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as **Presenter**

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Table of contents

Volume 602

2019

Previous issue Next issue

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View all abstracts

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Published online: 6 September 2019

Preface

Papers

Sustainable Innovation in Electrical Engineering

OPEN ACCESS 012030

Towards hand gesture-based control of virtual keyboards for effective communication

Muhammad Ilhamdi Rusydi, Oktrison, Willy Azhar, Samuel W Oluwarotimi and Febdian Rusydi

+ View abstract PDF

OPEN ACCESS 012031

Development of rogowski coil sensor for partial discharge detection

E P Waldi, A Y Frenzi, R Fernandez, Darmawan, Darwison, H D Laksono, Aulia, A Hazmi, A Andre, H Abral, S Arief, Z Nawawi, M H Ahmad and N Hozumi

+ View abstract PDF

OPEN ACCESS 012032

Static VAR compensator for improving voltage profiles and transmission losses: Case study in Batam

S Yunus, Y I Rahmi, R Nazir, Aulia and U G S Dinata

+ View abstract PDF

OPEN ACCESS 012033

Modification of arms patch of double layer printed antenna for partial discharge detection

U Khayam and Y M Hamdani

+ View abstract PDF

OPEN ACCESS 012034

Partial discharge signal denoising by using hard threshold and soft threshold methods and wavelet transformation

A Zaeni, T Kasnalestari and U Khayam

+ View abstract PDF

OPEN ACCESS 012035

Preliminary results on the development of monoester type insulating oil from coconut oil

A Rajab, F E Putra, J S Ramadhani, M S I Silitonga, R Kurniawan, K Qibran, M Latif and M I Hamid

+ View abstract PDF

Industrial and Manufacturing Systems

OPEN ACCESS 012036

Formulation of optimization model of raw material composition to achieve clinker quality standards (Case study PT Semen Padang Plant IV)

S Rijal, A S Indrapriyatna and A H B Adi

+ View abstract PDF

The effect of alum addition on shrinkage temperature, chemical properties, and morphology in the manufacture of vegetable-tanned leather

E Kasmudjiastuti, B Pidhatika, G Griyanitasari and I F Pahlawan

+ View abstract PDF

OPEN ACCESS 012045

Assessing safety performance of tire retreading production employees

P Fithri, E Wirdianto and A Yoselina

+ View abstract PDF

OPEN ACCESS 012046

Chili sauce production planning model considering raw material availability: An application of Mixed Integer Linear Programming Method

Jonrinaldi, A H B Adi and R Novira

+ View abstract PDF

OPEN ACCESS 012047

Designing of welding jig for productivity improvement and cost-savings in thresher's cover assembly: A Case Study on CV Citra Dragon Assembly Plant

I H Mulyadi, N T Putri and F Muhammad

+ View abstract PDF

OPEN ACCESS 012048

Technical characteristics' determination of crumb rubber product by using quality function deployment (QFD) phase I

R Ginting and Widodo

+ View abstract PDF

OPEN ACCESS 012049

Optimization of significant factors of cement compressive strength at PT Semen Padang

P Fithri, D Meilani, N T Putri and F H Chotimah

+ View abstract PDF

OPEN ACCESS 012050

Waste assessment using a lean approach in receiving process of container terminal: a case of Teluk Bayur Port

E Amrina, I Kamil and D Rahmad

+ View abstract PDF

OPEN ACCESS 012051

The evaluation of bullwhip effect on distribution system of a supply chain using centralized demand information method

I Kholidasari, JR A Bidiawati and M E Sari

+ View abstract PDF

Innovation in Environmental Engineering

OPEN ACCESS 012052

The use of protein binder from shaving waste for leather finishing: Judging from the physical, chemical, and morphological properties of lizard skin leather

S Sutyasmi, I F Pahlawan and G Griyanitasari

+ View abstract PDF

OPEN ACCESS 012053

Food packaging development of bioplastic from basic waste of cassava peel (*manihot uttilisima*) and shrimp shell

