indus river. Khairpur is divided into eight talukas,namely Kingri, Khairpur, Kot Diji, Gambat, Sobho Dero, Thari Mirwah, Nara and Faiz Gunj.

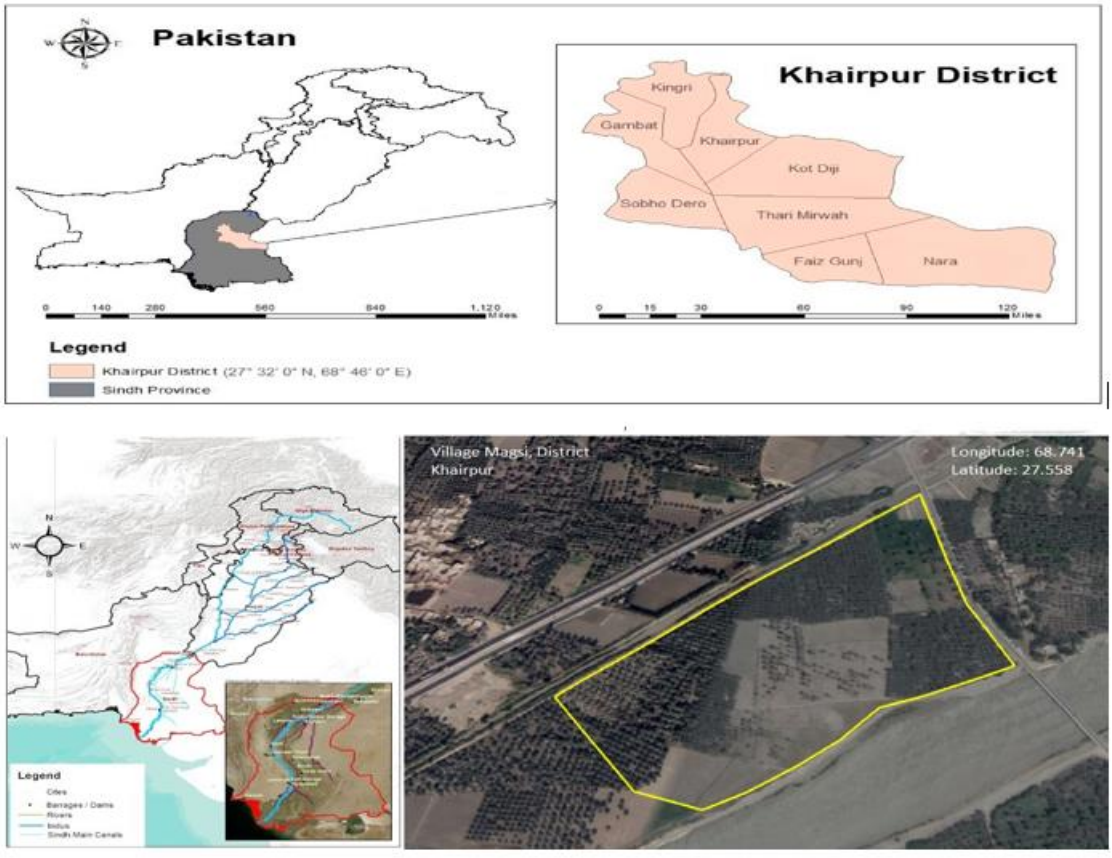

Figure 1. Map showing study area boundary (Village Magsi goth khairpur)

2.2. Data acquisition

For the last ten years, essential metrological data was gathered from Pakistan meteorological department (PMD). Relative humidity, wind speed, maximum temperature, and lowest temperature were all included in the data. PMD also provided crop coefficient for different growing phases of the wheat crop.

2.3. Satellite data

Correction were required. Landsat8 photos from different months (November to March) of 2021-2022 were acquired from the USGS website. The procedure for picture capture are illustrated in Figure 2 as a flow chart.

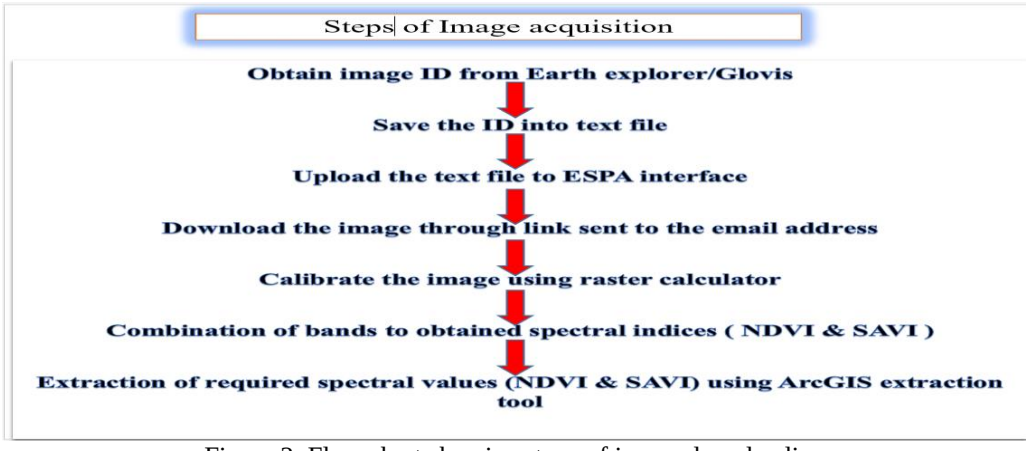

Figure 2. Flow chart showing steps of image downloading

2.4. Description of Indices

Two indices namely Normalized Difference Vegetation Index (NDVI), and Soil-Adjusted Vegetation Index (SAVI), were invoked and tested in this study.

2.5. Determination of Plant Height

With the use of a measuring tape and GPS device, the actual grid based plant height, as well as longitude and latitude, were recorded at 5m of intervals. The plant was branded with a permanent marker at the time of the initial recoding. Then just plant height data for the tagged plant was obtained.

2.6. Determination of Field data based Kc values

$$\mathbf{Kc\ stage(n)} = \mathbf{Kc\ stage\ (n)(tab)} + [\mathbf{0.04(u2-2)} - \mathbf{0.004(RH-45)}](\frac{\mathbf{h}}{\mathbf{3}})^{\mathbf{0.3}}) \quad (1)$$

The field-based Kc values for different growth stages of Wheat crop were determined using above equation:

Where,

$K_{cStage(n)\ (Tab)}$= crop coefficient values obtained from DRC for wheat crop

u_2 = the average wind speed [m/s].

RH_{min} = the usual minimum relative humidity [%]

h =the Plant elevation for each growth stage [m]

The average values of relative humidity and wind speed data was used. Kc values for different stages were obtained from PMD.

2.7. Assessment of relationship between vegetation indices and crop coefficients

To test the link between Kc values and spectral indices, the coefficient of regression equation were assessed

$$Kc = \alpha + \beta \times NDVI$$
$$Kc = \alpha + \beta \times SAVI$$

2.8. Validation

Following criteria were used to validate newly developed equation. When values of these two criteria are minimum it means tested models are good

Root Mean square error

$$\text{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(\text{Oi} - E_i)^2}$$

Where,

n = Total numbers (Observations)

Oi = Field based observed Kc value

Ei = Estimated Kc value

BIAS

$$\text{BIAS} = \frac{\sum_{i=1}^{n}(\text{E}_i - \text{Oi})}{\sum_{i=1}^{n}\text{Oi}}$$

Where,

n = Total numbers (Observations)

Oi = Field base observed Kc value

Ei = Estimated Kc value

3. Results and Discussion

The pertinent data obtained and collected for assessing spectral indices are present in Table 1. The plant height ranged from 30 to 86 cm. The Kc values obtained from DRC varied from 0.33 to 1.15 for different growth stages. The calculated/actual Kc values ranged from 0.348 to 1.146. The maximum values for temperature, relative humidity, wind speed, and sun shine hours were in the order of 33.12 °C**,** 43.96%, 1.364 m/s and 9 hours for different growing stage

Table 1. Average values of crop coefficients, plant height and pertinent climatic data

Kc (Table)	Plant Height (cm)	Temp (min℃)	Temp (max℃)	RH (%)	Wind speed m/s	Sun Shine (hr.)	Kc (Cal)	Stages
0.7	30	18.98	30.63	37.73	0.718	8	0.688	Initial
0.7	33.5	14.54	25.36	41.15	0.701	9	0.681	Initial
1.15	66	12.23	23.42	43.96	1.054	9	1.128	Mid
1.15	73	13.25	23.97	38.06	1.185	8	1.146	Mid
0.33	86	19.21	33.12	31.95	1.364	9	0.348	Final

3.1. Evaluation of connection between NDVI and single yield coefficient.

The result regarding relationship of NDVI and single crop coefficients are portrayed in and table-2. The Developed relation is presented as chart-1 for three growing stages namely; Initial stage, mid stage and late stage.

Table.2: Relation between single crop coefficient (Kc) with NDVI

Initial Stage	Middle Stage	Late Stage
$R^2 = 0.85$	$R^2 = 0.94$	$R^2 = 0.92$

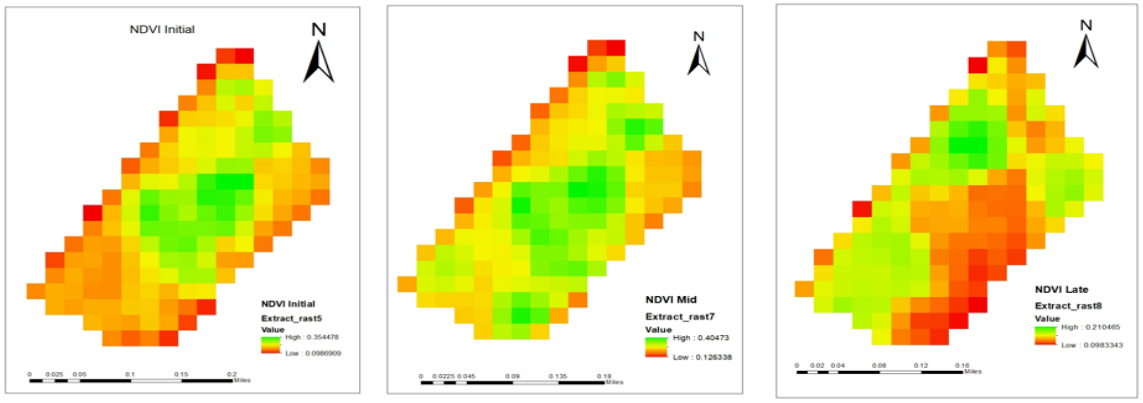

Figure 3. NDVI maps of Wheat crop during growth stages namely initial mid and Late

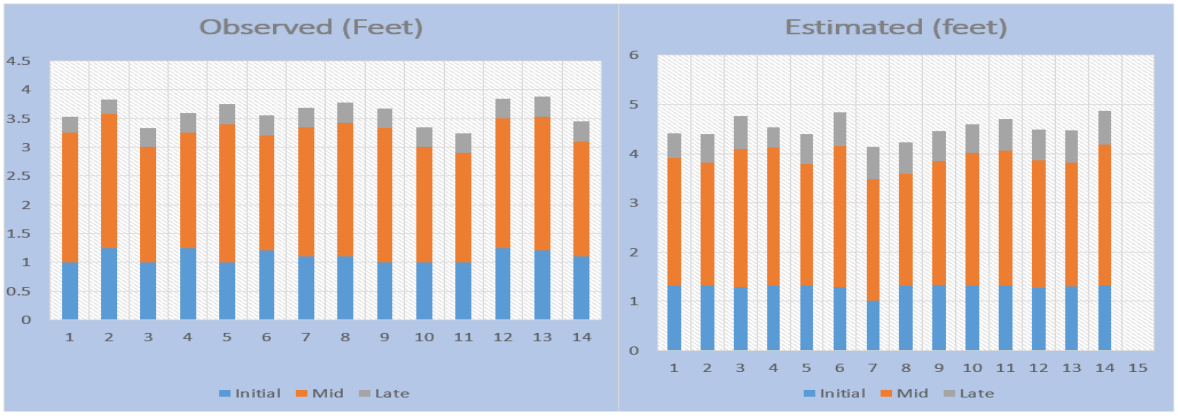

Figure 4. Statically criteria for evaluation relationship of NDVI Chart-1

There is a substantial association between NDVI and single crop coefficient, as evidenced by the R^2=0.92 value, indication that NDVI is responsible for 92 % of the variance in kc values across stages.

It can be shown that the constructed equation performed well when compared to benchmark values, with decreased bias 11% and inaccuracy 0.0083.

3.2. Evaluation of connection among SAVI-1 and single yield coefficient.

The result regarding relationship of SAVI and single crop coefficients are portrayed in and table-3. The Developed relationis presented as chart-2 for three growing stages namely; Initial stage, mid stage and late stage.

Table 3. Relation between single crop coefficient (Kc) with SAVI-1

Initial Stage	Middle Stage	Late Stage
$R^2 = 0.79$	$R^2 = 0.75$	$R^2 = 0.77$

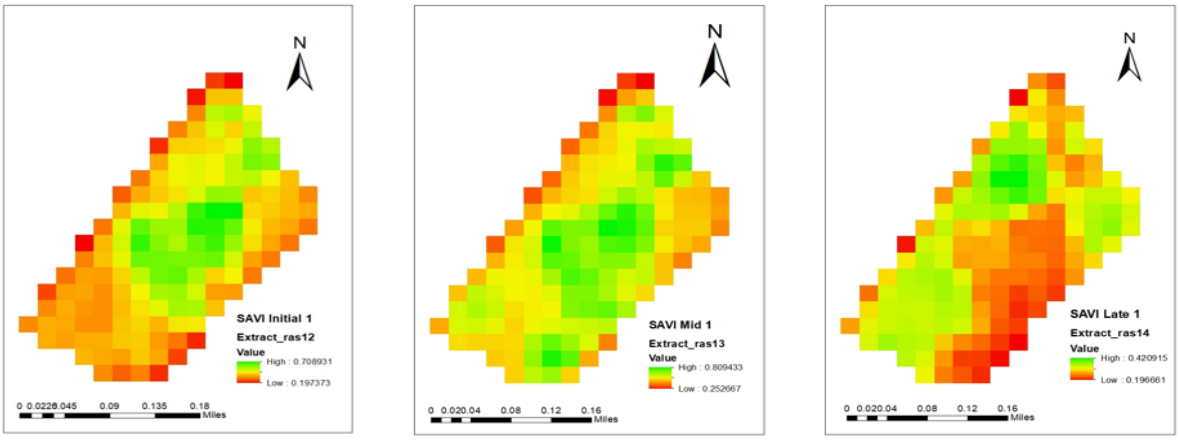

Figure 5. SAV-1 maps of Wheat crop during growth stages namely initial mid and Late

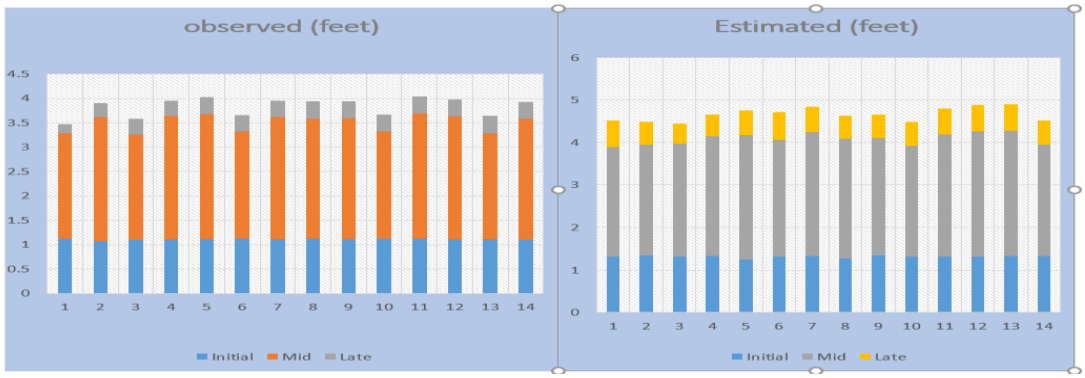

Figure 6. Statically criteria for evaluation relationship of SAVI-1 Chart-2

A substantial association between SAVI-1 and the single crop coefficient, indicated by the R^2=0.79 value Obliquely at table-3, and chart-2 show that equations provided good predictions when compared to bench marks values,with less bias 10% and error 0.009.

3.3. Evaluation of connection among SAVI-0.5 and single yield coefficient

The result regarding relationship of SAVI and single crop coefficients are portrayed in and table-4. The Developed relations presented as chart-3 for three growing stages namely; initial stage, mid stage and late stage.

Table 4. Relation between single crop coefficient (Kc) with SAVI-0.5

Initial Stage	Middle Stage	Late Stage
$R^2 = 0.83$	$R^2 = 0.81$	$R^2 = 0.78$

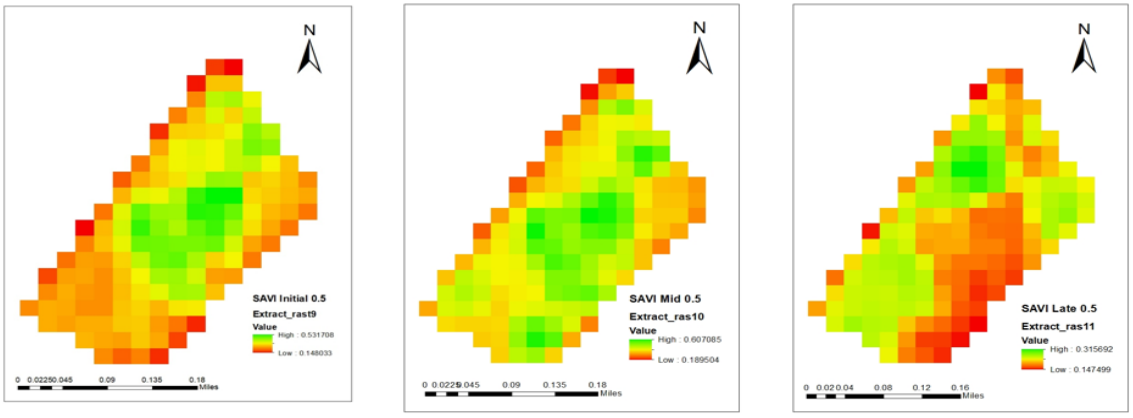

Figure 7. SAVI-0.5 maps of Wheat crop during growth stages namely initial mid and Late

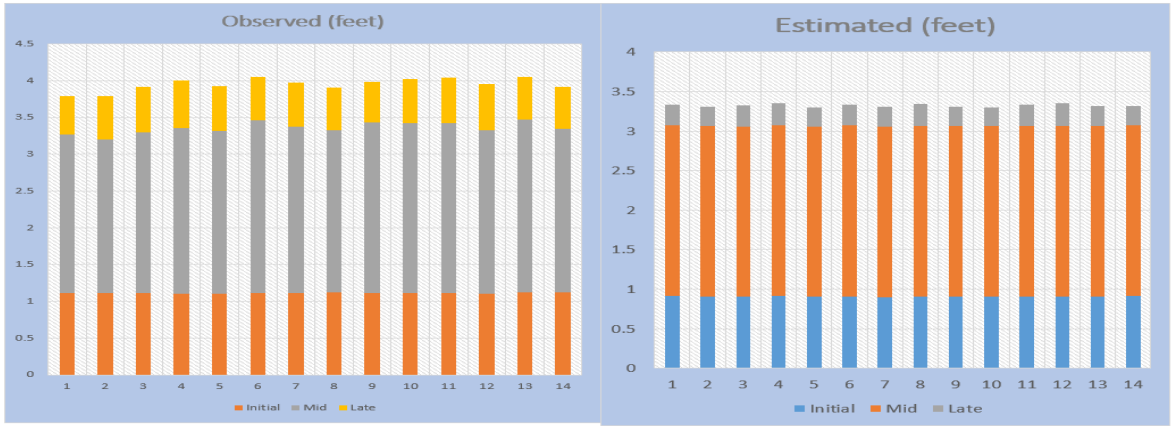

Figure 8. Statically criteria for evaluation relationship of SAVI-0.5 Chart-3

The R2=0.83 result indicates that there is a strong association between SAVI-0.5 and single crop coefficient, shows that the recognized equations performed well in comparison to then bench mark values, less bias 10.5% error 0.0019.