Dasumiati, N Saridewi and M Malik

+ View abstract PDF

OPEN ACCESS 012054

Effect of tannery wastewater exposure on chromium detected in the gill of *oreochromis niloticus*

T Edwin, T Ihsan and H T Tamsin

+ View abstract PDF

OPEN ACCESS 012055

Minimization of household hazardous solid waste (HHSW) with 4R concepts (reduce, reuse, recycle and recovery) in Padang City, Indonesia

Y Ruslinda, S Raharjo, Y Dewilda, Hidayatullah and R Aziz

+ View abstract PDF

OPEN ACCESS 012056

Greenhouse knockdown in Merauke

M Alahudin, R D Latuheru and N L S Suryaningsih

+ View abstract PDF

OPEN ACCESS 012057

Distribution of organic contamination based on depth stratification in Maninjau Lake, Indonesia

P S Komala, A Nur and I Nazhifa

Mechanical and Thermal Systems

The determination of workspace and the performance evaluation of PRoM-120 with 3 and 4 kinematic constants

Adriyan and Sufiyanto

+ View abstract PDF

OPEN ACCESS 012065

Thermal characteristics and phase transformation of iron ores containing varied crystalline water with coal mixtures

M M F Sinuhaji, S Harjanto and A Hapid

+ View abstract PDF

OPEN ACCESS 012066

The influence of some solution candidate on the performance of boundary element inverse analysis in detecting rebar corrosion

S Fonna, Gunawarman, S Huzni and A K Ariffin

+ View abstract PDF

OPEN ACCESS 012067

Sound absorption characteristics of the natural fibrous material from coconut coir, oil palm fruit bunches, and pineapple leaf

M Rusli, M Irsyad, H Dahlan, Gusriwandi and M Bur

+ View abstract PDF

OPEN ACCESS 012068

Effect of garlic oil as lubricant additive into coconut and palm oils on the physical and tribological properties

D Gasni, D Chandra, A A Putra and R Fajri

+ View abstract PDF

OPEN ACCESS 012069

Natural frequencies of twisted cantilever beam

J Malta, Jefri, M Bur and E Satria

+ View abstract PDF

OPEN ACCESS 012070

Corrosion Resistance of β type titanium (TNTZ) in 3%NaCl solution

J Affi, Gunawarman, Y Yetri, H Fajri, D Juliadmi, N F Nuswantoro, Nurbaiti, S Fonna, D H Tjong and M Manjas

+ View abstract PDF

OPEN ACCESS 012071

Hydroxyapatite Coatings on Titanium Alloy TNTZ using Electrophoretic Deposition

Gunawarman, N F Nuswantoro, D Juliadmi, H Fajri, A Budiman, D H Tjong and M Manjas

+ View abstract PDF

OPEN ACCESS 012072

Synthesis and characterization of calcium precursor for hydroxyapatite synthesis from blood clam shell (*Anadara antiquata*) using planetary ball mill process

Gunawarman, J Affi, Y Yetri, Ilhamdi, D Juliadmi, N F Nuswantoro, H Fajri, A Ahli, R Gundini and Hadi Nur

+ View abstract PDF

OPEN ACCESS 012073

Production of pig iron nugget from low-grade iron ore and pyrolyzed oil-palm-empty-fruit-bunch composites

A Setiawan, R P Suratha, S Harjanto and E Kusrini

+ View abstract PDF

OPEN ACCESS 012074

Experimental evaluation of tuned liquid column damper and tuned mass damper in a space structure model

L Son, M Bur and A D Andria

+ View abstract PDF

OPEN ACCESS 012075

Atmospheric corrosion map of structural steel in industrial area: a preliminary investigation

S Huzni, Affandi, I Tanjung and S Fonna

+ View abstract PDF

OPEN ACCESS 012076

Corrosion potential of reinforced steel in reinforced concrete in Kabupaten Bireun: Analysis of groundwater content used as a concrete mixture