3.4. Assessment of integrated usage of spectral indices for estimating crop coefficient

The relevant result of relationship between various spectral indices NDVI and SAVI-1) and single crop coefficients. The developed relation is reachable as Table.5 for three growing stages namely; Initial stage, mid stag and late stage

Table 5. Relation between single crop coefficient (Kc) with NDVI& SAVI-1

Initial Stage	Middle Stage	Late Stage
$R^2 = 0.82$	$R^2 = 0.89$	$R^2 = 0.87$

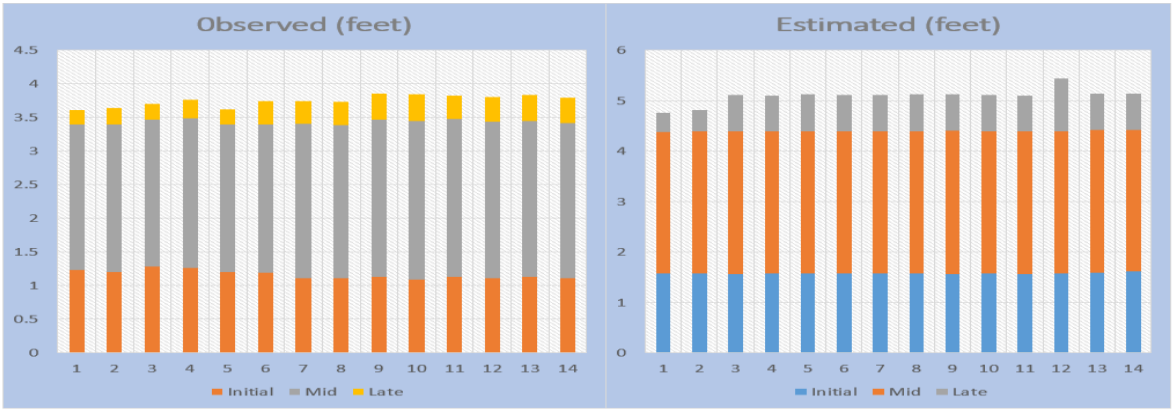

Figure 8. Statically criteria for evaluation relationship of NDVI & SAVI-1 with crop Coefficient chart-4

It is clear that there is a strong relationship between NDVI,SAVI-1 and single crop coefficient, as evidenced by R^2=89 value show that the recognized equation performed well in comparison to the benchmark values with decreased bias 10% and error 0.205.

3.5. Assessment of integrated usage of spectral indices for estimating crop coefficient

The relevant result of relationship between various spectral indices NDVI and SAVI-0.5 and single crop coefficients. The developed relation is reachable as Table.6 for three growing stages namely; Initial stage, mid stag and late stage

Table 6. Relation between single crop coefficient (Kc) and NDVI & SAVI-0.5

Initial Stage	Middle Stage	Late Stage
R^2 = 0.90	R^2 = 0.92	R^2 = 0.94

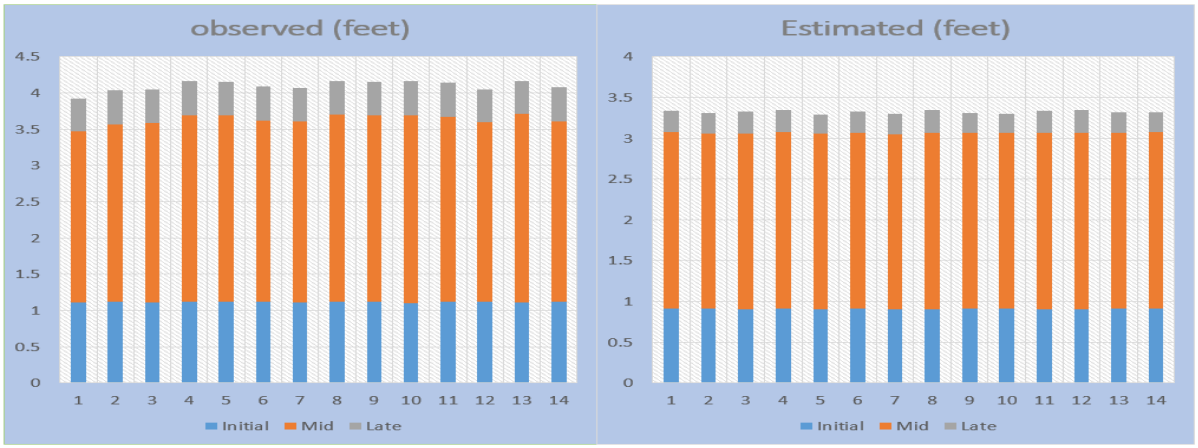

Figure 9. Statically criteria for evaluation relationship of NDVI and SAVI-0.5 with crop Coefficient chart-5

Show that there is astrong association between NDVI and SAVI-0.5 and single crop coefficient, as evidenced by R^2=94 value. It show that the recognized equation performed well against bench values, with decreased bias 12% and error 0.71.

4. Conclusion

This study demonstrated that remotely sensed data can be used to estimate crop coefficients. The method of finding the crop coefficient (Kc) based on (NDVI) and (SAVI) is an effective approach to do so. It is a simple compared to other methods for determining (Kc), such as field methods or relying on FAO publications It is concluded that the kc values and individual spectral index have a strong link. Based on the finding, it can be concluded that the variation in kc values is batter explained by the combined use of spectral indices than by the separate application of spectral indices For wheat crop, the association between NDVI and Kc values is shown to be more significant than the relationship between NDVI and SAVI.

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Study of Agung Sleman Mosque Minaret Construction Design: Errors and Solutions

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Abstract

This study helps to solve the problem at the minaret of Agung Mosque which costs about (Rp16.000.000.000), located in Yogyakarta city, Indonesia, Sleman street, where its high sixty seven meters from the ground and it consists of fifty floors, where analyze and prove the safety of the minaret dome, replace the dome, repair the fallen parts from middle floors, and calculate the total cost of replacing the dome and repairing fallen parts of the minaret. This study proved that the existing design reinforcement of the dome is totally safe, estimated the total cost of solving the minaret problems which (Rp2, 281,873,633.54). Where the total costs of replacing the dome were (Rp2, 073,135,813), the total costs of fixing the damaged "fallen" parts of the middle floors were (Rp1, 294,762.24), and the total of the unexpected costs were (Rp207, 443,057.59)

Keyword:
Design, Dome, High Construction, Minaret

1. Introdution

The minaret in Arabic, it is a word derived from the verb "Adhan". This means a tall tower that is attached to mosques and is designed to convey the sound of the call of prayer people and call them to pray. In English, it's a tall slender tower, typically part of a mosque, with a balcony from which a muezzin calls Muslims to their prayers.

1.1. History of minaret:

Many different theories about the origin of the minaret and it is historically confirmed that after the completion of the construction of the Almasjid Alnabawii Alsharif, the muezzin of the prophet Bilal bin Rabah had to climb one of the closest and tallest houses near from the mosque to bring his voice to the inhabitants of "Medina", From that moment on all history of Islam, the idea crystallized to expand the scope of this spiritual voice crystallized, the core of the idea was based on the fact the higher the person lifts off the ground, the greater the sound dispersion of his voice. (Ibrahim, 2022)

1.2. The minaret geometrically:

Architectural and engineering composition of the lighthouses is summed up in a square body that rises from the building of the mosque; this style was transferred to the Maghreb and the countries of Andalusia, and it was developed starting from the sixth century hijra and the design of the minarets differed with the passage of time and the different Islamic cities, the minaret, regardless of its location in the mosque, consists of an entrance that is inside the courtyard and then the ascent staircase, which is usually an internal spiral that revolves around the axis of the minaret, and reaches the high balconies that surround the body of the minaret. (Tarchaoui B. , 2017).

This study uses the descriptive approach where data, conclusions, and hypotheses are collected and tested to arrive at engineering solutions that help to solve the problem of the Agung Sleman Mosque minaret, through questions and inquiries, and meetings with both the project manager and supervisors, and the company who build this project which Dinas Pekerjaan Umum, Perumahan, dan Kawasan Permukiman company in Yogyakarta city, Indonesia, and through the database, designs and the blueprints for the project that obtained by the researcher from the construction company that own the minaret project officially.

2. Literature review

This study differs from previous studies many faces, namely in the total project cost of the project, the type and amount of materials used in the construction of the minaret of Agung Sleman Yogyakarta Mosque minaret, The massive weight of the dome, and the high altitude of this minaret that topped by the iron dome, also the time during which the investigation was carried out between 2021 - 2022. The terms of the minaret age, the construction was completed in 2018 and the technical problems and errors appeared in 2021.

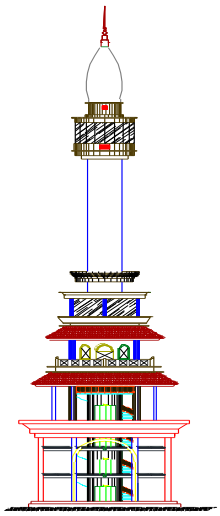

Figure 1. Agung Sleman mosque minaret construction design. (Mulia, 2017)

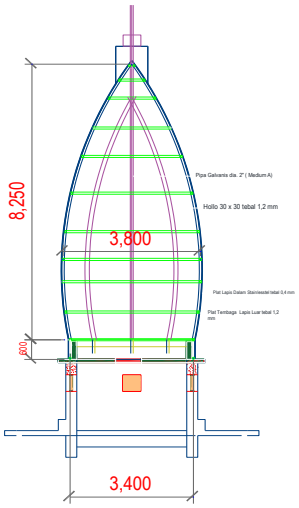

Figure 2. Agung Sleman mosque minaret dome construction design. (Mulia, 2017)

1. Based on (Asaad Alomari et al.2020), Calculate the bearing capacity of Al-Hadba minaret foundation, the elements of the permissible soil bearing capacity of the minaret foundation are analyzed. It is assumed that the foundation rests on the clay layer at a depth of 9 m, the square base is 15 x 15 m, the internal friction angle φ = 29 degrees, and cohesion c = 21 kPa. The stresses were reduced along the southeast corner of the minaret foundation from 761 kPa to 561 kPa for normal soils.
2. Based on (Zerari Sami et al. 2020), highlight the formal and stylistic features of the columns on the basis of the minarets selected in chronological order. The main criterion for classifying minarets according to their morphological features is the formation of the column, whether it is pyramidal, prismatic, and conical or hybrid.
3. Based on (Mohammed Alajmi et al. 2022), analyze the hierarchy of the minaret section according to different design patterns. The tall, towering minarets are often preserved because they are a direct result of the mosque's size. The column and the base are the two most important elements in the architecture of minarets.
4. Based on (Asaad Al-Omari et al. 2021), reconstruction of the missing parts, as the dome was destroyed, but the minaret is still standing. Debris of the original brick material was collected (the dome and part of the cylindrical body of the minaret) near the minaret, reused by crushing and reshaping to create new molds in the same shape as the original bricks.
5. Based on (Wulan Astrini et al. 2019), observation, collection of primary data, to test theories by examining relationships between variables. The minaret of the Sabilillah Malang Mosque is about 45 meters high, the minaret is divided into two parts: The body and the top of the minaret. The body is hexagonal in shape, 38 meters high. In the body there are four rectangular slots on each side and are arranged vertically.

6. Based on (College of fine arts, University of Baghdad, Iraq. 2018), Find the collection of stalactites in the minaret of a mosque (Alkhalafaa). The stalactites of the minaret begin in a decorative line with brick paving where they protrude like a rope twisted between the circle of the basin and the trunk of the minaret.
7. Based on (Muhammad Fatih et al. 2019), the actual function of the minarets and their suitability to the current architecture. The minaret exists only as an aesthetic sight as a unit in the design philosophy of the entire mosque complex and minarets are present in contemporary mosques necessarily to serve functional needs.
8. Based on using a series of 16 small arches to construct the inner dome in the style of "mold". The Kallon Minaret was built in 1127, which is topped by a high dome.
9. Based on (Pinar Usta. 2021), the preserve historical building minarets and pass them on to future generations by performing finite element modeling and linear dynamic structural analyzes of Antalya Kesik Minaret. Antalya Kesik Minaret has the lowest displacement value due to the absence of the upper part of it. Yivli Minaret was the least affected by pressures due to its different thick structure.
10. Based on (Safaeianpour, Ali et al. 2022), modify the dimensions and shapes of the bricks to form trapezoidal shapes. Several tire belt training sessions that contain different gear patterns. This study provided new interpretations regarding practical solutions to implement girih patterns on the curved surface of the Minaret, as reducing the distance between the bricks helped to maintain the engineering integrity to a large extent.
11. Based on (Ashadi, Ashadi. 2021), interpreting the results of the comparison on how the process of architectural acculturation occurs. The construction of the Kudus Minaret is a cultural product between the Hindu culture represented by the building of the temple, and the Javanese culture represented by the crown building, and Islam represents the function of the call to prayer among these three elements.
12. Based on (Mohammad, Arif, Kamal. 2021), Review the different functional aspects of minarets and their evolution in history. Islamic architecture entered northern India who used to construct minarets as symbolic elements in buildings from Persia through Afghanistan via the Turks. The minaret has become a symbol of Islamic architecture, whether used separately or attached to the mosque.
13. Based on (Kimence, Bahattin. 2020), modeling of two types of minarets, similar to the properties and their contrast, according to the height of each, so that the ratio of the thickness of the mortar to the total thickness is 0.6 and 0.2. Period, horizontal displacement of minarets, characteristic model and فـhe anisotropic models are very close to each other. The anisotropic effect of the solution increases with increasing thickness of the slurry.
14. Based on (Sahar, Diab. 2020), Creating a new function for the minaret to give it a contemporary look in line with contemporary technology. Developing legislation and orientation to modernity and using modern technology to formulate the new features of minaret architecture. Government agencies collaborated with designers to come up with a mature architectural form for mosque architecture, minarets to break out of the traditional design.
15. Based on (Farhana Binti Safar, et al. 2021), analyze the building plan by identifying the entry point and movement pattern. Observe and identify architectural elements that portray the usage of natural elements. The roof is supported by four columns in the middle of the mosque creating a large indoor space - for warm air to ventilate upwards to the upper level. The minaret built of bricks and shaped like a pagoda within the mosque complex.
16. Based on (Holik A.A.R et al. 2017), collecting data on mosque architecture using field observation for mosque architecture. The minaret is designed in harmony with the building, the materials made of Karawangan, the simple design without any frills, and the simple shape, the presence of the minaret expands the sound of the call to prayer.

3. Research Method

Gathering the greatest amount of data and information about the problem, developing hypotheses or questions conjecturing solutions to the problem given it, providing explanations and performing statistical analysis, extracting conclusions and clues, and testing hypotheses to ensure their reliability or not using descriptive method. This study was completed in Yogyakarta city, Indonesia, street of Parasamya, Beran Lor, Tridadi, Kec. Sleman, Kabupaten Sleman, Daerah Istimewa 55511. This study was completed during the years 2021- 2022, starting in December and ending in April.

1. Getting the permission from the director of the masjid Agung Sleman minaret project, during the researcher requests a research permit and a university ethical letter.
2. Field visit to the engineering company specialized in building the minaret and requesting references, books and final reports for the construction of the minaret.
3. The field visit to the minaret project site and request permission from the project supervisors.
4. Obtaining official permission and permits from the engineering company, and the project manager and supervisors.

5. With the help of the project manager, the researcher searches and collects data from records of the construction of minarets in the same city, recording data and observations by age, height, location and materials used in construction.
6. The researcher categorizes the obtained data according to meeting the required criteria.
7. The researcher investigates the appropriateness of the quality of the materials used in the construction of the minaret according to both the American and the Indonesian engineering cod.
8. The researcher is investigating the accuracy of the engineering designs that were used in the construction of the minaret in general and the dome of the minaret in particular.
9. The researcher extracts engineering errors that occurred during the construction process, which are summarized in the weight of the dome of the minaret and the difficulty of lowering it and installing new ones, which prove the safety of the dome, the thickness of dome plate and the fallen parts at the middle floors.
10. The researcher presents the results sequentially and in conformity with the engineering standards.
11. The researcher presents suitable solutions for the restoration and repair of minaret Masjid Agung Sleman Yogyakarta.

4. Finding And Discussion

1. Structural analysis of a concrete plate exposed to the pressure of the dome of the minaret and proof of its safety.

a. calculation of dome plate and the body mass

1) Based on the calculations of dome plate load and the body mass, using the materials, galvanized pipe, hollow steel, stainless plate, and copper plate. Through the calculation of each of density, area, coefficient ratio, thickness and the volume the data was taken from the minaret reports. Results showed that the dome weight (Total body mass) is equal to (1019.13 kg/m^3).

2. The strength of the plate concrete base under the pressure of the dome, through assuming that the data design of the dome plate structure is a rectangle shape each of the following should be calculated:

a. Dome plate concrete dimensions

Based on the (Mulia, 2017), plate dimensions are 4.7m for the length, 2.2mofr the width and 10cm for the thickness.

b. Dome plate concrete strength

Based on the (Mulia, 2017), plate concrete strength is 14.99 Mpa.

c. Dome plate concrete steel type

Based on the (Mulia, 2017), the plate concrete steel type should be (BJ 37).

d. Dome plate concrete moment calculation

Based on the calculations and by dividing (ly/lx). Results showed that (ly/lx) is equal to 2.136363636, where ly is the length and lx is the width of the dome plate concrete. Through the moment calculations in the table of (Mlx) and (Mly) above. Results showed that Mlx equal to 91 and Mly equal to 17, where (Mlx) or indeed (-Mtx) is the moment at join of the plate and (Mly) is the moment in the middle of plate.

e. Dome load

Based on the (Mulia, 2017), the dome load should be equal to 1019.128842 kg/m^2.

f. Dome plate concrete area

Based on (Chair & Secretary, 2018), the formula to find the area is $A = \pi X (R^2-r^2)$. Where (A) is the area, (π) equal to 3.14, (R^2) is the radius of the circle, r^2 is the diameter of the circle. Based on the calculations. Results showed that (A) is equal to 9.550441667 m^2, where(R) is equal to 2.3, (r) is equal to 1.5.

g. Dome plate concrete dead load

Regarding on the (Mulia, 2017), and the soft drawings the plate dead load should be equal to 2400 x 0.1, and it could be 240 kg/m^2.

h. Area load of dome plate

Based on (Chair & Secretary, 2018), 2018, the formula to find the area load of dome plate is (q) and it's equal to (dome weight) $\div \pi \times (R^2-r^2)$, which actually could be (The load of them / Area), and the load of the dome is equal to 1019.128842 kg/m^2 as the calculation showed before and (Area) where indeed it's $\pi \times (R^2-r^2)$, and equal to 9.550441667 m^2,as the calculation showed before. Results showed that area load of dome plate is equal to 106.7101269 kg/m^2, and through collecting the area load of the dome plate + Dead load of the plate the, results showed that final area load of dome plate is equal to 346.7101269 kg/m^2.

Regarding to Source: (ITS, 2002), the moment in a rectangular slab table and by calculating (Mlx) where the moment in a rectangular slab of (Mlx) is (0.001) multiplied with the (Area load dome plate) which equal to 346.7101269 kg/m^2, and multiplied with the (width of the dome plate) which equal to (2.2m) and multiplied with the moment in a rectangular slab table of (Mlx) that equal to (0.001) which equal to (91), results showed that (Mlx) is equal to 152.7050083 kgm, and by calculating (My) where the moment in a

rectangular slab of (Mly) is (0.001) multiplied with the (Area load dome plate) which equal to 346.7101269 kg/m^2, and multiplied with the (length of the dome plate) which equal to (4.7m) and multiplied with the moment in a rectangular slab table of (Mly) that equal to (0.001) which equal to (17), results showed that (Mly) is equal to 130.200054 kg/m.

i. Reinforcement ratio

Based on (SNI - 1729:2015), the formula to find the ρmin is (ρmin is equal to 1.4/fy), where (fy) is the type of the steel which (BJ37), through the calculation, Results showed that ρmin is equal to 0.005833333.

j. (ρmin) and (ρmax), calculation

Based on (ITS, 2002), the formula to find the (ρmax) is (ρmax) equal to 0.75 multiplied with (β) multiplied (fc') and divided by (240Mpa), multiplied with 0.85, and multiplied with (600) that divided by (600) plus (240Mpa). Where the (ρmax) is equal to 0.75 multiplied with 0.85 which the (ρmin), multiplied with the concrete strength which (fc') and its equal to 14.99, divided by (fy) which the type of the steel which (BJ37), and it's equal to 240Mpa, multiplied with 0.85, multiplied with (600) that divided by (600) plus 240 Mpa. Results showed that the (ρmax) is equal to 0.024174721.

k. (d), calculation

Based on the calculation (d) is the effective height and its equal to (0.07m). Where (d) is equal to (The thickness – the diameter of steel reinforcement – the specification), which would be (10 – 2 – 1) and it's equal to (7cm) and by changing from (cm) to (m) it's going be (0.07m).

l. (b), calculation

Based on the (Mulia, 2017), (b) is the beam width and its equal to 1000mm, and by changing from (mm) to (m) it would be (1m).

m. (***Φ***), calculation

Regarding to the calculation (***Φ***) should be (0.8). Where (***Φ***) equal to the total of (d), which the effective height plus (b), which the beam width and it's going equal to 0.007, and by approximate (0.007) it would be (0.8).

n. Calculate of ultimate moment in the middle of the plate

Based on (PBI-1971 & SNI 2847-2002), where (Mlx) is the moment at join of the plate and (Mly) is the moment in the middle of plate. Mu is equal to (- Mtx) where its means (Mlx) and it's equal to 152.705 kgm. Regarding to the calculation of (Mlx) above where (Mlx) = (- Mtx) = 152.7050083 kgm.

o. (Rn), calculation

Based on (SNI - 1729:2015), where (Rn) is equal to (Mu) divided by Φ which the total of (b) and (d), multiplied with (b) which the beam width, and multiplied with (d^2) which the effective height and through the calculation it's equal to 38955.359 kg/m^2, which actually equal to 0.53 Mpa by changing from kg/m^2, to Mpa.

p. (ω), calculation

Based on (SNI - 1729:2015), where (ω) is equal to 0.58 multiplied with (1 subtracted from the root of 1 subtracted from 2.353 multiplied with (Rn) which equal to 0.53 Mpa and divided by (fc') which equal to 14.99 Mpa. Through the calculation, results showed that (ω) is equal to 0.0361.

q. using ρmin for design

Based on (SNI - 1729:2015), where (ρ) is equal to (ω) which is equal to 0.0361, multiplied with (fc') which is the concrete strength, and divided by (fy) which is the steel type of (BJ37). Through the calculation (ρ) is equal to 0.00226 which is bigger than (ρmin) which is the minimum generator power, where it's equal to 0.00583.

r. Using ρmin for design to calculate (As)

Based on (SNI - 1729:2015), where (As) is equal to (ρmin) which is the minimum generator power, where it's equal to 0.00583, multiplied with (b) which the beam width, and multiplied with (d) which is the effective height and through the calculation. (As) is equal to 0.000408333m^2, and by changing from m^2 to mm^2 it would equal to 408.3333333 mm^2.