R D I Kurnia, Suhaimi, S Huzni and S Fonna

+ View abstract PDF

OPEN ACCESS 012077

Design of solid desiccant air conditioning system

D A Saputra, N A Saputra, L Susanti, P Fithri and D I Putra

+ View abstract PDF

OPEN ACCESS 012078

Numerical analysis of U-shaped hysterisis steel damper with energy absorber for seismic areas

E Satria, L Son, M Bur, M D Akbar and S Haris

+ View abstract PDF

OPEN ACCESS 012079

Optimization of matrix compositions of Al_2O_3, SiO_2, Caolin, and CaO on the mechanical properties of a geopolymer composite with short carbon fiber

J Akmal, M Badaruddin, M K Ismoyo and S D Yuwono

+ View abstract PDF

OPEN ACCESS 012080

Characterization on particle size distribution of reduced lateritic nickel ore using biomass carbon reduction

F Abidin, S Harjanto, A Kawigraha and N V Permatasari

+ View abstract PDF

OPEN ACCESS 012081

The effect of solar water heater performance by variation of the plate shaped

D Harun, M I Maulana and Akhyar

+ View abstract PDF

OPEN ACCESS 012082

The experimental performance of the semi-cylindrical type of solar concentrator collector on the addition of heat storage material

D Harun, Zulfadhli and Akhyar

+ View abstract PDF

OPEN ACCESS 012083

Analysis cutting forces and surface roughness of fibre reinforced polymer for end mill processes

F Ridwan, R Havendri, O Susanti, Gusriwandi and Yulhizhar

+ View abstract PDF

OPEN ACCESS 012084

Surface characterization of the ceramic coating process on aluminum matrix composite reinforced particulate

H Sukma, D Rahmalina, B Sulaksono and E A Pane

+ View abstract PDF

OPEN ACCESS 012085

The potential of rising husk fiber/native sago starch reinforced biocomposite to automotive component

Nusyirwan, H Abral, M Hakim and R Vadia

+ View abstract PDF

OPEN ACCESS 012086

The effect of particle compositions on the activation energy of the pa6/bagasse composite

S Thalib, S Huzni, S Fonna, C H Azhari and S Zakaria

+ View abstract PDF

OPEN ACCESS 012087

Hardness and impact energy absorbed produced by Q&T steel and DQ&T teel

Yurianto, Pratikto, S Rudy, S Wahyono, Y Eflita, S Agus and U Yusuf

+ View abstract PDF

OPEN ACCESS 012088

Mechanical properties of mild steel by adding *Theobroma Cacao* Peels Extract (TCPE) inhibitor

Y Yetri, Gunawarman, R Hidayati and A Zamri

+ View abstract PDF

OPEN ACCESS 012089

The needs to investigate the effect of road surface vibrations to the fatigue life of a coil spring

M Ali, Husaini, T E Putra and N Ali

+ View abstract PDF

OPEN ACCESS 012090

Corrosion behavior of Ti6Al4V ELI coated by bioceramic HA in artificial saliva at fluctuating temperatures

R Muharni, Gunawarman and Y Yetri

+ View abstract PDF

OPEN ACCESS 012091

In vitro of Mg-1.6 Gd alloys after hot extruded for biomaterial application

O Susanti, E W Bachtiar, S Harjanto and Gunawarman

+ View abstract PDF

OPEN ACCESS 012092

Effect of coating time and protective current on thickness of paint layer of Steel ST-37 by continuous painting

Z Mansjur, Arrijani and M F Suharto

+ View abstract PDF

OPEN ACCESS 012093

Effect of Pouring Temperatures on Porosity and Mechanical Properties of Gravity Die Casting Magnesium Alloy

I P Nanda, M H Jahare, M H Idris, S B Kumar, M H Hassim and A Arafat

+ View abstract PDF

OPEN ACCESS 012094

Mechanical and degradation properties of zinc adopted magnesium alloys for biomedical application