3. The existing design is using steel reinforcement diameter 10 mm with distance 150 mm

s. Calculate the existing design using steel reinforcement diameter (10 mm) with distance (150 mm), area of steel diameter (10 mm) which equal to (78.53981634 mm^2), total steel need where it's equal to (5.199061474), distance steel reinforcement which equal to (192.3424074 mm). Through the calculations above the existing design reinforcement is totally safe.

4. Analysis the total cost of replacing the dome of minaret masjid Agung Sleman Yogyakarta and the damaged parts of the middle floors of the minaret.

t. Preparation work

Based on the (Mulia, 2017), the preparation work types that should be done during this study are: clearing the land, mobilization, and disposal. Through the calculation, result showed that the total cost of clearing the land is (Rp2, 000,000), mobilization total cost is (Rp30, 000,000), and disposal total cost is (Rp2, 000,000). Therefore the total cost for preparation work is (Rp34, 000,000).

u. Dome slab concrete work using concrete type of (fc = 14.5 Mpa) for each (1m^3) and labor cost calculation

Based on the (Mulia, 2017), one of the dome slab concrete work types using concrete type of (fc = 14.5 Mpa) for each (1m^3) that should be done during this study is labor cost which contains collection of works such as: Worker, craftsman, and foreman. Through the calculations, result showed that the total cost for Workers is (Rp25, 928.57), craftsman total cost is (Rp4, 821.43), and foreman total cost is (Rp1, 660.00). Therefore the total cost of labor cost is (Rp32, 410.00).

v. Dome slab concrete work using concrete type of (fc = 14.5 Mpa) for each (1m^3) and material cost calculation

Based on the (Mulia, 2017), one of the dome slab concrete work types using concrete type of (fc = 14.5 Mpa) for each (1m^3) that should be done during this study is material cost which contains collection of works such as: Ready concrete mix K-175, steel, begistis plate and scaffolding, and unload formwork. Through the calculations, result showed that the total cost of ready concrete mix K-175 is (Rp791, 972), the steel total cost is (Rp737, 820), and begistis plate and scaffolding total cost is (Rp2, 427,210), and unload formwork total cost is (Rp103, 950). Therefore the total cost of the material cost is (Rp4, 060,952).

w. Dome slab concrete work using concrete type of (fc = 14.5 Mpa) for each (1m^3) and equipment cost calculation

Based on the (Mulia, 2017), one of the dome slab concrete work types using concrete type of (fc = 14.5 Mpa) for each (1m^3) that should be done during this study is equipment cost which contains collection of works such as: Concrete vibrator, concrete pump, and the device. Through the calculations, result showed that the total cost of concrete vibrator is (Rp1, 000,000), concrete pump total cost is (Rp5, 000,000), and (Rp500, 000). Therefore the total cost of the equipment cost is (Rp6, 500,000).\

Based on the calculations for each of labor cost, material cost, and equipment cost, results showed that the total cost for the dome slab concrete work types using concrete type of (fc = 14.5 Mpa) for each (1m^3) is (Rp10,593,362).

x. Dome replacing work

Based on the (Mulia, 2017), the dome replacing work types that should be done are: Crane mobilization and demobilization, crane rental, steel work, and welder. Through the calculation, result showed that the total cost of crane mobilization and demobilization is (Rp8, 000,000), crane rental total cost is (Rp279, 730,000), steel work total cost is (0), and welder total cost is (Rp386, 285.71). Therefore the total cost of dome replacing work is (Rp288, 116,285).

y. Dome lighting and finishing works

Based on the (Mulia, 2017), dome lighting and finishing works types that should be done are: Special panel sport lamp and tovur cable, spotlight high (CR; COB 30 watt 2700K 23 IP65), Lummens (21001m) and cable installation (Zone), Ledstnpught (26 watt/ meter 2700K 90 IP65 24V) and cable installation (Zone 2), Ledstripught (26 watts / meter 2700K 90 IP65 24V) and cable installation (Zone 3), Stripught (24V) Led Driver (320 watt 13.4A IP65) and cable installation (Zone 2&3), Ledspot Rgb (40 Chips-14R, 14G, 128 - 115 watts 15), rgb spot led (40 Chips-14R, 146.128 115 watt 45 IP66 220V) and cable installation (Zone 4), Rgb controller compatible with Led spot rgb (40 Chips-14R, 146.128), led wall washer (20 watt 9x multichip rgbw 30' IP66 220V) and cable installation (Zone 5), rgb controller compatible with led wall washer (20 watt 9xMultichip), led stripught IQ watts/meter rgb (IP68 24V) and cable installation (Zone 6), rgb controller compatable with led stripught (10 watt/ meter), 24V 150 watt IP65 driver + cable installation (Zone 6), Zone 2 and 3 Installation -strip light, Zone 2 & 3 Installation – Driver, (AM724T) Zone 4 Installation, Zone 4 Installation and (CMX), Zone 5 Installation (graze 9Q AM711 CAT), Zone 5 Installation and (CM), Zone 6 strip light rgb Installation, Zone 6 Installation and DMX, Zone 6 Installation and driver, and Old MX custom panel box Installation.

Through the calculation, result showed that the total cost of Special panel sport lamp and tovur cable is (Rp19, 250,000), spotlight high (CR; COB 30 watt 2700K 23 IP65), Lummens (21001m) and cable installation (Zone) total cost is (Rp79, 200,000), Ledstnpught (26 watt/ meter 2700K 90 IP65 24V) and cable installation (Zone 2) total cost is (Rp18,425,000), Ledstripught (26 watts / meter 2700K 90 IP65 24V) and cable installation (Zone 3) total cost is (Rp18,425,000), Stripught (24V) Led Driver (320 watt 13.4A IP65) and cable installation (Zone 2&3) total cost is Rp8,613,000, Ledspot Rgb (40 Chips-14R, 14G, 128 - 115 watts 15) total cost is (Rp230,560,000), rgb spot led (40 Chips-14R, 146.128 115 watt 45 IP66 220V) and cable installation (Zone 4) total cost is (Rp228,800,000), Rgb controller compatible with Led spot rgb (40 Chips-14R, 146.128) total cost is (Rp15,290,000), led wall washer (20 watt 9x multichip rgbw 30' IP66 220V) and cable installation (Zone 5) total cost is (Rp71,016,000), rgb controller compatible with led wall washer (20 watt 9xMultichip) total cost is (Rp7,782,500), led stripught IQ watts/meter rgb (IP68 24V) and cable installation (Zone 6) total cost is (Rp19,580,000), rgb controller compatable with led stripught (10 watt/ meter) total cost is (Rp1,320,000), 24V 150 watt IP65 driver + cable installation (Zone 6) total cost is (Rp5,115,000), Zone 2 and 3 Installation -strip light total cost is (Rp20,676,100), Zone 2 & 3 Installation – Driver total cost is (Rp546,150), (AM724T) Zone 4 Installation total cost is (Rp6,387,648), Zone 4

Installation and (CMX) total cost is (Rp19,680,022), Zone 5 Installation (graze 9Q AM711 CAT) total cost is (Rp2,789,024), Zone 5 Installation and (CM) total cost is (Rp9,584,811), Zone 6 strip light rgb Installation total cost is (Rp827,044,000), Zone 6 Installation and DMX total cost is (Rp9,136,011), Zone 6 Installation and driver total cost is (Rp819,225), old MX custom panel box Installation total cost is (Rp1,200,000). Through the calculations, results showed that the total cost of dome lighting and finishing works is (Rp1, 621,239,491.00).

z. Peel coating finishing work

Based on the (Mulia, 2017), peel coating finishing works types that should be done are: Dome coating finishing, and enamel and galvalume cross 20 - 25. Lightweight steel frame. Through the calculations, results showed that the total cost of enamel and galvalume cross 20 - 25. Lightweight steel frame is (Rp117, 036,675). Therefore the total cost of peel coating finishing works is (Rp117, 036,675).

1. Dome upholstery finishing works

Based on the (Mulia, 2017), dome upholstery finishing works type that should be done is: Finishing of the dome coating of lightweight enameled iron and galvalume cross 20-25 cm. Through the calculations, results showed that the total cost of dome upholstery finishing work is (Rp117, 036,675). Therefore the total cost of dome upholstery finishing work is (Rp2, 073,135,813).

2. Fixing the damaged part of the middle floors Plafond ceiling repair of (IV), and (V) Floors
   1) Based on the (Mulia, 2017), fixing the damaged part of the middle floors plafond of the (IV) floor ceiling repair works type that should be done are: Hollow metal stud ceiling frame, gypsum ceiling 6 mm, kalsi board ceiling 6 mm, and gypsum ceiling paint. Through the calculations, results showed that the total cost of hollow metal stud ceiling frame is (Rp199, 237.50), gypsum ceiling 6 mm total cost is (Rp77, 713.90), kalsi board ceiling 6 mm total cost is (Rp88,124.30), and gypsum ceiling paint total cost is (Rp33,312.68).
   2) Based on the (Mulia, 2017), fixing the damaged part of the middle floors plafond of the (V) floor ceiling repair works type that should be done are: Hollow metal stud ceiling frame, gypsum ceiling 6 mm, kalsi board ceiling, and gypsum ceiling paint. Through the calculations, results showed that the total cost of hollow metal stud ceiling frame is (Rp448, 284.38) gypsum ceiling 6 mm total cost is (Rp174, 856.28), kalsi board ceiling total cost is (Rp198, 279.68), and gypsum ceiling paint total cost is (Rp74, 953.53). Therefore the total cost of fixing the damaged “fallen” parts of the middle floors plafond of the (V) and (IV) floors ceiling repair work is (Rp1, 294,762.24).
   3) This study estimated the total cost of solving the minaret problems which: Structural analysis of a concrete plate exposed to the pressure of the minaret dome and proof of its safety, and analysis the total cost of replacing the dome and the damaged parts of the middle floors of the masjid Agung Sleman minaret. Based on the calculations above, the results showed that the existing design reinforcement of the plate concrete under the dome pressure is totally safe, the total cost of replacing the dome is (Rp2, 073,135,813), the total cost of fixing the damaged “fallen” parts of the middle floors plafond of the (V) and (IV) floors ceiling repair is (Rp1, 294,762.24).
   4) This study estimated the total cost of unexpected costs, through adopting the ratio 10% from total cost of operations that done to solve the minaret problems and it was around (Rp207, 443,057.59). This study proved the safety of the concrete plate under the pressure of the dome where it’s totally safe, estimated the total cost for solving masjid Agung Sleman minaret problems which (Rp2, 281,873,633.54). Based on the engineering company expectations the total cost of solving the minaret problems would be around (3.000.000.000 – 4.000.000.000). This study estimated and the total cost of solving the minaret problems during this study are around (2.000.000.000 – 2.500.000.000).

5. Research Result

This study solved the minaret masjid Agung construction problems that emerged after four years of construction completion, through analyzed two main points. Where prove the minaret dome safety, calculated the total cost of replacing the dome and repairing the middle floors plafond ceiling which the fourth and fifth floors damage “fallen” parts. Several operations are fulling under these points mentioned below:

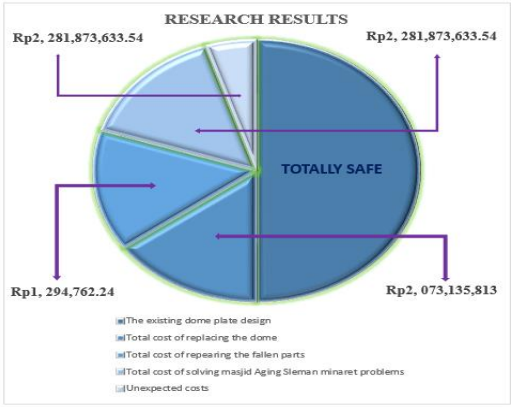

Figure 1. Research Result

1. Dome minaret safety

Based on calculations, in this study the minaret dome safety has been proven. Through analyzing and substantiation the safety of the plate concrete that incur beneath dome pressure through proving that the existing design of concrete plate under the pressure of the dome is totally safe.

2. The total cost of replacing the dome

Based on calculations, this study reached the total cost of replacing the dome from the minaret that rise sixty seven maters from the ground which (Rp2, 073,135,813).

3. The total cost of repairing the middle floors damage “fallen” parts

Based on calculations, this study reached the total cost of repairing the middle floors damage “fallen” parts, where the fourth and fifth floors from the minaret, which (Rp1, 294,762.24).

The chart above in this study shows the size of the discrepancy between the total costs of the Al-minaret project from its establishment until its restoration, where the chart showed that the total costs of the project are around (14.000.000.000 - 16.000.000.000), the total costs of the engineering company expectations are around (3.000.000.000 – 4.000.000.000), and the total cost of solving the minaret problems during this study are around (2.000.000.000 – 2.500.000.000).

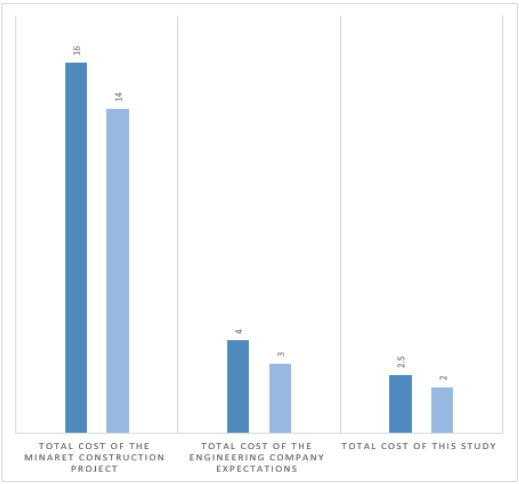

Figure 2. Research Result

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Analysis of Land Subsidence Using A Combination of Preloading and Prefabricated Vertical Drain Methods

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Abstract

Pertamina Balongan Indramayu's New Construction Jetty & Temporary Access Road Construction Project is the construction of a new jetty (silting prevention pier) located on a loamed land, which consists of dredging work on the area to be built by the jetty, protection of existing pipes, and erection of piles. In the implementation of the jetty construction, there are several reviews that need to be considered, such as soil elastic subsidence and soil consolidation subsidence. The method used for land subsidence is the Preloading method and is combined with the use of PVD to increase the time of decline. The results of this study found an elastic decrease using the Preloading method, a result of 0.7765 meters was obtained due to the presence of a stockpile load and an implementation load of 22.1312 kN/m^2 on Elv. ± 1.00 m – STA. 0 + 025 m. Meanwhile, the decrease in consolidation (S_c + S_s) using the Preloading method, obtained a result of 4,949 meters due to the heap load and implementation load of 27,201 kN/m^2 on Elv. ± 1.00 m – STA. 0 + 025 m and the length of time it takes to achieve the degree of consolidation of the plan (U_v = 90 %) using the Preloading method obtained results, which is 297 days. When the Preloading method is combined with using the Prefabricated Vertical Drain (PVD) method, the result of the length of time (t) needed to achieve the degree of consolidation of the plan (U_v = 90 %) is 158 days using a quadrilateral pattern installation PVD with a distance of 0.8 meters.

Keywords
Consolidation; Preloading; Prefabricated Vertical Drain.

1. Introduction

1.1. Background

Clay soil is a type of soil that is quite detrimental to construction because it has low soil carrying capacity, high moisture content, and is difficult to drain due to relatively low soil permeability. It is known that there are several methods that can be used to increase soil strength, one of which is the soil improvement method, which is carried out using the preloading method with a combination of Prefabricated Vertical Drains (PVD). This method is used to speed up the time of consolidation and the degree of consolidation. (Ronal, 2021).

The decreasing case is caused by several things, including underground erosion that brings soil grains to flow, so that there is a reduction in volume in the soil. In addition, a decrease can occur due to vibration, because it can cause the movement of soil grains that crowd the surrounding space, so that the volume of the soil decreases. Pertamina Balongan Indramayu's New Construction Jetty & Temporary Access Road Construction Project is the construction of a new jetty (silting prevention pier), which consists of dredging work on the area to be built by the jetty, protection of existing pipes, and erection of piles. In the implementation of the jetty construction, there are several reviews that need to be considered, such as soil elastic subsidence and soil consolidation subsidence. Therefore, a soil improvement method is needed that can increase the strength of the soil carried out, namely the preloading method. Furthermore, this method is carried out by installing a vertical drainage system in the form of a Prefabricated Vabricated Drain.

1.2. Problem Formula

1. How much does the elastic decrease and consolidation decrease by using the preloading method?
2. How long does it take to achieve the required degree of consolidation using the preloading method?
3. How long does it take to achieve the required degree of consolidation by using a combination of the preloading method and the prefabricated vertical drain method?

1.3. Purposes and Objectives of the Study

1. By using preloading and knowing the amount of elastic decrease and consolidation decrease.
2. Knowing the time required to achieve the required degree of consolidation using preloading.

3. By knowing the time required to achieve the required degree of consolidation by using a combination of the preloading method and the prefabricated vertical drain

2. Literature Review

2.1. Subsidence of Elastic Soil (S_i)

Elastic subsidence (S_i) is a land subsidence that occurs in elastic conditions.

$S_i = P \cdot B \cdot 1 - \mu 2Es \cdot IP$

Information :

S_i= Elastic subsidence (m)

P = Net Pressure Charged (kN)

B = Width of the Foundation (m)

μ = Poissons' Ratio Ground Number

E_s = Modulus of Soil Elasticity (kN/m^2)

IP = Influence Factor For Bending Foundation Type & Rigid Foundation

2.2. A Decrease in Primary Consolidation (S_c)

Clay soils are normally consolidated when the preconsolidation pressure (pc') is equal to the effective pressure of overburden (po'). Whereas clay soils are under over-consolidated conditions if the preconsolidation pressure is greater than the effective overburden pressure that exists at the present time (pc' > po'). For normally consolidated clay, you can use the following equation:

$$S_c = \frac{C_c H}{1 + e0} log(\frac{P_0 + \Delta P}{P_0})$$

When the soil is overconsolidated→ $(po + \Delta p) \leq pc$, so :

$$S_c = \frac{C_c H}{1 + e0} log(\frac{P_0 + \Delta P}{P_0})$$

When the soil is overconsolidated→ $(po + \Delta p) > pc$, so :

$$S_c = \frac{C_s H}{1 + e0} log \frac{P_c}{P_0} + \frac{C_c H}{1 + e0} log(\frac{P_0 + \Delta P}{P_0})$$

Information :

S_c = Primary consolidation decrease(m)

C_s = Expansion index

C_c = Compression coefficient

H= Thickness of compressed clay soil sublayer (m)

e_o = porous number

p_o = Effective sublayer overburden pressure (kN/m^2)

p = Vertical pressure addition for sub-layers (kN/m^2)

2.3. Secondary Consolidation Decrease (S_s)

The decrease in secondary consolidation (S_s) is a decrease caused by the plastic adjustment of the soil grains when the primary consolidation process has ended, so as to use the equation

$$S_s = \frac{C_{re} H}{1 + e0} log(\frac{P_0 + \Delta P}{P_0})$$

2.4. Preloading Method

Preloading increases the carrying capacity and reduces the compressibility of soft soils. Preloading makes loose sand soils dense or makes clay and silt soils consolidate (Hausmann, 1990). A simple solution for preloading is preloading by using a backlog. Although it can be carried out on any type of soil, preloading is more effectively applied to soft, cohesive soils.

2.5. Prefabricated Vertical Drain Method

To accelerate the occurrence of settlement, it is necessary to reduce the length of the pore waterway. This can be done by installing a Prefabricated Vertical Drain (PVD) in the ground at a certain distance with a triangular or quadrilateral formation. PVD (Prefabricated Vertical Drain) is one of the geosynthetics products that function as a drainage. The function of PVD in soft clay soil improvement work preloading method with the use of PVD is to speed up the process time.