I P Nanda, M H Hassim, M H Idris, M H Jahare, S S Abdulmalik and A Arafat

+ View abstract PDF

Sustainable Civil Engineering Solutions

OPEN ACCESS 012095

The Effects of the distance between ground-sill and double cylinder-piers against the scour patterns

M Mera and M Thaahaa

+ View abstract PDF

OPEN ACCESS 012096

Analytical Network Process (ANP) for priority setting of strategic roads handling at Tebo Regency

Yosritzal, J Permana, B Istijono, B Hidayat, T Ophiyandri and H Gunawan

+ View abstract PDF

OPEN ACCESS 012097

Simulation of the effect of floodway on Batang Kandis River flood control

Junaidi, S Marona and Dalrino

+ View abstract PDF

OPEN ACCESS 012098

Identification and analysis of application of Construction Management System (CMS) in the implementation of construction management

B Hidayat, A Suraji and R Frankly

+ View abstract PDF

OPEN ACCESS 012099

Intersection performance evaluation and designing intersection at concourse between arterial road and ramp of Medan-Kualanamu-Tebing Tinggi Highway

Amrizal and A H S Harahap

+ View abstract PDF

OPEN ACCESS 012100

Sensitivity analysis of stormpav composite pavement

E E Putri, F J H Rewani, M A Mannan, W H W Ibrahim, M R Kabit, L S Tirau, R A Chan and R Buking

+ View abstract PDF

OPEN ACCESS 012101

Infrastructure maintenance system for community development projects to improve the quality of infrastructure services in West Sumatra Province

G Vitri and H Herman

+ View abstract PDF

OPEN ACCESS 012102

The Study Of Riverbed Change And Bed-load Transport In The Middle Segment Of The Batang Kuranji River

Junaidi, E D E Putra, A Junaidi, Sunaryo and Nurhamidah

+ View abstract PDF

OPEN ACCESS 012103

Determining the priority of new road development according to the West Sumatera provincial government perception

R D Susanti, Purnawan and Yossyafra

+ View abstract PDF

OPEN ACCESS 012104

Shear behavior of fly ash reinforced concrete beam without shear reinforcement

A E Nasution, R Kurniawan and R Thamrin

+ View abstract PDF

OPEN ACCESS 012105

Determining the priority criteria and ranking of provincial bridge maintenance in West Sumatra using a combination of the Fuzzy Analytical Hierarchy Process and VIKOR-Modification methods

Yossyafra, N Angelia, Yosritzal, Meyadtri and D I Mazni

+ View abstract PDF

OPEN ACCESS 012106

Marshall immersion test of warm mix asphalt polymer using Bayat natural zeolite

A T Handayani, S N Peni and H Pandita

+ View abstract PDF

OPEN ACCESS 012107

Analysis of water balance on Lake Maninjau, West Sumatera

Sunaryo, Y D Nola, B Istijono and Junaidi

+ View abstract PDF

OPEN ACCESS 012108

Seismic retrofitting analysis using concrete jacketing and shear wall on dental hospital building of Andalas University

Fauzan, F A Ismail and Z A Jauhari

+ View abstract PDF

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LEMBAR
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Padang, 24 Februari 2020
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RIKA ARNIZA H BOMBUNA

NIP : 197307251999032003
Unit Kerja : TEKNIK

Bidang Ilmu : TEKNIK INDUSTRI
Jabatan/Pangkat : PROFESOR / PEMBINA TK I

* Dinilai oleh dua Reviewer secara terpisah
** Coret yang tidak perlu
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HASIL PENILAIAN SEJAWAT SEBIDANG ATAU PEER REVIEW
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Afdar Hotan