3. Research Methods

The stages of this research will be presented in the form of a flowchart as below:

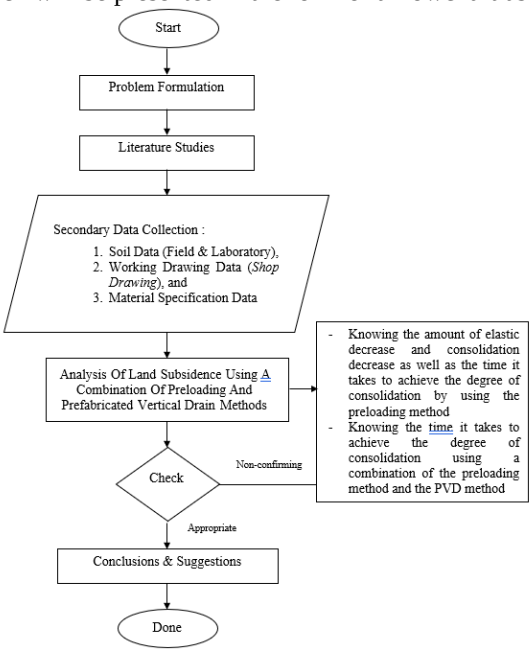

Figure 2. 1 Flowchart
(Source : Writer, 2022)

4. Results And Analysis

4.1. Consolidation Decrease Calculation Using the Preloading Method

4.1.1. Ground Stress Calculation

1. Overburden on Effective Voltage ($\Delta\sigma'0$)

The calculation of the effective voltage of overburden ($\Delta\sigma'_0$), which is as follows:

1) Layer I – A

$H_{(I-A)}$ = 1,00 m

$\gamma_{(I-A)}$ = 10,14 kN/m^3

$\sigma'_{0(I-A)} = [(\gamma_{dry(I-A)} \cdot \frac{H_{(I-A)}}{2})]$

$= [(10{,}14 \cdot \frac{1{,}00}{2})]$

= 5.07 kN/m^2

2) Layer II – A

$H_{(II-A)}$ = 1,45 m

$\gamma_{eff\ (II-A)}$ = 10,14 kN/m^3

$\sigma'_{0(II-A)} = (\gamma_{dry(I-A)} \cdot H_{(I-A)} + (\gamma_{eff(II-A)} \cdot \frac{H_{(II-A)}}{2})]$

$= [(10{,}14 \cdot 1{,}00) + (10{,}14 \cdot \frac{1{,}45}{2})]$

= 17.4915 kN/m^2

2. Voltage Addition ($\Delta\sigma'_0$)

The calculation of the addition ofvoltage ($\Delta\sigma'_0$), which is as follows:

1) Layer I – A

a_{Pile} = 0,25 m

b_{Pile} = 4,40 m

$z_{(I-A)}$ = 0,50 m

q_{0Total} = 22,131 kN/m^2

$I_{(I-A)}$ = 0,500

$\Delta\sigma'_{0(I-A)} = (2 \cdot q_{0Total} \cdot I_{(I-A)})$

$= (2 \cdot 22{,}131 \cdot 0{,}500)$

= 22,131 kN/m^2

2) Layer II – A

a_{Pile} = 0,25 m
b_{Pile} = 4,40 m
$z_{(II-A)}$ = 1,73 m
q_{0Total} = 22,131 kN/m^2
$I_{(II-A)}$ = 0,446
$\Delta\sigma'_{0(II-A)} = (2 \cdot q_{0Total} \cdot I(I_{I-A}))$
$= (2 \cdot 22{,}131 \cdot 0{,}446)$
= 19,741 kN/m^2

4.1.2. Elastic Drop Calculation (S_i)

The stages of calculating the elasticdecrease (S_i) with the preloading method, are as follows:

1) Layer I – A

B_{Pile} = 4,40 m
A_{Pile} = 0,25 m
$\Delta\sigma'_{0(I-A)}$ = 22,131 kN/m^2
$E_{s(I-A)}$ = 2298,25 kN/m^2
$\mu_{(I-A)}$ = 0,25
$I_{p(I-A)}$ = 1,024

$$S_{i\,(I-A)} = \Delta\sigma'_{0(I-A)} \cdot (b_{Pile} + 2 \cdot a_{Pile}) \cdot \frac{1-\mu\,(I-A)^{\,2}}{Es(I-A)} \cdot I_{p(I-A)}$$

$$= 22{,}131 \cdot (4{,}40 \cdot 2 \cdot 0{,}25) \cdot \frac{1-0{,}25^{\,2}}{2298{,}25} \cdot 1{,}024$$

= 0,0453 m

2) LayerII – A

B_{Pile} = 4,40 m
a_{Pile} = 0,25 m
$\Delta\sigma'_{0(II-A)}$ = 19,741 kN/m^2
$E_{s(II-A)}$ = 2298,25 kN/m^2
$\mu_{(II-A)}$ = 0,25
$I_{p(II-A)}$ = 1,024

$$S_{i\,(II-A)} = \Delta\sigma'_{0(II-A)} \cdot (b_{Pile} + 2 \cdot a_{Pile}) \cdot \frac{1-\mu\,(II-A)^{\,2}}{Es(II-A)} \cdot I_{p(II-A)}$$

$$= 19{,}741 \cdot (4{,}40 \cdot 2 \cdot 0{,}25) \cdot \frac{1-0{,}25^{\,2}}{2298{,}25} \cdot 1{,}024$$

= 0,0404 m

Recapitulation of Elastic Decrease S_i to Elv. ± 2.00 meters can be shown in the table below.

Table 1. Recapitulation of Si Calculation (Elv. ± 0.25 meter s/d Elv. ± 1,00 meter)

No.	STA. Point (m)	± Pile (m)	Si Settlement (m)
1	0 + 025	0,25	0,1567
2	0 + 025	0,50	0,2075
3	0 + 025	0,75	0,1826
4	0 + 025	1,00	0,2297
Total Elastic Decrease (Si)			0,7765

(Source : Data Processing Results)

4.1.3. Calculation of Primary ConsolidationDecrease (S_c)

As for the calculation of the decrease in primary consolidation (S_c), it can be carried out using the results of the analysis of the determination of soil properties.

1) Layer I – A

$H_{(I-A)}$ = 1,00 m
$C_{s(I-A)}$ = 0,21
$e_{0(I-A)}$ = 1,54
$\sigma'_{0(I-A)}$ = 5,070 kN/m^2
$\Sigma\sigma'_{0(I-A)}$ = 27,2012 kN/m^2

$$S_{c\,(I-A)} = \frac{C_{c(I-A)} \cdot H_{(I-A)}}{1+e_{0(I-A)}} \cdot \log\left(\frac{\Sigma\sigma'_{0(I-A)}}{\sigma'_{0(I-A)}}\right)$$

$= \frac{0,21 \cdot 1,00}{1+1,54} \cdot \log\left(\frac{27,2012}{5,070}\right)$

= 0,4194 m

2) Layer II – A

$H_{(II-A)}$ = 1,45 m

$C_{s(II-A)}$ = 0,21

$e_{0(II-A)}$ = 1,54

$\sigma'_{0(II-A)}$ = 17,492 kN/m^2

$\Sigma\sigma'_{0(II-A)}$ = 37,2325 kN/m^2

$S_{c\,(II-A)} = \frac{C_{s(II-A)} \cdot H_{(II-A)}}{1+e_{0(II-A)}} \cdot \log\left(\frac{\Sigma\sigma'_{0(II-A)}}{\sigma'_{0(II-A)}}\right)$

$= \frac{0,21 \cdot 1,45}{1+1,54} \cdot \log\left(\frac{37,2325}{17,492}\right)$

= 0,0393 m

Primary Descent Recapitulation of S_c to Elv. ± 2.00 meters can be shown in the table below.

Table 2. Recapitulation of Sc Calculation (Elv. ± 0.25 m s/d Elv. ± 1.00 m)

No.	STA. Point (m)	± Pile (m)	Sc Settlement (m)
1	0 + 025	0,25	0,4022
2	0 + 025	0,50	0,5290
3	0 + 025	0,75	0,5477
4	0 + 025	1,00	0,6474
Total Decrease in Primary Consolidation (Sc)			2,1263

(Source : Data Processing Results)

4.1.4. Calculation of Secondary Consolidation Decrease (S_s)

The stages of calculating the decrease in secondary consolidation (S_s) by the preloading method can be done in the following way:

1) Layer I – A

$H_{(I-A)}$ = 1,00 m

$C_{re(I-A)}$ = 0,63

$e_{0(I-A)}$ = 1,54

$\sigma'_{0(I-A)}$ = 5,070 kN/m^2

$\Sigma\sigma'_{0(I-A)}$ = 27,2012 kN/m^2

$S_{s(I-A)} = \frac{C_{re(I-A)} \cdot H_{(I-A)}}{1+e_{0(I-A)}} \cdot \log\left(\frac{\Sigma\sigma'_{0(I-A)}}{\sigma'_{0(I-A)}}\right)$

$= \frac{0,63 \cdot 1,00}{1+1,54} \cdot \log\left(\frac{27,2012}{5,070}\right)$

= 0,1810 m

2) Layer II – A

$H_{(II-A)}$ = 1,45 m

$C_{re(II-A)}$ = 0,21

$e_{0(II-A)}$ = 0,63

$\sigma'_{0(II-A)}$ = 17,492 kN/m^2

$\Sigma\sigma'_{0(II-A)}$ = 37,2325 kN/m^2

$S_{s(II-A)} = \frac{C_{re(II-A)} \cdot H_{(II-A)}}{1+e_{0(II-A)}} \cdot \log\left(\frac{\Sigma\sigma'_{0(II-A)}}{\sigma'_{0(II-A)}}\right)$

$= \frac{0,63 \cdot 1,45}{1+1,54} \cdot \log\left(\frac{37,2325}{17,492}\right) \cdot 0$

= 0,1180 m

Recapitulation of Secondary Descent Ss to Elv. ± 2.00 meters can be shown in the table below.

Tabel 3. Recapitulation of S_s Calculation(Elv. ± 0.25 m s/d Elv. ± 1.00 m)

No.	STA. Point (m)	± Pile (m)	S_s Settlement (m)
1	0 + 025	0,25	0,5458
2	0 + 025	0,50	0,6998
3	0 + 025	0,75	0,7017
4	0 + 025	1,00	0,8750
Total Decrease in Secondary Consolidation (S_s)			**2,8223**

(Source : Data Processing Results)

4.1.5. Calculation of Consolidation Time (t) & Degree of Consolidation (U_v)

The following recapitulation of thecalculation of the consolidation time (t) and degree of consolidation (U_v) with U_v = 50 %, can be explained in one of thepieces (STA. 0 + 025 – Elv. ± 0.25 meters) :

Table 4. Recapitulation of Calculation t & U_v= 50 % (Elv. ± 0.25 m s/d Elv. ± 1.00 m)

No	STA.Point (m)	± Pile (m)	Scores of Hdr2 (Uv = 50 %)	Scores of Uv (Uv = 50%)	Scores of Tv (Uv = 50%)	Scores of Cv (m2/ hari)	Scores of t (Hari)
1	0 +025	0,25	32,00	50,00	0,197	0,731	68,944
2	0 +025	0,50	31,31	50,00	0,197	0,746	64,972
3	0 +025	0,75	30,49	50,00	0,197	0,766	60,040
4	0 +025	1,00	29,68	50,00	0,197	0,787	55,378

(Source : Data Processing Results)

The following recapitulation of the calculation of the consolidation time (t) and degree of consolidation (U_v) with U_v = 90 %, can be described in one of the pieces (STA. 0 + 025 – Elv. ± 0.25 meters) :

Table 5. Recapitulation of Calculation t & U_v= 90 % (Elv. ± 0.25 m s/d Elv. ± 1.00 m

No	STA .Point (m)	± Pile (m)	Scores of H_{dr}^2 (U_v = 90%)	Scores of U_v (U_v = 90%)	Scores of T_v (U_v = 90%)	Scores of C_v (m^2/hari)	Scores oft (Hari)
1	0 +025	0,25	32,00	90,00	0,848	0,731	**296,775**
2	0 +025	0,50	31,31	90,00	0,848	0,746	**279,677**
3	0 +025	0,75	30,49	90,00	0,848	0,766	**258,447**
4	0 +025	1,00	29,68	90,00	0,848	0,787	**238,378**

(Source : Data Processing Results)

4.1.6. Prefabricated Vertical Drain (PVD)

Based on the results of the analysis using the Prefabricated Vertical Drain (PVD) method, a consolidation time of 388 days was obtained to achieve a consolidation degree of >90%. Meanwhile, the consolidation time required using the preloading method is 297 days. This shows that the installation of a quadrilateral pattern Prefabricated Vertical Drain (PVD) with a distance of (S) = 1.00 meters is not enough to speed up the consolidation time. So, it is necessary to install PVD at a tighter distance than what is currently used at a distance of 0.80 meters.

Based on the results of the analysis using the Prefabricated Vertical Drain (PVD) method, the quadrilateral installation pattern with a distance of 0.80 m obtained a consolidation time of 158 days to achieve a degree of consolidation of >90%.

5. Conclusion

From the calculation results, the elastic decrease using the Preloadingmethod, obtained a result of 0.7765 metersdue to the presence of a stockpile load andan implementation load of 22.1312 kN/m^2 on Elv. ± 1.00 m – STA. 0 + 025 m. Meanwhile, the decrease in consolidation (S_c + S_s) using the Preloading method, obtained a result of 4,949 meters due to theheap load and implementation load of 27,201 kN/m^2 on Elv. ± 1.00 m – STA.0 + 025 m.

Based on the calculation results, the length of time it takes to achieve the degree of consolidation of the plan (U_v = 50 %) using the preloading method is 69 days. Meanwhile, the length of time (t) required to achieve the degree of consolidation of the plan (U_v = 90 %) using the method.

When the preloading method is combined with using the Prefabricated Vertical Drain (PVD) method, the result is the length of time (t) needed to achieve the degree of consolidation of the plan (U_v = 90 %) is 158 days using a quadrilateral pattern installation of PVD with a distance of 0.8 meters. Installation with such distances is considered faster to achieve the degree of consolidation of the plan (U_v = 90 %) compared to the quadrilateral installation pattern with a distance of 1.00 meters, which takes 388 days. The use of the preloading method is faster than combining using the Prefabricated Vertical Drain (PVD) method of mounting a quadrilateral installation pattern of 1.0 meters. This is because the heap layer is relatively small, which makes the consolidation time quite fast. Thus, the use of the Prefabricated Vertical Drain (PVD) method of a quadrilateral installation pattern with a distance of 0.8 meters is considered more effective to use and combine when the stockpile is relatively small.

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The Effect of Concrete Mixture on Usage Fly Ash and Chicken Egg Shell Powder as Cement Substitutions in Concrete Compressive Strength

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Abstrak

The purpose of this study was to determine the effect of utilizing fly ash and chicken egg shell powder on the compressive strength of concrete, workability, density and water absorption. In this study, testing was carried out with the use of fly ash waste and chicken egg shell powder with variations of 15% fly ash waste and variations of chicken egg shell powder by 10% and 17.5% at the age of 3 days, 7 days, 14 days, and 28 days. for the test objects used measuring with a diameter of 10 cm and a height of 20 cm as many as 36 test samples by making variations of the day as many as 3 samples of test objects.
Concrete with a mixture of 15% Fly Ash waste and 10% Egg Shell Powder in test sample 2 obtained a compressive strength at the age of 28 days of 29.45 Mpa. Variation of the Normal Concrete sample got a compressive strength at the age of 28 days of 30.37 MPa. Variation of test sample 3 got a compressive strength at the age of 28 days of 21.16 Mpa.

1. Introduction

1.1. Background

Concrete is a composite material made from a mixture of aggregate and cement. The most common form of concrete is concrete with portland cement, which consists of coarse aggregate (gravel/split), fine aggregate (sand), cement and water. Concrete is the most widely used material as a construction material. Concrete is used because it is strong, durable, water-resistant, wear-resistant, and has very small shrinkage (Tjokrodimuljo, 1996).

The development of construction throughout the world is growing rapidly, as a result, the need for materials for the manufacture of concrete is getting higher. This triggers environmental problems because all the ingredients for making concrete come from mining. In today's development, there are many modifications of concrete making materials to solve problems that occur in the environment to be more environmentally friendly. The purpose of modifying the material for making concrete is to reduce limestone and sand mountain mining and make the environment more friendly. Because if limestone mountains and sand mountains are continuously mined, the materials for making concrete will be lost if they are not assisted with other modified materials.

Sand mining, especially illegal mining, causes various negative impacts, including; soil becomes prone to erosion, air pollution due to dust, noise pollution, road damage due to heavy equipment. silting of rivers, reduced clean water, to the threat of biodiversity around the mining area (Pitchaiah, 2017). According to previous research by adding fly ash in a high-quality concrete mixture as a substitute for cement, it was stated that the greater the concentration of fly ash in the concrete mixture, the higher the concentration of fly ash in the concrete mixture. will increase the compressive strength value, but the compressive strength will decrease if the use of fly ash is too much (Ervianto et al., 2016). Research using fly ash as a substitute for cement on the compressive strength of concrete. The concentration of fly ash used varies from 5% to 12.5% with an interval of 2.5%. The optimum compressive strength using fly ash with a concentration of 12.5% is 231.04 Kg/cm2 (Setiawati, 2018). The use of fly ash in making mortar mixtures designed by weight provides cost savings of 50% to 60% while the heavy method provides cost savings of 9% to 16%, in this study fly ash was used as a cement substitute (Jain & Islam, 2013).

1.2 Problem Formulation

Based on the above background, the formulation of the problem in this study is as follows:

1. How is the effect of using fly ash and chicken egg shell powder as a substitute for cement in a concrete mixture on workability?
2. How is the effect of variations in the mixture of waste using fly ash and chicken egg shell powder on the compressive strength of concrete?
3. How is the effect of the mixture of fly ash and chicken egg shell powder on the density of the concrete?

4. How is the effect of variations in the mixture of waste using fly ash and chicken egg shell powder on water absorption in concrete

1.3. Purpose and Purpose

The aims and objectives of this research are as follows:

1. Knowing the effect of using a mixture of fly ash and chicken egg shell powder as a cement substitution material in concrete on the compressive strength test of concrete and the workability value of the concrete slump value test.
2. Knowing the variation of fly ash and chicken egg shell powder in the variation of the concrete mixture that has the strongest compressive strength.
3. Knowing the effect of using a mixture of fly ash waste and chicken egg shell powder on the compressive strength of concrete.
4. Knowing the effect of variations in the mixture of waste using fly ash and chicken egg shell powder on water absorption in concrete.

2. Literature Review

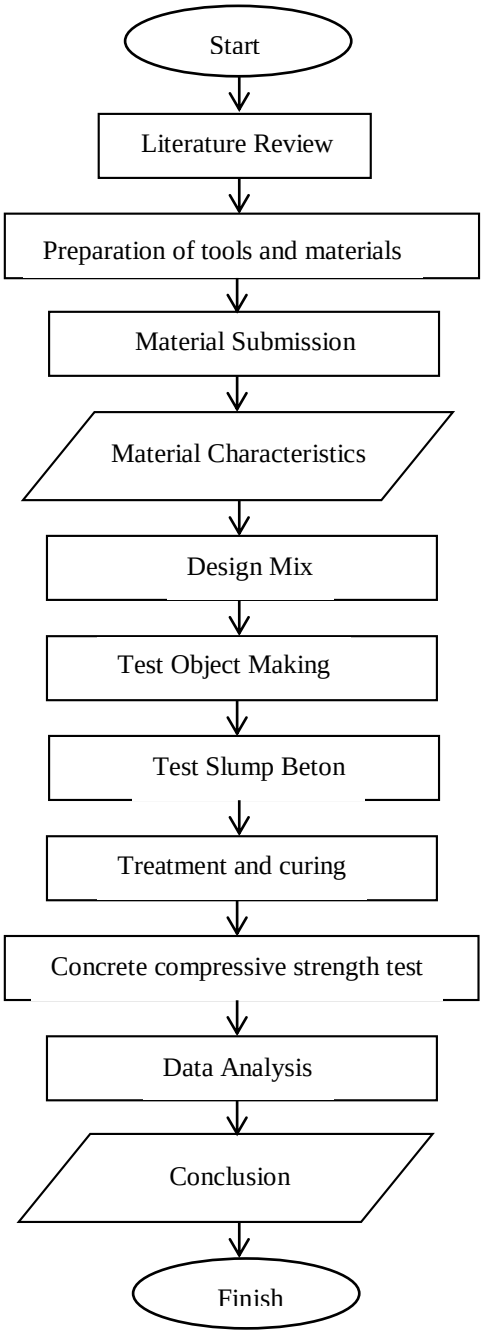
Concrete is the most widely used material as a construction material. Concrete is used because it is strong, durable, water-resistant, wear-resistant, and has very small shrinkage. Cement will react with water and bind the aggregate so that the material is hard and durable.

Sometimes one or more addictive ingredients are added to the concrete to produce concrete with certain characteristics, such as ease of work, compressive strength, and speed up setting time. The basic materials supporting the manufacture of concrete are very supportive of quality, quality planning for concrete is very important to get maximum results.

3. Research Method

The research method used is the experimental method. The experimental method is a method to determine whether the cause (independent variable) affects the effect (dependent variable) (Hermawan, 2006).

Table 1.



4. Results and Discussion

4.1. Slump (Wokability)

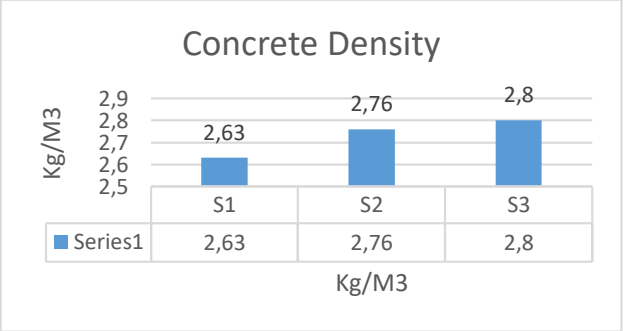
Table 2. Slump . Test Results

Sample Type	Slump Value	Unit
S1	100	mm
S2	100	mm
S3	100	mm

In concrete without substitution, the slump value was 100 mm and in the third sample it was increased to 140 mm.

4.2. Concrete Density

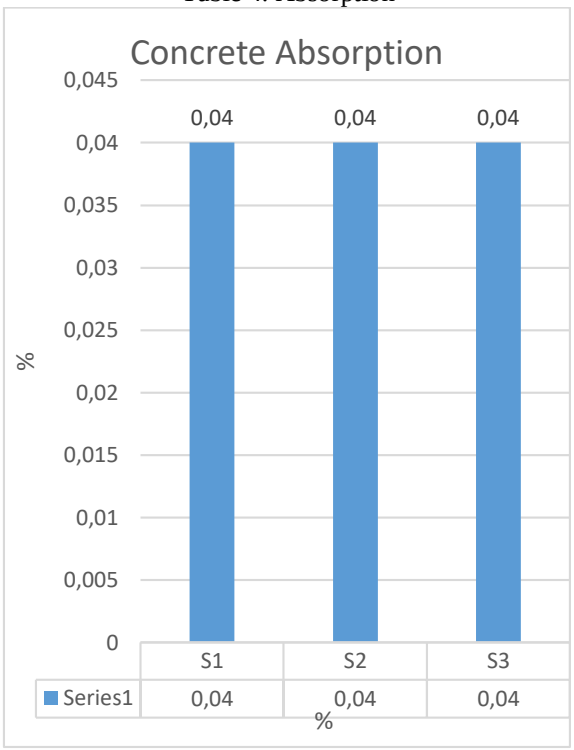
Table 3. Concrete Density Results



This table explains that the density of concrete with the following data, sample 1 with a normal variation obtained 2.63 kg/m3, sample 2 with a variation of 15% fly ash and 10% chicken egg shell powder obtained 2.76 kg/m3 and the sample to 3 with a variation of 15% fly ash and 17.5% chicken egg shell powder to 2.80 Kg/M3.

4.3. Water Absorption

Table 4. Absorption



This table explains that the absorption of concrete with the following data, sample 1 with a normal variation of 0.04%, sample 2 with a variation of 15% fly ash and 10% chicken egg shell powder obtained 0.04% and sample 3 with a variation of 15 % fly ash and 17.5% chicken egg shell powder got 0.04%.

4.4. Days Compressive Strength Test Results

Table 5. Day Compressive Strength Test Results

3 days								
Sample Type	Test Object Code	Weight (Kg)	Density	Average Density	Load (Kn)	Mpa	Mpa Average	Absorption Average
S1	3.1	3.92	2.51	2.77	157.2	20	19.23	0.04
	3.2	4.49	2.89		150.9	19.2		
	3.3	4.52	2.9		145.9	18.5		
S2	3.1	4.35	2.8	2.61	127.2	16.1	16.57	0.05
	3.2	4.37	2.82		125.4	15.9		
	3.3	3.45	2.22		139.4	17.7		
S3	3.1	4.3	2.75	2.8	129.2	16.4	18.77	0.03
	3.2	4.51	2.89		146.1	18.5		
	3.3	4.3	2.75		168.7	21.4		

Based on the results obtained, the addition of the sample to 2 fly ash as much as 15% and chicken egg shell powder 10% and the 3rd sample fly ash as much as 15% and chicken egg shell powder 17.5% decreased from the normal concrete sample that has been made, p. This is because not all of the fly ash waste as much as 15% and 10% chicken egg shell powder binds intact, as much as in the concrete with the substitution of the 2nd sample getting a compressive strength of 16,567 MPa and the 3rd sample getting a compressive strength of 18.76.

4.5. Days Compressive Strength Test Result

Table 6. Day Compressive Strength Test Results

7 Days								
Sample Type	Test Object Code	Weight (Kg)	Density	Average Density	Load (Kn)	Mpa	Mpa Average	Absorption Average
S1	7.1	3.97	2.56	2.52	175.3	22.3	19.63	0.05
	7.2	4.56	2.5		116.9	14.8		
	7.3	4.51	2.5		172	21.8		
S2	7.1	4.37	2.8	2.8	137	17.4	16.63	0.03
	7.2	4.39	2.82		127.1	16.1		
	7.3	4.33	2.77		129.2	16.4		
S3	7.1	4.36	2.8	2.84	186.4	23.7	23.4	0.04
	7.2	4.51	2.89		167.9	21.3		
	7.3	4.39	2.82		198.2	25.2		

Based on the results obtained, the addition of sample to 2 fly ash as much as 15% and chicken egg shell powder 10% and sample 3 fly ash as much as 15% and chicken egg shell powder 17.5% decreased in sample 2 and increased in sample 3 with The comparison of normal concrete that has been made, the second sample gets 16.63 mpa lower than the 1st sample, which is normal concrete 19.63 and in the 3rd sample it gets 23.4 mpa.

4.6. Press strength test results 14 Days

Table 7. Compressive Strength Test Results 14 Days

14 Days									
Sample Type	Test Object Code	Weight (Kg)	Density	Average Density	Load (Kn)	Mpa	Mpa Average	Absorption	Absorption Average
S1	14.1	4.49	2.88	2.73	197.6	25.14	23.96	0.04	0.05
	14.2	3.82	2.45		197.6	25.14		0.04	
	14.3	4.46	2.86		170	21.6		0.04	
S2	14.1	4.46	2.87	2.83	129.1	16.43	21.38	0.05	0.06
	14.2	4.31	2.78		208.2	26.4		0.06	
	14.3	4.42	2.84		167.6	21.3		0.05	
S3	14.1	4.42	2.85	2.8	114.5	14.5	13.6	0.06	0.05
	14.2	4.28	2.75		94.8	12		0.05	
	14.3	2.35	2.8		112.6	14.3		0.06	

Based on the results obtained, the addition of the sample to 2 fly ash as much as 15% and chicken egg shell powder 10% and the 3rd sample fly ash as much as 15% and chicken egg shell powder 17.5% decreased from the normal concrete sample that has been made, p. This is because not all fly ash waste is 15% and 10% chicken egg shell powder binds intact, as much as in concrete with the substitution of the 2nd sample getting a compressive strength of 21.37 MPa and in the 3rd sample obtaining a compressive strength of 13.6 mpa, the 3rd sample experienced a very high decrease due to the 3rd sample material 15% fly ash waste and 17.5% chicken egg shell powder were not mixed evenly.

4.7. Days Compressive Strength Test Results

Table 8. Compressive Strength Test Results 28 Days

28 Days									
Sample Type	Test Object Code	Weight (Kg)	Density	Average Density	Load (Kn)	Mpa	Mpa Average	Absorption	Absorption Average
S1	28.1	3.95	2.54	2.52	250.7	31.9	30.37	0.05	0.05
	28.2	3.92	2.5		236.3	30		0.02	
	28.3	3.89	2.52		230	29.2		0.08	
S2	28.1	4.35	2.82	2.83	229.8	29.2	29.45	0.09	0.06
	28.2	4.43	2.85		239	30.4		0.05	
	28.3	4.4	2.83		225.9	28.75		0.05	
S3	28.1	4.27	2.71	2.76	176.4	22.45	21.16	0.05	0.05
	28.2	3.39	2.82		181.8	23.13		0.04	
	28.3	4.28	2.76		141	17.9		0.06	

Based on the results obtained, the addition of the sample to 2 fly ash as much as 15% and chicken egg shell powder 10% and the 3rd sample fly ash as much as 15% and chicken egg shell powder 17.5% decreased from the normal concrete sample that has been made, p. This is because not all of the fly ash waste as much as 15% and 10% chicken egg shell powder binds intact, as much as the concrete with the substitution of the 2nd sample obtained a compressive strength of 29.45 Mpa and the 3rd sample obtained a compressive strength of 21.16 Mpa, this decrease was due to the mixture The waste of the 2nd fly ash sample was 15% and the chicken egg shell powder 10% was not completely glued and the 3rd fly ash sample was 15% and the 17.5% chicken egg shell powder was not completely mixed evenly.

5. Conclusion

There are several conclusions that can be drawn from this study regarding the effect of Fly Ash and Eggshell Powder as a substitute for cement as a cement mixture against concrete that has been carried out, namely:

1. The slump value using Fly Ash and Eggshell Powder is in the range of 10 cm - 14 cm, so it can be concluded that the use of Fly Ash and Eggshell Powder affects the workability of concrete. The higher the variation of the Telot Shell Powder, the higher the slump value will be.
2. The research proves that Fly Ash and Eggshell Powder have a significant effect on the compressive strength of concrete. Concrete with a mixture of 15% Fly Ash waste and 10% Egg Shell Powder in test sample 2 obtained a compressive strength at the age of 28 days of 29.45 Mpa. Variation of the Normal Concrete sample got a compressive strength at the age of 28 days of 30.37 MPa. Variation of test sample 3 got a compressive strength at the age of 28 days of 21.16 Mpa.
3. The use of waste fly ash and egg shell powder in the concrete mixture produces a density at the age of 28 days which is relatively stable in the range of 2.76 – 2.8 Kg/m3. For normal concrete samples at the age of 28 days, it is 2.63 kg/m3
4. The research proves that waste Fly Ash and Eggshell Powder does not affect the water absorption factor in concrete, in concrete with a mixture of 15% Fly Ash waste and 10% Eggshell Powder gets 0.04% water absorption, in the concrete sample mixture of waste Fly Ash 15% and Egg Shell Powder 17.5% got 0.04% water absorption and for normal concrete samples, water absorption was 0.04%.

6. Suggestions

There are several suggestions in this study regarding the effect of Fly Ash and Eggshell Powder as a substitute for cement as a cement mixture against concrete that has been carried out, namely:

1. In the study of powdered chicken egg shells, it must be really very smooth because in In my research, I used only a 100 size sieve, it would be better if the chicken egg shell powder was in a 200 filter or pan.
2. In the process of making the test object when it is inserted into the mixer, the materials must be considered carefully so that the ingredients for making concrete are evenly mixed.
3. In the process of making test objects, many things must be considered to reduce errors in data collection, from the materials used, equipment and manufacture of test objects.
4. In the process of making the test object when it is inserted into the cylinder, care must be taken to avoid the occurrence of porous concrete.

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Experimental Study of Utilization Coconut Fiber as Additional Material and Slag as a Cement Substitution Against Compressive Strength and Split Tensile Strength of Concrete

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Abstract

Development developments have an impact on the building materials industry sector. To reduce CO2 emissions due to soaring productivity of cement, the industry can use Ground Granulated Blast Furnace Slag (GGBFS) as a substitute for cement. This study aims to determine the effect of using GGBFS as a substitute for cement and coconut fiber as an additive on the workability, density, water absorption, compressive strength and split tensile strength of concrete at 3, 7, and 28 days. In this study using the experimental method with a total of 84 samples of cylindrical specimens with a size of 10cm x 20cm. This research was conducted with variations of GGBFS substitution of cement (0%, 35.5%, 43.5%) and coconut fiber as an additive (0.23%, 0.63%).The results of this study indicate that the optimum compressive strength test value at the age of 28 days is at GGBFS (35.5%) and coconut fiber (0.63%) reaches an average compressive strength of 32.32 Mpa. The SU1 variation (24.63 Mpa), SU2 variation (30.20 Mpa), SU3 variation (30.77 Mpa), SU5 variation (28.16 Mpa), SU6 variation (28.31 Mpa). Optimal splitting strength at the age of 28 days, namely the SU4 variation with GGBFS 35.5% and coconut fibers (0.63%) reached an average split tensile strength of 2.23 Mpa.

Keywords :
Compressive Strength of Concrete, Ground Granulated Blast Furnace Slag, Split Tensile Strength of Concrete

1. Introduction

1.1. Backround

The development of infrastructure have an impact on the industrial sector of building materials, in the year 2021 the Indonesian government allocated a budget for the construction of the infrastructure of the country to reach Rp 417,4 trillion, which is budget the biggest for the last 6 years (Annur, 2021).

Concrete is a building material that is most widely used because of its performance is satisfactory in the power requirements and its ability to be molded into various shapes and sizes according to the needs (Oluborode & Olofintuyi, 2015).

The increasing needs of the concrete will directly have an impact on the demand for cement so as to make the productivity of the cement industry will be the soaring, based on data from the Intergovernmental Panel on Climate Change (IPCC) Industry manager cement in a year can produce CO2 gas (Carbon Dioxide) amounted to 930 million tonnes, ranked second after the power plant so that it can contribute about 7% of the total emission of CO2 gas ranges 13.470 million tons/year (M. Natsir Abduh, 2017). Concrete eco-friendly solution in an effort to reduce the emissions of carbon dioxide (CO2), began to do various kinds of research to find the raw materials that have elements compounds such as cement (Ratisno, 2021).

To reduce the emission of CO2 (Carbon Dioxide) due to the industrial manufacture of cement can utilize waste material such as waste material such as material waste, such as waste materials like Ground Granulated Blast Furnace Slag (GGBFS) as a substitution material on the cement. The GGBFS is a waste derived from the industrial processing of steel and can produce up to 940.000 tons of the GGBFS on 2019 is increased (Arief, 2019). The GGBFS is the waste that comes from the process of the manufacture of iron which is a compound consists primarily of SiO2, CaO, Al2O3, and MgO, similar to the main compound manufacture of cement (Turu'allo, 2013). Based on the research that has been done by Anand et al, (2017) found that occurs the increase of concrete compressive strength on concrete M40 with variations of a mixture of 40% on the concrete, so that the GGBFS useful for structural concrete and can reduce CO2 emissions and reduce pollution on the environment. The GGBFS is cementitious and has a content of compounds of similar chemical cement portland in general, so it could potentially be used as a material of the adhesive aggregates such as cement in general (Saranya, Nagarajan, & Shashikala, 2018). This research will use the GGBFS as a substitution material in cement

and fibers coconut as an ingredient added to the mix of concrete against the weight of the concrete. Coconut fibers are very easily obtained, especially in the area of the coastal region of indonesia, the vast coconut plantations reached 3.76 million hectares and total production reached 14 billion grains coconut (Rachman, Banjarsanti, & Pranoto, 2020). With production reached 14 billion coconuts so that it has the potential to produce waste coconut fibers and the utilization of coconut fibers to absorb the waste into a material that is valuable and useful. Based on previous research, the use of coir fibers as a material added in the concrete, shows results that fibers of coconut increases the compressive strength of concrete with the variation of the addition of 0.6 % with the results of the compressive strength of 25,07 Mpa (Rachman et al., 2020). With the addition of coconut fibers as a material added to the concrete mix is expected to increase the economic value and the value of the order on the product fibers of the coconut to be able to manage the coconut fiber which is a waste material in the cities into the useful material.

The need for more research on the properties of concrete fiber with a combination of the composition of the GGBFS as cement substitution and coconut fibers as add to the weight of the concrete on the variation of the percentage of the different from research previous to get the results of percentage composition of the material mixture, the optimum has become a trigger for this study with the hope of making a satisfactory result in the material used for construction in the concrete mix. This study aims to utilize the GGBFS as a substitution material for cement and coconut fibers as material added to minimize the use of cement and increase the value of the order as well as the economic value of coconut fibers on the compressive strength and split Tensile strength of concrete.

1.2. Formulation of the Problem

Based on the description above background, the formulation of the problem, namely:

1. How the influence of variations in the mixture of waste the GGBFS and Coconut Fiber as the material mix on the concrete against the workability of concrete?
2. How the influence of variations in the mixture of waste the GGBFS and Coconut Fiber as the material mix on the concrete against the density of concrete?
3. How the influence of variations in the mixture of waste the GGBFS and Coconut Fiber as the material mix on the concrete against water absorption of concrete?
4. How the influence of variations in the mixture of waste the GGBFS and Coconut Fiber as the material mix on the concrete on the compressive strength of concrete?
5. How the influence of variations in the mixture of waste the GGBFS and Coconut Fiber as the material mix on the concrete against the split tensile strength of concrete?

1.3. Purpose and Objectives

The Purpose of this research is:

1. To determine the influence of variation of mixed waste the GGBFS and Coconut Fiber as the material mix on the concrete against the workability of concrete
2. To determine the influence of variations in the mixture of waste the GGBFS and Coconut Fiber as the material mix on the concrete against the density of concrete?
3. To determine the influence of variations in the mixture of waste the GGBFS and Coconut Fiber as the material mix on the concrete against water absorption of concrete?
4. To determine the influence of variations in the mixture of waste the GGBFS and Coconut Fiber as the material mix on the concrete on the compressive strength of concrete?
5. To determine the influence of variations in the mixture of waste the GGBFS and Coconut Fiber as the material mix on the concrete against the split tensile strength of concrete?

2. Literature Review

1. V. R. Anand, Pradeep Kumar, & Bhat, (2017) researched on the effects of concrete with the use of the GGBFS at high volume. (Subarkah, Sjah, & Maknun, 2020) examines the effects of the ggbfs and aggregate recycling of concrete compressive strength.
2. Cahit Bilim, Cengiz D. Atis, Harun Tanyildizi & Okam Karahan, (2008) examines the compressive strength of concrete the ggbfs using artificial neural network.
3. Vinayak Awasare & Prof. M. V. Nagendra, (2018) examines the analysis of the characteristics of strength in the concrete of the GGBFS.
4. Karim et al, (2020) researching about the Improvement of the Binding Properties of the Facades on White Portland Cement Using Ground Granulated Blast Furnace Slag (GBBFS).
5. Rizki Amalia Tri Cahyani, Ernawan Setyono, & Yunan Rusdianto (2020) researching on the Performance of Concrete With Ground Granulated Blast Furnace Slag Against Sulfate Attack.
6. Granulated Blast Furnace Slag Against Sulfate Attack.
7. Cahit Bilim, Cengiz D.Atis, Harun Tanyildizi & Okam Karahan, (2008) researching the compressive strength of GGBFS concrete using artificial neural networks.
8. Siti Fitriani, Wiki Muhammad Fathul M & Ida Farida, (2018) examines the Influence of Ground Granulated Blast Furnace Slag On the Properties of Physics Portland Cement Type-I.

9. Rachman et al, (2020) examines the Comparison of Abaca Fiber And fiber Coconut Fiber As a Material Added To the Concrete Mix.
10. Septian Maulana, (2017) researching about the Influence of the Substitution of Cement With Ash Seashell (Galolnia Expansa) And The Addition Of Fiber Coconut Fiber On The Concrete.
11. (Ir. H. Zainuddin & Wahyudi, 2019) research on the Influence of the Addition of fiber Coconut Fiber In Normal Concrete With the Test of Compressive strength And Flexural strength.

3. Research Methods

In this research use experimental methods with the use of waste the GGBFS or slag as a substitute against the cement and the addition of coir fibers against the weight of the concrete that will be testing the workability, density, water absorption, compressive strength and split tensile strength of concrete. All the process or procedure inconducting this research refers to the SNI (Standard Nasional Indonesia) and ASTM (American Society for Testing and Materials).