NIP : 195312181980021001
Unit Kerja : TEKNIK

Bidang Ilmu : TEKNIK INDUSTRI
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Optimization of significant factors of cement compressive strength at PT Semen Padang

by Prima Fithri

Optimization of significant factors of cement compressive strength at PT Semen Padang

Optimization of significant factors of cement compressive strength at PT Semen Padang

P Fithri, D Meilani, N T Putri and F H Chotimah

Industrial Engineering Department, Universitas Andalas, Padang, Indonesia

E-mail: primafithri@eng.unand.ac.id

Abstract. The quality measurement of cement production is focussed on five factors, namely: Blaine fineness (Blaine), SO3 content (SO3), Sieving on 45 μm (Sieve), Loss on ignition value (LOI) and Biomass-to-liquid value (BTL). They were measured when cement was 3rd, 7th and 28th days old. This study analyzed the effect of significant influence using multiple regression analysis and the optimal value of the five factors that affect compressive strength using the Response Surface Method (RSM). The results obtained for Portland Composite Cement(PCC)significant factor for 3rd day: Blaine: 379 m2/kg; SO_3: 1.72%; Sieving on 45 μm: 8.78%; LOI: 5.40% and BTL: 7.75%. For 7th day compressive strength: Blaine: 389 m2/kg; SO_3: 1.72%; sieving on 45 μm: 9.47%; LOI: 4.17% and BTL: 10.98%. For 28th day compressive strength: Blaine: 388 m2/kg, SO_3: 1.78%, sieving on 45 μm: 8.49%, LOI: 4.20% and BTL: 8.18%.

1. Introduction

The cement industry is one industry that is experiencing rapid development due to increasing infrastructure development. PT Semen Padang is the cement companies located at Padang City, West Sumatra. One of the products produced every day by the company is Portland Composite Cement (PCC). PCC is the cement that is currently widely produced because PCC uses a small amount of clinker and the addition of an objective material to increase the compressive strength of PCC. So that PCC can minimize environmental impacts and be more economical. The main thing that consumers concern is quality [1]–[4]. If the product quality is good, it can increase customer satisfied, and customers will always use the product. So that, to reach that goal, quality must concern to its product and also service [5]. Therefore, every company needs to carry out quality control to maintain the quality of products produced so that consumers do not switch to similar products produced by competing companies and can compete globally, both nationally and internationally.

The parameters of cement quality regarding consumers are based on the compressive strength produced by cement. Testing of compressive strength of cement was carried out when cement was 3rd, 7th, 28th days old. Testing the compressive strength of cement at the age of 3rd and 7th days was done to obtain the initial compressive strength of cement as the prediction of the final compressive strength produced later. While testing the compressive strength of cement at 28th days was done to obtain the final compressive strength of cement. PT Semen Padang controls the quality of the compressive strength of cement at compressive strengths 3rd, 7th and 28th days. The better the compressive strength produced by cement, the higher the ability of cement to hold a load so that the resulting infrastructure is stronger and durable. The compressive strength of cement is influenced by several

main factors, namely the amount of SO_3, the percentage of Dissolved Parts (BTL), the percentage of Loss On Ignition (LOI), Blaine and sieve on 45 μm [6]. Blaine, sieve on 45 μm, SO_3, LOI, and BTL, can be used to determine the amount of material in cement making. In controlling cement quality, PT Semen Padang sets quality standards for each of the factors that affect cement and cement compressive strength.

PT Semen Padang's quality control system is using a trial and error system based on a range of quality standards. PT Semen Padang has not received optimal value for each of the factors that affect the compressive strength of 3rd, 7th and 28th days of PCC. PT Semen Padang also does not know among the factors that affect the compressive strength that most significantly influences the compressive strength of PCC. As a result of not getting optimal value from the factors that affect the compressive strength, the number of additional material in cement production has not been fixed and the compressive strength of 3rd, 7th and 28th days of PCC have fluctuated.