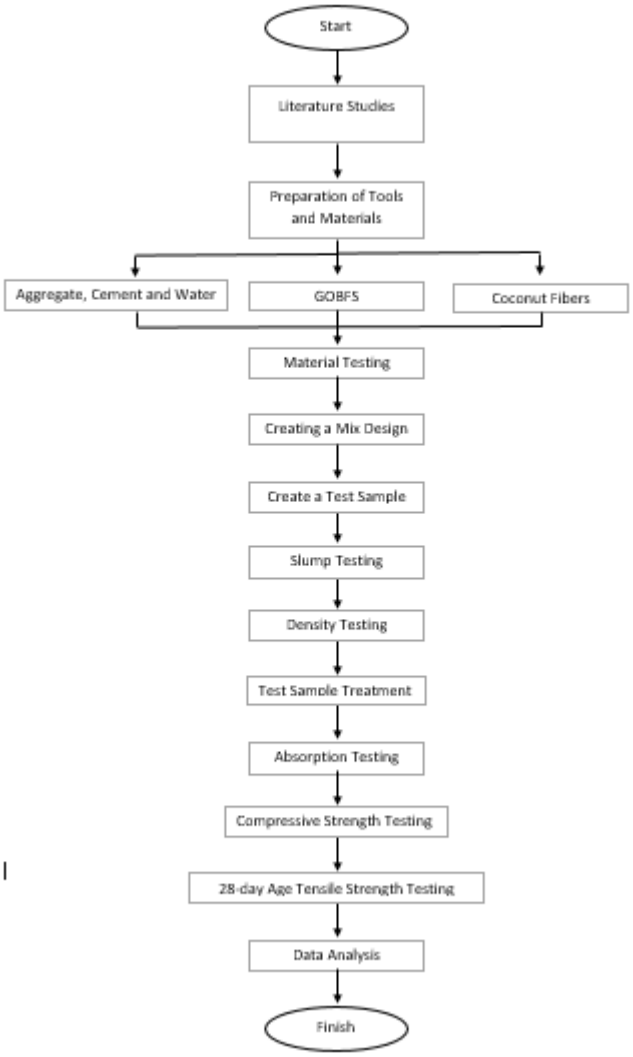

Figure 1. Flowchart Of Research Method

4. Results and Discussion

4.1. workability

Table 1. The Results of The Slump Test

Sample Code	Slump (cm)
BN	10
SU1	11
SU2	11
SU3	12
SU4	12
SU5	12
SU6	12

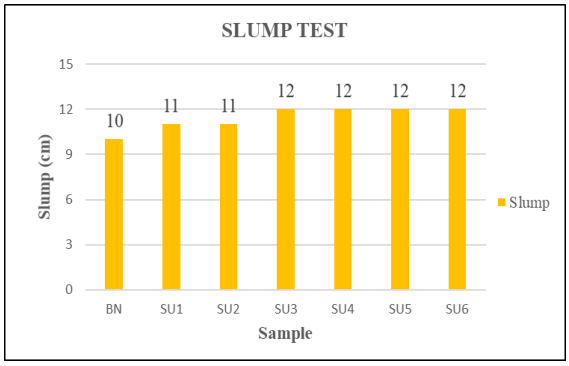

Figure 2. Diagram of Slump Test

From table 1 and figure 2 the results obtained from the slump on a mixture of normal concrete having a slump value of 10 cm which is lower than the test sample other, on the concrete with the addition of the GGBFS and coconut fibers to get the results of slump value by 11 cm - 12 cm. This shows that with the use of superplasticizer on the correct dose that can make the value of the slump in the concrete mixture of the GGBFS and coconut Fibers increased so as to make the concrete easier to work with.

4.2. Densitas Beton

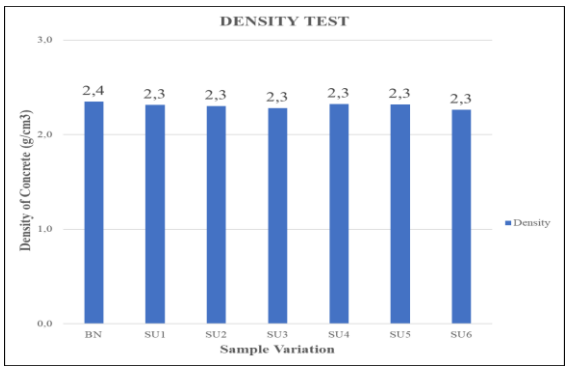

Figure 3. Diagram of Density Test

In figure 3 above explains that the value of the density is highest at the age of 3 days of 2.4 g/cm3 and a low of 2.3 g/cm3. The value of the density is highest at the age of 7 days of 2.4 Kg/m3 and a low of 2.2 g/cm3. The value of the density is highest at the age of 28 days of 2.4 g/cm3 and a low of 2.2 g/cm3. For the density values ranged between 2.3 to 2.4 g/cm3, with the presence of the GGBFS and coir fibers resulted in a density increase compared to the density of the normal concrete.

4.3. Water Absorption

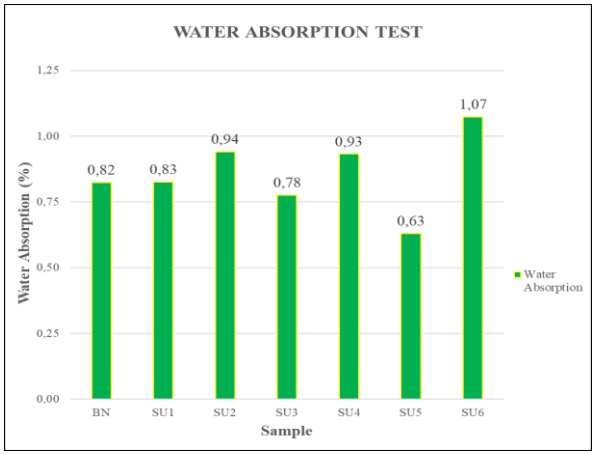

Figure 4 Diagram of Water Absorption

In figure 4 above explains that the value of the absorption of the optimum water contained in the test sample 6 of 1.07 % and minimum water absorption contained in the test sample 5 of 0.63 %. More and more use of coconut fibers resulted in the increasing value of water absorption in concrete.

4.4. Compressive Strength of Concrete on 3 Days

Table 2. Compressive Strength Result on 3 Days

No	Sample Kode	Percentage Coconut Fiber + GGBFS (%)	Compressive Strength F'c (Mpa) 3 Days
1	BN	0%S+0%G	14,35
2	SU1	0,23%S+0%G	13,59
3	SU2	0,63%S+0%G	15,12
4	SU3	0,23%S+35,5%G	15,77
5	SU4	0,63%S+35,5%G	16,79
6	SU5	0,23%S+43,5%G	16,64
7	SU6	0,63%S+43,5%G	16,97

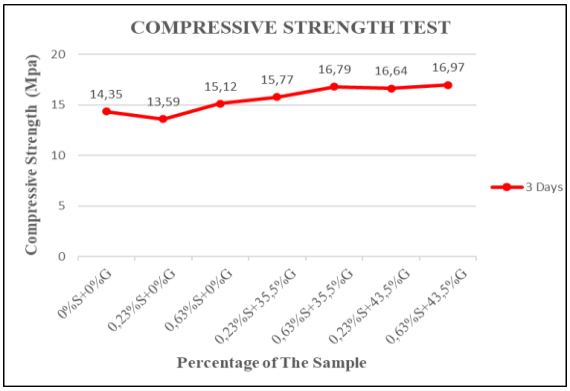

Figure 5. Graph of Compressive Strength on 3 Days

From table 2 and figure 5 the results obtained from the compressive strength at the age of 3 days with the optimum compressive strength on the SU6 by 16,97 Mpa and compressive strength minimum are on the SU1 by 13,59 Mpa. So with the addition of the GGBFS make the compressive strength increased at the time of fastening the beginning or 3 days compared to only wear the coconut fibers in the concrete.

4.5. Compressive Strength of Concrete on 7 Days

Table 3. Compressive Strength Result on 7 Days

No	Sample Code	Percentage Coconut Fiber + GGBFS (%)	Compressive Strength F'c (Mpa) 7 Days
1	BN	0%S+0%G	24,51
2	SU1	0,23%S+0%G	19,99
3	SU2	0,63%S+0%G	21,77
4	SU3	0,23%S+35,5%G	21,93
5	SU4	0,63%S+35,5%G	22,84
6	SU5	0,23%S+43,5%G	17,28
7	SU6	0,63%S+43,5%G	20,40

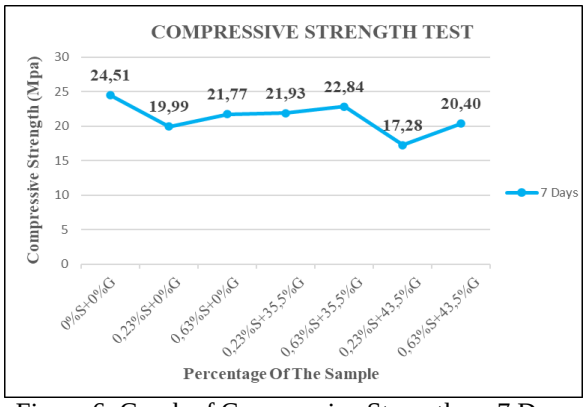

Figure 6. Graph of Compressive Strength on 7 Days

From table 3 and figure 6 the results obtained from the compressive strength at age of 7 days with the optimum compressive strength on the SU4 by 22,84 Mpa and compressive strength minimum are on the SU5 by 17,28 Mpa. So with the existence of the GGBFS and coconut Fibers create a strong press experience decrease compared to normal concrete as the control of a compressive strength, a strong decline press occurs due to the presence of the GGBFS and fibers of coconut create a drop time of pavement concrete that affect the strength of concrete at the age of 7 days.

4.6. Compressive Strength of Concrete on 28 Days

Table 4. Compressive Strength Result on 28 Days

No	Sample Code	Percentage Coconut Fiber + GGBFS (%)	Compressive Strength F'c (Mpa) 28 Days
1	BN	0%S+0%G	30,03
2	SU1	0,23%S+0%G	24,63
3	SU2	0,63%S+0%G	30,20
4	SU3	0,23%S+35,5%G	30,77
5	SU4	0,63%S+35,5%G	32,32
6	SU5	0,23%S+43,5%G	28,16
7	SU6	0,63%S+43,5%G	28,31

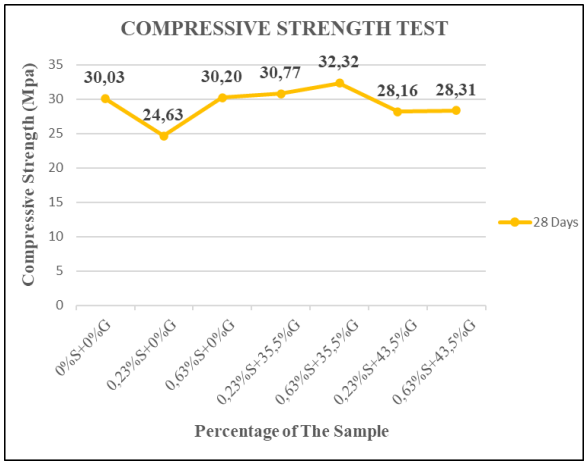

Figure 7. Graph of Compressive Strength on 28 Days

From table 4 and figure 7 the results obtained from the compressive strength at age of 7 days with the optimum compressive strength on the SU4 by 32,32 Mpa and compressive strength minimum are on the SU1 about 24,63 Mpa. So with the existence of the GGBFS and coconut fibers on concrete create a strong press to have an increase in the percentage of substitution of the GGBFS 35.5% and coconut fibers0.63 percent, at the age of 28 days the concrete increased the compressive strength on the percentage of the GGBFS 35,5%, this indicates that in the percentage of the cement can still receive substitution resulting in increased compressive strength while on the percentage of the GGBFS 43,5% occurs decrease in compressive strength, which prove that at the percentage of the cement is not able to work for a maximum due to receive a substitution of 43.5% so that the decline in the compressive strength at the age of treatment 28 days.

4.7. Compressive Strength of Concrete on 3, 7 and 28 Days

Table 5. Compressive Strength For All Age

No	Sample Code	Compressive Strength F'c (Mpa)		
		3 Days	7 Days	28 Days
1	BN	14,35	24,51	30,03
2	SU1	13,59	19,99	24,63
3	SU2	15,12	21,77	30,20
4	SU3	15,77	21,93	30,77
5	SU4	16,79	22,84	32,32
6	SU5	16,64	17,28	28,16
7	SU6	16,97	20,40	28,31

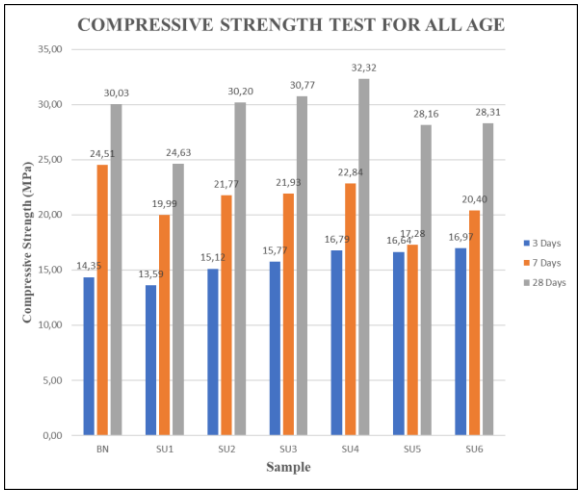

Figure 8. Compressive Strength For All Age

In table 5 and figure 8 above shows that the variation that produces compressive most high is in the test sample 4 at the age of 28 days is equal 32,32 MPa with the percentage of the GGBFS by 35,5% and coconut fibers of 0.63%, while the yield compressive most small variations of the test sample 5 at the age of 28 days is equal 24,63 MPa with the percentage of the GGBFS 43.5% and coconut fibers of 0.23%. Based on the above data, it can be concluded that the substitution of waste The ggbfs to cement has a tendency to increase the compressive strength of concrete on the percentage of substitution of the 35.5% compared with the percentage of substitution of 43.5% with coconut fiber as a natural admixture.

4.8. Kuat Tarik Belah Beton

Table 6. Kuat Tarik Belah Beton

No	Sample Code	Percentage Coconut Fiber + GGBFS (%)	Compressive Strength F'c (Mpa) 28 Hari
1	BN	0%S+0%G	2,08
2	SU1	0,23%S+0%G	2,19
3	SU2	0,63%S+0%G	2,16
4	SU3	0,23%S+35,5%G	2,14
5	SU4	0,63%S+35,5%G	2,23
6	SU5	0,23%S+43,5%G	2,08
7	SU6	0,63%S+43,5%G	2,00

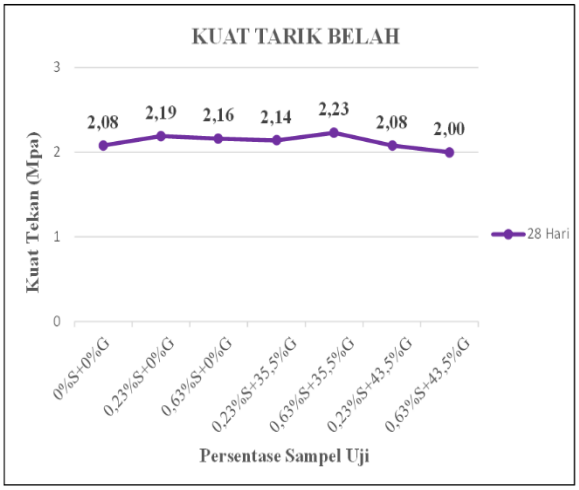

Figure 9. Split Tensile Strength

From table 6 and figure 9 above is known that the split tensile strength optimum contained in the sample test 4 by 2,23 Mpa and split Tensile strength minimum of contained in the sample test 6 amounted to 2.00 Mpa. With the addition of coconut fibers on the concrete resulted in an increase for split tensile strength of concrete while with the substitution The GGBFS by 35,5% and the addition of coconut fibers of 0.63% making the optimum increase in split tensile strength of concrete by 2,23 Mpa. The substitution of the GGBFS on the percentage of 43.5% make split tensile strength the decline compared to the substitution on the percentage of the GGBFS 35,5% against the cement.

5. Conclusion

There are some of the conclusions obtained in this study regarding the influence of waste the GGBFS as a substitute in cement and fiber coconut fiber as the material of the concrete mix, namely :

1. The value of the slump in the range of 10 cm – 12 cm, so it can be concluded that the use of superplasticizer in the concrete mixture of the ggbfs and coir fibers can affect the workability of the concrete. With the presence of superplasticizer make the slump value increases so that the obtained concrete in accordance with the slump plan.
2. Use the GGBFS and coconut fibers in the concrete mix to produce the density at the age of 28 days, which is relatively stable in the range of 2.3 to 2.4 g/cm3. Based on the use of the GGBFS is not so affect the density of the concrete.
3. Water Absorption value by using the The GGBFS gets the value of the water absorption of the highest on the test sample 6 of 1.07 % and the lowest in the test sample 5 of 0.63 %, so it can be drawn the conclusion that the use of the GGBFS and fiber coconut fiber affects absorption of water on the concrete. The higher the variation of the GGBFS (43,5%) the higher for absorption of water on the concrete.
4. The research proves that the waste of the GGBFS
5. and coconut fibers can affect the compressive strength of concrete. Concrete with the mixture of waste the GGBFS as much as 35.5% and coconut fibers as much as 0.63% on the sample test 4 get the compressive strength of the most high at the age of 28 days 32,32 MPa which increased 7,62 % from the variation of the normal concrete. The variation of the sample test 1 got the compressive strength at the age of 28 days by 24,63 Mpa which fell Variations of the test sample 2 gets the compressive strength at 28 days of 30,20 MPa, which increased by 0.56 percent. Variations of the test sample 3 got the compressive strength at 28 days of 30,77 MPa which rose at 2.46 %. Variations of the test sample 5 gets the compressive strength at 28 days of 28,16 MPa which fell to 2.66 %. Variations of the test sample 6 got a strong hit at the age of 28 days by 28,31 MPa which is where the down 5,72 %.
6. It can be concluded that the substitution of the GGBFS against the cement above
7. The research proves that the waste of the GGBFS
8. And fiber coconut fibers can affect the split tensile strength of concrete. Powerful Drag the sides of the highest on the test sample 4 by 2,23 Mpa, which increased by 7,21 % and split tensile strength low on the test sample 6 amounted to 2.00 Mpa with a decrease of 3,84 %. The use of waste slag as a material substitution to cement and fiber coconut fiber as the added material can increase the strong pull the sides of the concrete on the percentage of 35.5% of the slag and of 0.63 % coconut fibers at the age of 28 days. It can be concluded that the use of waste slag or the GGBFS more than 35.5% as a substitution material for cement that will lower the split tensile strength of concrete.

6. Suggestions

The suggestions that can be taken from this research , namely:

1. The use of the ggbfs in concrete mixture Fc 30 MPa will be better in the range of use of the 35.5% with a compressive strength 32,32 MPa and Fibers coconut fibers will be better used in the range of 0.63%.
2. Need to research more on the use of waste coconut fibers so obtained the percentage of usage is optimum on the quality of concrete that can be utilized for the construction of the construction and can reduce the waste coconut fibers. In doing research, should be more thoroughly to the selection, storage and handling of the material or of the material and samples of the concrete so that the quality of the concrete maintained.
3. At the time the special care is needed of the testing materials that can be used, the mix design, curring control, and compressive test to get the results as expected .

7. Thank You

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Analysis of Drainage System for Overcoming Floods on Untung Jawa Island, South Thousand Islands District, DKI Jakarta

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Abstract

In general, drainage can be used to reduce excess water, whether from rainwater, seepage, or excess irrigation water from an area, so that the function of the area is not disturbed. This study aims to analyze and examine the drainage problems that exist on Untung Jawa Island, South Seribu Islands District, DKI Jakarta, the drainage channels are poorly maintained and frequent flooding. The data used in this study are primary and secondary data, in planning the calculation of flood discharge a 2-year return period is used. For the calculation of flood discharge, the plan uses a rational method and is added to household flood discharge, and the results will be compared with the existing condition of the drainage channel on Untung Jawa Island, South Thousand Islands District, DKI Jakarta. The results obtained that the largest design flood discharge is 3.277 m3/second on channel A8 and the smallest design flood discharge is 0.094 m3/second on channel C5. for the existing condition of the drainage channel, there are 11 channels that fall into the unsafe category because the condition of the existing channel capacity is less than the planned flood discharge, namely channels A2, A3, A4, A5, A6, A7, A8, A10, B2, B3 and B4. Infiltration wells are planned to accommodate the excess flood discharge, and it takes 19 infiltration wells on channel B4, 13 pieces on channel B3, 9 pieces on channel A8, 6 pieces on channel A2, A3, A6 and B2, 4 pieces on channel A7 , 2 pieces on channel A10, 1 piece on channel A4 and A5.

Keywords:
Drainage, Hydrological Analysis, Infiltration Wells, Planned Flood Discharge.

1. Preliminary

Population growth in Indonesia is increasing every year and requires a lot of land to be used as housing, one of which is in the Thousand Islands area. The lack of land and the large number of residential developments and their supporting facilities make a lot of inappropriate land use. The impact of many human activities and the lack of attention to the environment in the Thousand Islands area causes problems, namely the presence of puddles when it rains. When the rainfall is quite high, it is not uncommon for water to stagnate on the roads, this can be due to the many clogged drainages or the unconnected drainage on the island. Stagnant water that occurs can also be caused by the lack of functioning of the drainage system or inadequate channels to accommodate water discharge. If no action is taken to overcome this problem, it can disrupt the activities of the community and tourists who are visiting the island.