Fluctuating compressive strength values will affect the product price and quality of PCC products. Based on these problems, the company needs to know the significant factors that influence the compressive strength of 3rd, 7th and 28th days of PCC products as a reference in controlling the quality and optimal value of these factors.

2. Method

Data processing in this study is grouped based on the objectives to be achieved; there are knowing the significant factors that affect the compressive strength of 3rd, 7th and 28th days of PCC products and measuring affects the compressive strength of 3rd, 7th and 28th days of PCC products to produce strong optimal press. The first goal was achieved by using multiple regression analysis methods. The initial step taken was the determination of the independent and dependent variables, the independent variables used are Blaine, SO3, sieving on 45 μm, LOI and BTL and the dependent variables used are compressive strength 3rd, 7th and 28th days. After that, designed the compressive strength model, the selection of the model based on the value of the largest R-Square and a signature model with the tools used are Design Expert 7. The selected model was tested for classical assumptions as validation of the model. If the model fulfilled the classical assumption test, the model is estimated with the output in the form of model coefficients, model coefficient tests and significant factors that affect compressive strength.

The compressive strength model in regression analysis was used as a model in obtaining optimal values. To get the optimal value, the factors that influence the strength of the measurement results are based on the results of PT Semen Padang. Determine optimal conditions for each independent variable by using Expert Design software 7. Selection of optimal values based on maximum desirability values (close to 1).

3. Result and Discussion

3.1. Analysis of Factors Affecting Compressive Strength 3rd, 7th and 28th days PCC Products

Analyses of factors affecting compressive strength use multiple regression method.

3.1.1. Design a PCC Cement Press Strength Model. Selection of the best model is obtained based on The recommendation of Design Expert 7. Software recommendations focus on the highest value of Adjusted R-Square and Predicted R-Square and the lowest PRESS (Prediction Error of Square) values of several models available in Fit Summary. The PCC cement compressive strength 3rd is obtained in the equation below.

$$\begin{aligned} Y = {} & 359.14233 - 1.19690\,X_1 - 55.65896\,X_2 + 8.97836\,X_3 + 44.70652\,X_4 - 38.29970\,X_5 + 0.59474\,X_1X_2 \\ & + 0.027746\,X_1X_3 - 0.15254\,X_1X_4 + 0.13773\,X_1X_5 - 12.580\,X_2X_3 + 8.07579\,X_2X_4 - 9.23518\,X_2X_5 \\ & + 0.29102\,X_3X_4 + 0.42686\,X_3X_5 - 0.85982\,X_4X_5 \end{aligned} \quad (1)$$

Information:
Y: compressive strength
X_1: Blaine
X_2: SO3
X3: sieving on 45 μm
X_4: LOI
X_5: BTL

The PCC cement compressive strength 7th is obtained in the equation below.

$$Y = 71.72916 + 0.46940\,X_1 + 11.14397\,X_2 + 2.07820\,X_3 - 4.41102\,X_4 - 2.72922\,X_5 \quad (2)$$

The PCC cement compressive strength 28th is obtained in the equation below.

$$Y = 160.24986 + 0.49244\,X_1 + 17.99002\,X_2 + 1.76364\,X_3 - 10.55869\,X_4 - 1.15262\,X_5 \quad (3)$$

3.1.2. Classic Assumption Test. Classic assumption test was done as a validation of the regression model. Classic assumption test was based on the type of model produced. If the model is linear, the classic assumption test is normality, linearity, multicollinearity, heteroscedasticity, and autocorrelation. While the nonlinear model, the classic assumption test is normality, heteroscedasticity, and autocorrelation. In this study, a linear model is found at compressive strength 7th and 28th days. A nonlinear model was found at 3rd days compressive strength. The following is a classic assumption test performed on the 7th day compressive strength of PCC products:

a. Normality Test
This test was carried out by making decisions based on the assumed probability distribution on the empirical distribution, with the hypothesis used as follows [7].
H_0: distribution residue has a normal distribution
H_1: spread residue does not have a normal distribution
Accept H_0 if the significance value> α (0.05)

Table 1. Normality Test for PCC Product 7-Day Strength Press Model.