Planning and maintenance of drainage channels is very necessary to maintain the flow of water and minimize the occurrence of inundation. According to (Suripin 2020), drainage has the meaning of draining, draining, throwing or diverting water. In general, drainage is defined as a series of water structures that function to reduce and/or remove excess water from an area or land, so that the land can be used optimally.

So in this case it is necessary to analyze the drainage system to deal with flooding on Untung Jawa Island, South Seribu Islands District, DKI Jakarta, which based on the zoning map of the South Thousand Islands District is a residential zone in the island region and it is not uncommon for the roads on Untung Jawa Island to be flooded with water. at times of high rainfall.

1.1 Research Purposes

Based on the introduction above, this research has the following objectives.

1. Knowing the condition of the existing drainage channel on Untung Jawa Island, South Thousand Islands District, DKI Jakarta.
2. Knowing the amount of flood discharge capacity on Untung Jawa Island, South Thousand Islands District, DKI Jakarta.
3. Knowing whether or not a new drainage system planning and its complementary buildings are needed on Untung Jawa Island, South Thousand Islands District, DKI Jakarta.

2. Literature Review

In the field of civil engineering, drainage can generally be defined as a technical action to reduce excess water, either from rainwater, seepage, or excess irrigation water from an area/land, so that the function of the area/land is not disturbed. Drainage can also be interpreted as an attempt to control the quality of groundwater in relation to salinity. (Suripin 2020)

2.1 Hydrological Cycle

Hydrology is the study of the intricacies of water, its occurrence and distribution, its physical and chemical properties, and its response to human behavior. While the Hydrological Cycle is a continuous process in which water moves from the earth to the atmosphere and then back to the earth again. (Triatmodjo 2016)

2.2 Frequency Analysis

The purpose of frequency analysis of hydrological data is related to the magnitude of extreme events related to the frequency of their occurrence through the application of probability distributions (Suripin 2020). The analyzed hydrological data is assumed to be independent and randomly distributed and stochastic. In statistics, there are several kinds of frequency distribution and four types of distribution that are widely used in the field of hydrology are the Normal Distribution, Log Normal Distribution, Log-Person III Distribution, and Gumbel Distribution. Then from the four distribution methods selected based on the requirements that must be met in table 1 as follows.

Table 1. Statistical Selection Conditions for a Distribution

Distribution Type	Distribution Terms
Normal Distribution	Cs = 0 and Ck = 3
Normal Log Distribution	Cs > 3 and Ck > 3
Gumbel Distribution	Cs = 1,139 and Ck = 5,402
Person III Log Distribution	Cs among 0 – 0,9

(Source : Hidrologi Terapan (2015:250)

Before analyzing rain data with one of the distributions above, it is necessary to approach with statistical parameters to determine the right distribution to use. These parameters include:

Coefficient of Variation (Cv)

$$\frac{S}{X} \quad (2.1)$$

Coefficient of Skewness (Cs)

$$\frac{n\sum(X_i-X)^3}{(n-1)(n-2)S^3} \quad (2.2)$$

Coefficient of Kurtosis (Ck)

$$\frac{n^2\sum(X_i-X)^4}{(n-1)(n-2)(n-3).S^4} \quad (2.3);$$

Standard Deviation (S)

$$\sqrt{\frac{\sum_{i=1}^{n}(X_i-X)^2}{n-1}} \quad (2.4)$$

2.3 Rainfall Intensity

Rain intensity is the height or depth of rainwater or height of rainwater per unit time (Suripin 2020). If short-term rain data is not available, only daily rain data is available, then the rainfall intensity can be calculated using the Mononobe formula.

$$I = \frac{X_T}{24}\left(\frac{24}{tc}\right)^{\frac{2}{3}} \quad (2.5)$$

2.4 Time Coefficient

The formula for the concentration time can be written as follows.

$$t_c = \left(\frac{0{,}87 \; x \; L^2}{1000 \; x \; S_0}\right)^{0{,}385} \qquad (2.6)$$

2.5 Design Plan Debit

(Suripin 2020) explains that the use of the rational method in drainage areas with several sub-drainage areas can be done by approaching the combined C value or average C and the rainfall intensity is calculated based on the longest concentration time (SNI 2415:2016).

Rational Method Formula:

Q = 0,278. C.I.A (2.7)

With:

Q = Design flood discharge (m3/second)

C = Flow coefficient

I = Rain intensity (mm/hour)

A = Watershed area (km2 or Ha)

2.6 Dirty Water Discharge

According to the Government Regulation of the Republic of Indonesia Number 82 of 2001, wastewater is the residue from a business and or activity in liquid form. Wastewater can come from household (domestic) or industrial (industrial). Discharge of dirty water is calculated based on (03-7065-2005) (Manfaat Serta Fungsi Struktur Organisasi Bagi Perusahaan - SNI Consulting n.d.)by calculating the total discharge of clean water usage multiplied by 80% and not tied to any coefficient, and the discharge of dirty water is discharged into the existing drainage channel using a mixed system.

2.7 Calculation of Drain Dimensions

The drainage channel capacity is calculated based on steady flow conditions using the Manning formula (Kustamar, 2019). The shape of the rectangular hydraulic cross section can be expressed in the following formula.

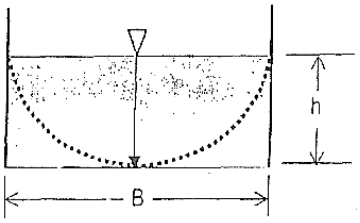

Figure 1. Rectangular drainage channel profile

(Source: Sistem Drainase Perkotaan yang Berkelanjutan, 2004:147)

Wide (A) = B.h (2.8)

Wet Around (P) = B+2h (2.9)

Hydraulic Radius = 1/2.h (2.10)

Peak Width (B) = 2.h (2.11)

Flow Speed (V) = $\frac{1}{n}.R^{\frac{2}{3}}.S^{\frac{1}{2}}$ (2.12)

Channel Discharge (Q)= A x V (2.13)

2.8 Infiltration Wells

Infiltration wells are a means to collect rainwater and seep it into the ground. Rainwater that falls on the roof of the house is not channeled into the gutter or yard, but is channeled using pipes or drains into the well so as to reduce the amount of runoff that occurs. (Lussiany 2019).

The procedure for planning rainwater infiltration wells refers to (SNI 03-2453-2002)To find the discharge of rainwater that falls to the roof surface, the Rational method mathematical equations are used which are expressed in the following form.

QIn= 0,278 x C x I x A (2.14)

With:

QIn = Design discharge that falls to the roof surface (m3/second)

C= Roof runoff coefficient

I = Roof area (ha)

A= Drainage area (m2)

3. Research Methodology

The method in writing this research is the library method and the field study method. The data used in this paper comes from several sources which are then analyzed and used to analyze the capacity of drainage waterways on Untung Jawa Island, South Thousand Islands Regency, DKI Jakarta. The steps in the preparation of this research are to collect data which includes data on the condition of existing waterways, rainfall data and population density data. After the data is collected, then data processing is carried out which includes hydrological analysis, calculation of the capacity of the existing drainage canal, calculation of planned discharge and planning of infiltration wells. As for the analysis of the planned flood discharge using the rational method, this is due to the small water catchment area.

Figure 2. Research Site Map

(Source: google Maps, 2021)

4. Results and Analysis

4.1 Selection of Distribution Type

Statistical parameters in selecting the type of distribution required are Standard Deviation (S), Skewness Coefficient (Cs), Kurtosis Measurement (Ck) and Coefficient of Variation (Cv). For the research that the researcher made, the researcher conducted an analysis through the four distribution methods presented in table 2.

Table 2. Parameters for Selection of Discharge Data Distribution

Spread Type	Criteria	Mark	Description
Log Normal	Cs > 3	0,555	unqualified
	Ck > 3	0,401	unqualified
Gumbel	Cs ≤ 1,1396	1,278	unqualified
	Ck ≤ 5,4003	0,476	unqualified
Log Pearson Type III	Cs≠0	0,555	Qualified
	Atau selain nilai diatas	0,401	Qualified
Normal	Cs = 0	1,278	unqualified
	Ck = 3	0,476	unqualified

(Source : Researcher Calculation Analysis, 2021)

4.2 Calculation of Concentration Time

The things that need to be considered in calculating the time of concentration of waterways are first to find the channel slope value (S), the crew hardness value (n) and the flow coefficient value (C). An example of the calculation of Channel A1, and the results of the complete concentration time calculation are presented in table 3.

$$S = \frac{14 - 13}{29{,}26} = 0{,}0342$$

Next look for the values of t0 and td:
L value = length of the farthest point to the drainage channel (m)

$$t_0 = \left[\frac{2}{3} \times 3{,}28 \times 29{,}26 \times \frac{0{,}017}{\sqrt{0{,}0342}}\right]$$

$$t_0 = 5{,}88 \text{ minutes}$$

Before looking for td, first find the value of the hydraulic radius (R) to get the value of the flow velocity (V):

$A = 0{,}5 \times 0{,}5 = 0{,}25\ m2$

$P = 0{,}5 + (2 \times 0{,}5) = 1{,}50\ m$

$$R = \frac{0{,}25}{1{,}50} = 0{,}167\ m$$

$$V = \frac{1}{0{,}017} 0{,}167^{\frac{2}{3}} . 0{,}034^{\frac{1}{2}} = 3{,}29\ m/second$$

$$t_d = \frac{29.26}{60\ .\ (3{,}29)} = 0{,}15\ minutes$$

So that the concentration time is obtained as follows:

$t_c = 5{,}88 + 0{,}15 = 6{,}03\ minutes$

The complete calculation of Channel Concentration Time (tc) is listed in table 3. as follows.

Table 3. waterway concentration time (tc)

Channel Number	L m	S	n	to menit	$A_{waterway}$ m2	A m2	P m	R m	V m/sec	td minutes	tc minutes
A1	29,26	0,034	0,017	5,88	0,25	0,25	1,50	0,167	3,29	0,15	6,03
A2	33,34	0,003	0,017	22,63	0,25	0,25	1,50	0,167	0,98	0,57	23,20
A3	22,84	0,004	0,017	12,83	0,25	0,25	1,50	0,167	1,18	0,32	13,15
A4	57,21	0,035	0,017	11,37	0,25	0,25	1,50	0,167	3,33	0,29	11,66
A5	48,10	0,021	0,017	12,40	0,25	0,25	1,50	0,167	2,57	0,31	12,71
A6	21,87	0,005	0,017	12,02	0,25	0,25	1,50	0,167	1,20	0,30	12,33
A7	20,68	0,048	0,017	3,50	0,25	0,25	1,50	0,167	3,92	0,09	3,58
A8	44,27	0,045	0,017	7,74	0,25	0,25	1,50	0,167	3,79	0,19	7,94
A9	53,84	0,019	0,017	14,69	0,25	0,25	1,50	0,167	2,43	0,37	15,06
A10	27,98	0,004	0,017	17,40	0,25	0,25	1,50	0,167	1,07	0,44	17,84
A11	25,70	0,039	0,017	4,84	0,25	0,25	1,50	0,167	3,51	0,12	4,97
A12	41,17	0,024	0,017	9,82	0,25	0,25	1,50	0,167	2,78	0,25	10,07
B1	170,43	0,006	0,017	82,71	0,25	0,25	1,50	0,167	1,36	2,08	84,79
B2	167,84	0,006	0,017	80,83	0,25	0,25	1,50	0,167	1,38	2,03	82,86
B3	163,67	0,006	0,017	77,84	0,25	0,25	1,50	0,167	1,39	1,96	79,80
B4	163,34	0,006	0,017	77,60	0,25	0,25	1,50	0,167	1,39	1,95	79,55
B5	164,18	0,012	0,017	55,30	0,25	0,25	1,50	0,167	1,97	1,39	56,69
C1	98,56	0,010	0,017	36,37	0,25	0,25	1,50	0,167	1,79	0,92	37,29
C2	92,93	0,011	0,017	33,30	0,25	0,25	1,50	0,167	1,85	0,84	34,14
C3	96,77	0,021	0,017	25,02	0,25	0,25	1,50	0,167	2,56	0,63	25,65
C4	100,23	0,030	0,017	21,54	0,25	0,25	1,50	0,167	3,08	0,54	22,08
C5	62,04	0,032	0,017	12,84	0,25	0,25	1,50	0,167	3,20	0,32	13,17
C6	63,87	0,031	0,017	13,42	0,25	0,25	1,50	0,167	3,15	0,34	13,75

(Source: Researcher Calculation Analysis, 2021)

4.3 Calculation of Rainfall Intensity

The return period that will be used in calculating rainfall intensity is a 2 year return period, because the catchment area is less than 10 hectares, and is located in a small town. The intensity of rainfall is calculated using the mononobe formula with the value of time of concentration (tc). The calculation of rainfall intensity on channel A1 is as follows:

$$I = \frac{136{,}64}{24} x \left(\frac{24}{6{,}03/60}\right)^{2/3} = 319{,}05\ mm/jam$$

4.4 Calculation of Drainage Rainwater Flow

Calculation of the flow of rainwater canal using the rational method, the parameters needed are equation 2.7.

The following is the calculation of the flow of rainwater from the ratio method on channel A1:

Calculation of A1 drains:

Wide (A) = 0,00898 km2

Drain Length (L) = 0,02926 km

The Slope of the Drain (S) = 0,034

Runoff Coefficient (C) = 0,40 (Village)

Concentration Time (tc) = 6,03 minutes = 0,1005 hour

Rain Intensity (I) $= \frac{523,85}{24} x \left(\frac{24}{0,18}\right)^{2/3} = 319,05$ mm/hour

Calculating flood discharge with rational method:

Q = 0,128 x C x I x A

Q = 0,128 x 0,40 x 219,10 x 0,00898 = 0,2189 m3/second

4.5 Dirty Water Discharge

The calculated dirty water discharge is the water discharge originating from household waste. The amount is influenced by the number of residents and the average water needs of the population. Estimated liquid waste disposal that is issued on average per person per day and concluded for the amount of waste water per person per day is 300 liters. The following is a calculation for channel B4.

Qak=Pn x 300 liter/person/day

Qak=Pn x 0,00347 liter/person/second

Qak=23 x 0,00347 liter/person/second

Qak=0,0784 m3/second

For channel B4 to get additional water discharge from stream A3, it will be added,

Qak B4+Qak A3=0,0784+0,4288

Qtotal B4=0,5072 m3/second

The recapitulation of flood discharge and dirty water discharge is presented in table 4. as follows.

Table 4. Planned Flood Discharge Recapitulation (Q)

Channel Number	Qp total m^3/sec	Qak total m^3/sec	Qr m^3/sec
A1	0,2189	0,2597	0,4786
A2	0,2505	0,3504	0,6010
A3	0,2902	0,4288	0,7190
A4	0,3933	0,6165	1,0099
A5	0,2012	0,6290	0,8301
A6	0,6216	1,5203	2,1419
A7	0,9814	2,0398	3,0212
A8	1,5537	3,0436	4,5974
A9	0,0513	0,1096	0,1609
A10	0,1125	0,2402	0,3528
A11	0,1844	0,3141	0,4984
A12	0,0383	0,0620	0,1004
B1	0,0388	0,2597	0,2985
B2	0,2583	0,5194	0,7776
B3	0,2655	0,4412	0,7067
B4	0,3034	0,5072	0,8106
B5	0,0371	0,1878	0,2249
C1	0,0287	0,1096	0,1383
C2	0,1143	0,2812	0,3955
C3	0,1362	0,3089	0,4451
C4	0,2124	0,3879	0,6004
C5	0,0327	0,0620	0,0947
C6	0,0701	0,1241	0,1942

(Source: Researcher Calculation Analysis, 2021)

4.6 Calculation of Drainage Channel Dimensions

The calculation of the dimensions of the existing drainage channel aims to determine whether the capacity of the channel is sufficient or not to accommodate the planned flood discharge. Furthermore, if there is an unsafe channel, a new drainage channel calculation will be carried out to determine the dimensions of the safe channel.

The following is a calculation for channel A1.

$A = 0,5 \text{ x } 0,5 = 0,25$ m2

$P = 0,5 + (2 \text{ x } 0,5) = 1,50$ m

$$R = \frac{0,25}{1,50} = 0,167 \text{ m}$$

$$V = \frac{1}{0,017} 0,167^{\frac{2}{3}} . 0,034^{\frac{1}{2}}$$

$$V = 3,29 \text{ m/second}$$

$Q_{sal} = A \times V = 0{,}25 \times 3{,}29 = 0.8234\ m^3/second$

The complete calculation of the dimensions of the existing drainage canal is presented in table 5, as follows:

Table 5. Calculation of Existing Drainage Channel Dimensions

Channel Number	b (m)	h (m)	A (m^2)	V (m/sec)	$Q_{waterway}$ (m^3/sec)	Q_{plan} (m^3/sec)	Description	Description
A1	0,50	0,50	0,25	3,29	0,8234	0,4786	$Q_{waterway} > Q_{plan}$	OK
A2	0,50	0,50	0,25	0,98	0,2439	0,6010	$Q_{waterway} < Q_{plan}$	Not Eligible
A3	0,50	0,50	0,25	1,18	0,2947	0,7190	$Q_{waterway} < Q_{plan}$	Not Eligible
A4	0,50	0,50	0,25	3,33	0,8327	1,0099	$Q_{waterway} < Q_{plan}$	Not Eligible
A5	0,50	0,50	0,25	2,57	0,6422	0,8301	$Q_{waterway} < Q_{plan}$	Not Eligible
A6	0,50	0,50	0,25	1,20	0,3012	2,1419	$Q_{waterway} < Q_{plan}$	Not Eligible
A7	0,50	0,50	0,25	3,92	0,9794	3,0212	$Q_{waterway} < Q_{plan}$	Not Eligible
A8	0,50	0,50	0,25	3,79	0,9466	4,5974	$Q_{waterway} < Q_{plan}$	Not Eligible
A9	0,50	0,50	0,25	2,43	0,6070	0,1609	$Q_{waterway} > Q_{plan}$	OK
A10	0,50	0,50	0,25	1,07	0,2663	0,3528	$Q_{waterway} < Q_{plan}$	Not Eligible
A11	0,50	0,50	0,25	3,51	0,8785	0,4984	$Q_{waterway} > Q_{plan}$	OK
A12	0,50	0,50	0,25	2,78	0,6941	0,1004	$Q_{waterway} > Q_{plan}$	OK
B1	0,50	0,50	0,25	1,36	0,3412	0,2985	$Q_{waterway} > Q_{plan}$	OK
B2	0,50	0,50	0,25	1,38	0,3438	0,7776	$Q_{waterway} < Q_{plan}$	Not Eligible
B3	0,50	0,50	0,25	1,39	0,3481	0,7067	$Q_{waterway} < Q_{plan}$	Not Eligible
B4	0,50	0,50	0,25	1,39	0,3485	0,8106	$Q_{waterway} < Q_{plan}$	Not Eligible
B5	0,50	0,50	0,25	1,97	0,4916	0,2249	$Q_{waterway} > Q_{plan}$	OK
C1	0,50	0,50	0,25	1,79	0,4486	0,1383	$Q_{waterway} > Q_{plan}$	OK
C2	0,50	0,50	0,25	1,85	0,4620	0,3955	$Q_{waterway} > Q_{plan}$	OK
C3	0,50	0,50	0,25	2,56	0,6403	0,4451	$Q_{waterway} > Q_{plan}$	OK
C4	0,50	0,50	0,25	3,08	0,7705	0,6004	$Q_{waterway} > Q_{plan}$	OK
C5	0,50	0,50	0,25	3,20	0,7997	0,0947	$Q_{waterway} > Q_{plan}$	OK
C6	0,50	0,50	0,25	3,15	0,7881	0,1942	$Q_{waterway} > Q_{plan}$	OK

(Source: Researcher Calculation Analysis, 2021)

4.7 Infiltration wells

Based on the calculation of the dimensions of the existing drainage channel in table 4.4, found channels that fall into the "unsafe" category, because the channel capacity is not sufficient to accommodate the planned flood discharge, namely in channels A2, A3, A4, A5, A6, A7, A8, A10 , B2, B3 and B4. In order to overcome this problem, infiltration wells will be planned.

Infiltration well planning is used to drain excess water discharge in several "unsafe" channels, by draining rainwater that falls from the roofs of residents' houses to seep into the ground by collecting the water in infiltration wells.

Infiltration Well Discharge Design Plan:

1. Infiltration = Discharge that can be absorbed by infiltration wells (m3/s)
2. Type of empty well circular view
3. The diameter of the well is planned to be 1 m = R = 0.5 m
4. F = geometric factor/circumference = $2\pi R$ = 2 x 3.14 x 0.5 = 3.14 m
5. H = Assumed depth of infiltration well = 1 m
6. K = For the value of soil permeability, it is assumed that the type of soil in Untung Jawa Island is sand with a value of K = 10-1 - 10-3 cm/s, the K value of 10-2 cm/s = 10-4 m/s is used.
7. The inlet/output channel uses a pralon pipe.
8. Well walls can use masonry without plastering
9. The bottom of the well and the gaps between the excavation and the wall where the water seeps are filled with fibers/gravel.

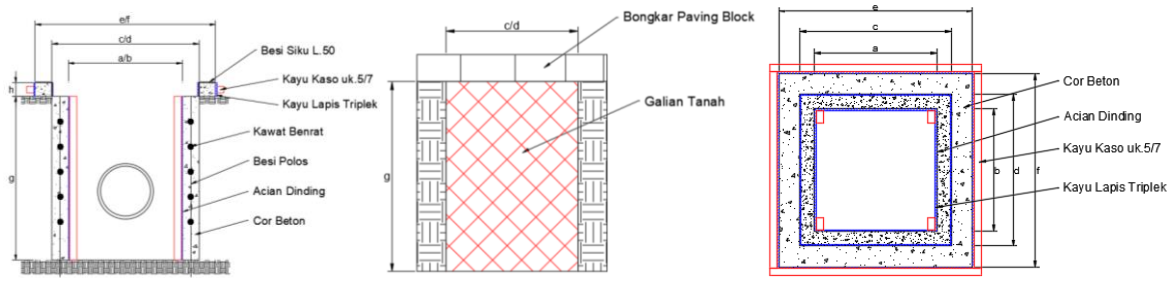

Figure 3. Infiltration Well Details
(Source: Researcher Calculation Analysis, 2021)

To find out the rain discharge that enters the infiltration well, it is necessary to first know the rain discharge that falls through the roofs of residents' houses. An example of a calculation using Channel A2 is as follows:

Known:
Croof = 0,75 (based on Roof Runoff Coefficient Standard)
IA2 = 89,25 mm/hour
Aroof = 0,00319 km2
Maka, Qin adalah:
Qin = 0,278 . 0,75 . 29,14 . 0,008 = 0,0593 m3/sec

The calculation of the rain discharge that falls to the roof surface will be presented in full in table 6. as follows:

Table 6. Calculation of Existing Drainage Channel Dimensions

Channel Number	C	I mm/hour	A_{roof} km^2	Q_{in} m^3/sec
A2	0,75	89,25	0,0032	0,0593
A3	0,75	130,28	0,0027	0,0744
A4	0,75	141,19	0,0066	0,1933
A5	0,75	133,28	0,0090	0,2507
A6	0,75	136,06	0,0032	0,0897
A7	0,75	310,01	0,0027	0,1768
A8	0,75	182,46	0,0065	0,2489
A10	0,75	106,35	0,0024	0,0536
B2	0,75	38,20	0,0093	0,0738
B3	0,75	39,17	0,0034	0,0281
B4	0,75	39,25	0,0030	0,0247

(Source: Researcher Calculation Analysis, 2021)

Furthermore, it is necessary to know the discharge of rainwater that enters the infiltration well (Qresapan). Calculation refers to Channel A2, as follows:

Q absorption = F . K. H
= 3,14 . 10-4 . 1
= 0,00031 m3/sec

The complete Qresapan calculation will be presented in table 7, as follows:

Table 7. Calculation of Existing Drainage Channel Dimensions

Channel Number	Rainwater infiltration discharge in Infiltration Wells			
	F (m)	K (cm/sec)	H (m)	Q absorption (m^3/sec)
A2	3,14	0,0001	1	0,000314
A3	3,14	0,0001	1	0,000314
A4	3,14	0,0001	1	0,000314
A5	3,14	0,0001	1	0,000314
A6	3,14	0,0001	1	0,000314
A7	3,14	0,0001	1	0,000314
A8	3,14	0,0001	1	0,000314
A10	3,14	0,0001	1	0,000314
B2	3,14	0,0001	1	0,000314
B3	3,14	0,0001	1	0,000314
B4	3,14	0,0001	1	0,000314

(Source: Researcher Calculation Analysis, 2021)

Furthermore, it will be found the difference in the remaining discharge from the rain discharge that has been accommodated into the infiltration well. After knowing the difference in the remaining discharge from the rain discharge that has been accommodated into the infiltration wells, it can be seen the number of infiltration wells needed in the house area in each channel. An example calculation refers to Channel A2:

Qin = 0,0593 m3/sec (table 6)
Qabsorption = 0,00031 (table 7)
Qaccommodate = Qin – Qabsorption
= 0,0593– 0,00031
= 0,0590 m3/sec

Excess Debit A2 = 0,3570 m3/sec
Qaccommodate = 0,0590 m3/sec

$$\text{Number of Infiltration Wells} = \frac{\text{Excess Debit}}{\text{Q accommodate}} = \frac{0,2870}{0,0590} = 6 \text{ pieces}$$

Calculation of the number of infiltration wells needs in full is presented in table 8 as follows:

Table 8. Calculation of Existing Drainage Channel Dimensions

Channel Number	Qexcess (m^3/sec) (3) = (2) - (1)	Qaccommodate (m^3/sec) (6) = (5) - (4)	Number of Infiltration Wells (7) = (2) : (6)
A2	0,3570	0,0590	6
A3	0,4243	0,0741	6
A4	0,1772	0,1930	1
A5	0,1880	0,2504	1
A6	0,5207	0,0894	6
A7	0,7219	0,1765	4
A8	2,3307	0,2486	9
A10	0,0865	0,0532	2
B2	0,4339	0,0735	6
B3	0,3586	0,0278	13
B4	0,4621	0,0244	19

(Source: Researcher Calculation Analysis, 2021)

From table 8, it is known that the number of infiltration wells needed is 73 points with details on channel B4 as many as 19 points, channel B3 as many as 13 points, channel A8 as many as 9 points, channels A2, A3, A6 and B2 as many as 6 points, channel A7 as many as 4 point, Channel A10 as much as 2 points and channel A4 and A5 as much as 1 point.

5. Conclusions

Based on the results of the discussion, the researcher can draw the following conclusions:

1. Based on the author's observations at the location, the condition of several drainage channels on Untung Jawa Island, Seribu Islands, is inadequate, the amount of organic waste such as leaves clogging the channel and sedimentation, one of which is caused by ROB water which carries grains of sand and some garbage from the sea into the water. ducts so that the ducts are difficult to clean.
2. In the calculation of the planned flood discharge which has been analyzed using the rational method of the drainage system on Untung Jawa Island, channel A8 is the channel that should accommodate the largest water discharge, which is 3.2774 M3/s, while channel C5 accommodates the least water discharge, which is 0.0947. M3/Second. However, after calculating the flood discharge capacity of the existing canal, channel A7 is the existing channel that has the largest water discharge capacity of 0.9794 M3/s while channel A2 is able to accommodate the least water discharge of 0.2439 M3/s. After comparing the existing channel discharge with the planned flood discharge, it turns out that there are 11 channels that are categorized as "unsafe" because the planned flood discharge is greater than the drainage capacity, namely A2, A3, A4, A5, A6, A7, A8, A10 channels. , B2, B3 and B4. the researchers provided a solution by building rainwater infiltration wells.
3. Based on the results of the author's analysis, the problem of flooding on Untung Jawa Island can be overcome, one of them by using infiltration wells at 72 points with details along the B4 channel as many as 19 points, along the B3 channel as many as 13 points, along the A8 channel as many as 9 points, along the There are 6 points along channel A2, A3, A6 and B2, 4 points along Channel A7, 2 points along Channel A10 and 1 point along Channel A4 and A5.

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Control of Costs and Working Time of Road Improvement Kh. Syafi'i

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Abstract

This study aims to analyze the optimum time and cost of completing the work after the acceleration of the duration of the KH Road Improvement Project. Syafi'i in Suci Village, Manyar District, Gresik Regency using the Microsfot Project. Acceleration analysis by adding working hours and considering the resulting critical path. This research is also to find out the project performance compared to the initial project plan in terms of cost and time, to find out the estimated final cost of the project needed after the acceleration of implementation.

Keywords:
Project, Microsoft Project, project cost and time

1. Introduction

1.1. Research Background

Time and cost are important in a project because the costs incurred during the developmentprocess are closely related to the time required for completion. When the work is in progress, the planned work schedule and the realization often run out of sync, resulting in an increase in implementation time and cost overruns so that project completion is hampered. Some of the causes that are a factor in the delay of a project, both in terms of nature in the form of weather, can be from a technical perspective in the form of changes inthe volume of work, or in the form of human resources, namely the lack of workers to complete the work.

It is necessary to accelerate the duration, because some projects should not be late and cannot be delayed with the aim that the project can be used immediately as needed. Although the duration is accelerated, the costs incurred are not infrequently too expensivedue to the addition of equipment or changes in implementation methods aimed at shortening the project implementation time. Given the limited manpower, an alternative that can be used to accelerate the implementation of project work is to increase the workinghours and increase the workforce so that it affects the total project cost.

1.2. Problem Formulation

The formulation of the problem to be discussed is:

1. How is the project performance compared to the initial project plan in terms of cost and time as a result of the effect of increasing project progress on project costs
2. How much is the estimated final project cost needed for project completion if the project implementation conditions are like during the review

2. Literatur Review

The first previous research conducted by Ariany Frederika in 2010 with the title "Analysis of the Acceleration of Implementation by Adding Optimum Working Hours on Construction Projects".

The problem discussed in this research is that the Super Villa Construction Project was chosenas the object of research because it experienced delays in its implementation, namely 24% dueto late material supply, and design changes made by the owner. To overcome these delays, efforts are needed to accelerate project completion with an analysis that is tried from one hourto four working hours using the Time Cost Trade Off Analysis Method. The conclusions of Ariany Frederika's research are:

1. The optimum cost is obtained by adding one working hour, with a cost reduction of Rp.784,104.16 from the normal total cost of Rp.2,886,283,000.00 to Rp.2,885,498,895.84, with a reduction of 8 days from normal time 284 days to 276 days.
2. The optimum time is obtained by adding two hours of work, by reducing the time for 14 days from the normal time of 284 days to 270 days, with a reduced cost of Rp. 700,377.35 from the normal cost of Rp. 2,886,283,000.00 which becomes Rp. 2,885,582. 622.65.

Research II – Sumaryani (2010)

The second previous research conducted by Sumaryani in 2010 with the title "Analysis of the Concept Value of Results in the Construction Project of the 4-Story Two-wheeled Parking Building UMS with the 2007 Microsoft Project Program".

The problems discussed in this research are how much cost has been spent for the implementation of this project and how much is the estimated total cost and time for project completion. Sumaryani's research conclusions are:

The amount of costs that have been spent until the 27th week for the implementation of this project is Rp. 3,146.038,880.92

Estimated total project completion cost is 17 August 2010 (295.15 days)

3. Research Method

3.1. Data Source

The source of the data in this study was obtained from the Department of Public Works andSpatial Planning of Gresik Regency for the Highways Sector. The data - the data needed inthe work of this research are:

1. Project planning drawings
2. Project time schedule
3. Budget plan (RAB) and unit price analysis

3.2. Data Analysis Method

Efforts are being made to speed up the execution time of the work by increasing the workinghours, so that labor productivity increases. The implementation of TCTO requires the calculation of crash duration and crash cost. To calculate crash cost and crash duration, it isnecessary to take the following steps:

1. Preparation of network diagrams
2. Analyze remaining work activities
3. Application of crashing
4. Application of time and cost exchange analysis
5. Evaluate the results of TCTO analysis

4. Analysis and Discussion

The following is the scope of work for KH Road Improvement. Syafi'i, which is located in theHoly Village, Manyar District, Gresik Regency

Picture 1. KH Syafi'i Road Improvement Work Items

No	DESCRIPTION	UNIT	QUANTITY
1	2	3	4
	General Division 1		
-	Pas. Direksi Keet	Unit	01.00
-	Measurement and Installation of Blow Plank	Ls	01.00
-	Pas. Project Nameplate	Bh	01.00
-	Traffic Security	Ls	01.00
-	Mobilization Demobilization Tools	Ls	01.00
-	Cleaning	Ls	01.00
-	Cleaning Quality Control Bending Pavement	Ls	01.00
-	Quality Control Precast Channel	Ls	01.00
	Number of Division 1 (Entry On Recapitulation of Quantity and Price List)		
	Division 2 Drainage		
-	U-Ditch Uk Channel Procurement. 100x100x120cm K-350 G.10	Pos	638.00
-	Installation of U-Ditch UK Channel. 100x100x120cm K-350 G.10	Pos	638.00
-	Procurement of U-Ditch Cover 100x120 K-350 G. 10 T (Fabrication)	Pos	638.00
-	Installation of U-Ditch Cover 100x120 K-350 G. 10 T (Fabrication)	Pos	638.00
-	Procurement of Monolith Box 120,120,120 cm K-350 G. 20 T (fabrication)	Pos	14.00
-	Installation of Monolith Box 120.120.120 cm K-350 G. 20 T (fabrication)	Pos	14.00

	Number of Division 2 (Entry On Recapitulation of Quantity and Price List)		
	Division 3 Earthworks and Geosynthetics		
3.1.(1)	Regular excavation (using heavy equipment)	M3	1624.14
-	Hard Soil Excavation	M3	53.09
-	Solid Sand Urugan	M3	98.28
3.2.(2)	Urugan Choice (sirtu)	M3	279.32
03.03	Road Body Preparation	M2	1183.23
3.4.(2)	Felling of Trees	Bh	52.00
-	Tree Planting	Bh	52.00
3.5.(3)	Installation of Geotextile Woven 250gr/m2	M2	2310.37
	Number of Division 3 (Entry On Recapitulation of Quantity and Price List)		
	Division 5 Grained Pavement		
5.1(2)	Grade B Aggregate Foundation Layer> 65%	M3	473.32
5.6(1)	Foundation Layer With Cement Treated Base (CBT)	M3	742.62
	Number of 5th Division (Included In The Recapitulation Of Quantity and Price List)		
	Division 6 Pavement Asphalt		
6.1(1)	Fastening Absorbent Layer (1Liter = 1.25m2)	Liter	2163.84
6.1.(2)	Adhesive Coating (1Liter = 2.5m2)	Liter	1081.92
6.3.(5)	Laston Wear Coating (AC-WC) = 4cm	M2	2676.80
-	Laston Lapis Aus (AC-WC) = 5cm	M2	28.00
6.3(6a)	Laston Intermediate Layer (AC-BC)	M3	160.61
	Number of 6th Division (Entry On Recapitulation of Quantity and Price List)		
	Division 7 Structure		
-	Concrete K-225	M3	11.94
-	Reinforcing Stell 24 Plain	Kg	249.53
-	Reinforcing Steel 32 Thread	Kg	425.54
-	Provision and Erection of Bamboo Crushed Foundations	M1	168.00
-	Reinforcing Stell Wiremesh M10-150	M2	28.00
	Number of Division 7 (Entry On Recapitulation of Quantity and Price List)		
	Division 9 Daily Work and Other Occupations		
-	Thermoplastic Road Markings	M2	110.38
-	Road Utility Pole Removal	Ls	7.00
	Number of 9th Division (Entry On Recapitulation of Quantity and Price List)		
-	PEKERJAAN K3 (KESEHATAN KESELAMATAN KERJA)		30.00
-	Helmet	Bh	30.00
-	Mask	Bh	30.00
-	Glove	Psg	30.00
-	Safety Shoes	Psg	30.00
-	P3K	Set	1.00
-	BPJS	Ls	1.00

From the results of the analysis of the work above using the Ms. software. Project, the criticalpath is obtained as follows:

ID	JOB DESCRIPTION	NORMAL DURATION (Day)
2	Pas. Direksi Keet	14
5	Pengamanan Lalu Lintas	150
7	Mobilisasi Demobilisasi Alat	14
8	Pembersihan	150
10	Quality Control Perkerasan Lentur	7
11	Quality Control Saluran Precast	7
12	Quality Control Saluran Precast	7
14	Pengadaan Saluran U-Ditch Uk. 100x100x120 cm K-350 G-10 (Fabrikasi)	63
21	Galian Tanah Biasa (Menggunakan Alat Berat)	63
23	Urugan Pasir Padat	63
24	Urugan Pilihan (Sirtu)	21
45	Marka Jalan Thermoplastic	7

Source : Ms. Project

The calculation of the duration for the acceleration of work on the critical path obtained from the output of Ms. The project planer can be described as follows:

aa. Normal working time: 8 hours/day
bb. Acceleration by using shift work: 3 shifts

For example for Solid Sand Backfill work:

1. Number of workers = coefficient x volume of work
   5. Foreman = 6. 0,139 7. x 8. 98,2 9. = 10. 13,69
   11. Worker = 12. 2,625 13. x 14. 98,2 8 15. = 16. 257,9 9
2. Number of jobs per day = Number of workers: duration
   17. Foreman = 18. 13,69 19. : 20. 63 21. = 22. 0,22
   23. Worker = 24. 257,99 25. : 26. 63 27. = 28. 4,10
3. Wages of labor = Wages x Number of workers
   29. Foreman = 30. 32.143 31. x 32. 0,22 33. = 34. 6.985
   35. Worker = 36. 17.857 37. x 38. 4,10 39. = 40. 73.125
4. Wages for 3 shift workers = Wages for labor x 3 shifts
   41. Foreman = 42. 6.985 43. x 44. 3 45. = 46. 20.955
   47. Worker = 48. 73.125 49. x 50. 3 51. = 52. 219.375
5. Average work productivity per day = Volume: normal duration
   53. = 54. 98,28 55. 56. 6 57. = 58. 1,56 59. m3/day 3
6. Average work productivity per day = Volume: normal duration
   60. = 61. 1,56 62. : 63. 8 64. = 65. 0,20 66. m3/hour
7. Accelerated duration = 2 shifts x hourly work productivity
   67. = 68. 16 69. x 70. 0,20 71. = 72. 3,12 73. m3/hour
8. 3 shift work productivity = work productivity per day + accelerated duration
   74. = 75. 1,56 76. + 77. 3,12 78. = 79. 4,68 80. m3/day
9. Duration of acceleration = volume of work: work productivity 3 shifts
   81. = 82. 98,28 83. : 84. 4,68
   85. = 86. 21,00 87. day 88.
10. Acceleration duration results in normal duration with acceleration duration
    89. = 90. Normal duration 91. - 92. Acceleration duration
    93. = 94. 63 95. - 96. 21,00
    97. = 98. 42,00 99. da y 100.
11. Normal Cost = Total labor wage x duration

Foreman = 101. 85 6.9 102. 103. 3 (104. 105. 9 440.04
Worker = 106. 125 73. 107. 108. 3 (109. 110. 874 4.606.
111. 112. 113. 114. 115. 923 5.046.

12. Acceleration Cost = Acceleration duration x 3 shift labor wages

Foreman =	42,00	x	20.955	=	880.097
Worker =	42,00	x	219.375	=	9.213.749
					10.093.846

$$\text{Cost slope} = \frac{Acceleration\ Fee - Normal\ Fee}{Normal\ duration - acceleration\ durati}$$

$$\frac{10.093.846 - 5.046.923}{63 - 42,00}$$

240.330

4.1. Calculation of Time and Cost Differences Normal Time Duration and Accelerated Time Duration

With the help of the Microsoft Project program, an analysis of the time and cost exchange was carried out by compressing or accelerating the critical path until the duration and cost of the project were obtained after accelerating.

This acceleration is intended so that the project completion can be in accordance with the planned schedule, namely in the 21st week, on the KH Road Improvement project. Syafi'i, the direct costs incurred are Rp. Rp3,629,707,782.19 With a duration of 150 days to complete the work.

Table 2. Total quick costs of activities on the critical path

ID	NORMAL DURATION (DAY)	ACCELERATION DURATION (DAY)	NORMAL COST (RUPIAH)	ACCELERATION COST (RUPIAH)	COST SLOPE
21	63	42	5.899.109	11.798.217	280.910
23	63	42	5.046.923	10.093.846	240.330
24	21	7	12.557.737	25.115.474	1.793.962
45	7	2	1.980.855	3.961.710	848.938

From the table above, it can be seen that with the project duration after acceleration, weget:

1. Completion duration : 150 day
   Total completion duration : Rp 3.629.707.782,19
2. Duration after accelerated : 109 day
   Total after accelerated : Rp. 3.632.871.922,19
3. Acceleration duration : Completion duration – acceleration duration
   : 150 – 109
   : 41 day
4. Acceleration Cost : Acceleration fee – completion fee
   116.:Rp3.629.707.782,19 - Rp3.632.871.922,19
   : Rp 3.164.140,00

5. Conclusion and Suggestions

Based on the results of the analysis that has been carried out in this writing, there are the following conclusions:

1. The results of the development schedule for the improvement of Jalan KH. Syafi'i Gresik Regency with the TCTO (Time Cost Trade Off) method, the completion time due to acceleration is 109 days from the initial schedule it takes 150 days to complete the project, there are 41 days to complete the project with no critical path

2. The costs obtained after accelerating the project are Rp. 3,632,871,922.19 of the original project value of Rp. 3,629,707,782.19. There was an additional project cost of Rp. 3.164.140.00 to complete the project on time with no critical path / path in it. In future research, it is expected to develop research related to the TCTO (Time Cost Trade Off) method, for example by increasing the number of workers and analyzing the calculation of materials used to accelerate the completion of project work

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