Kolmogorov-Smirnov			Shapiro-Wilk		
Statistic	Df	Sig.	Statistic	df	Sig.
.077	101	.143	.986	101	.368

Based on the results of the normality test, the value of Sig = 0.143 is obtained. Because of the value of Sig> α, the decision taken is to accept H_0, which means the distribution ε has a normal distribution.

b. Linearity Test
Linearity test was carried out for each of the influencing factors (Blaine, SO3, sieving on 45 μm, LOI and BTL) on the 7th and 28th days compressive strength of PCC products. The significance level used is 0.05 with a hypothesis [8]:
H_0: the independent variable has a linear relationship with the dependent variable.
H_1: the independent variable does not have a linear relationship with the dependent variable.
Accept H_0 if the significance value> α (0.05). **Table 2** shows the results of the Linearity Test in Blaine with 3-Day Compressive Strength of PCC Products.

Table 2. Linearity Test in Blaine with 3-Day Compressive Strength of PCC Products.

			Sum of Squares	df	Mean Square	F	Sig.
7 Days Press Strength Blaine	Between Groups	(Combined)	16948.412	41	413.376	1.288	.184
		Linearity	2309.090	1	2309.090	7.197	.009
		Deviation from Linearity	14639.321	40	365.983	1.141	.318
	Within Groups		18928.539	59	320.823		
	Total		35876.950	100			

c. Multicollinearity Test

Multicollinearity test is based on Variance Inflation Factor (VIF) and tolerance value; if the value of VIF value is <10 and the value of tolerance is> 0.1, then it can be said that the multicollinearity test is fulfilled [9]. Multicollinearity test of 7 days compressive strength model is VIF value <10 and tolerance value> 0.1.

Table 3. Multicollinearity Test for 7-Day PCC Product Presses Strong Model

Model	Collinearity Statistics	
	Tolerance	VIF
Blaine	.866	1.154
SO3	.875	1.143
Sieving on 45	.746	1.340
LOI	.673	1.486
BTL	.863	1.159

[a] Dependent Variable: 7 Days Press Strength

d. Heteroscedasticity Test

Heteroscedasticity test is fulfilled if there is no specific pattern on the Scatterplot graph or the resulting points spread above and below the zero on the Y-axis. Figure 2 is the result of heteroscedasticity test of 7 days PCC compressive strength model.

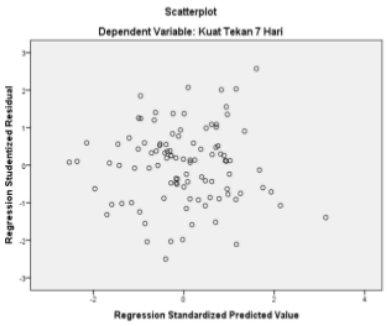

Figure 1. Heteroscedasticity test for PCC product 7-day strength press model

Heteroscedasticity test results do not form a particular pattern and the resulting points spread above and below zero on the Y-axis.

e. Autocorrelation Test
Autocorrelation test using the Durbin-Watson method, with the decision-making criteria used [10]:
1) DW values below -2 mean positive autocorrelation.
2) DW values between -2 to 2 mean there is no autocorrelation.
3) DW value above 2 means there is a negative autocorrelation.
Table 4 is the result of autocorrelation test of PCC cement compressive strength 7 days.

Table 4. Autocorrelation test of 7-Day Compressive Strength Model.

Model	Durbin-Watson
	1.198

[b] Dependent Variable: 7 Days Press Strength

Classic assumption tests are carried out for each compressive strength model 3rd, 7th and 28th days PCC, with the same steps and the same decision making. The three models have been fulfilled by the classical assumption test.

3.1.3. Model Estimation. Estimation of the regression model obtained is the regression model coefficient equation, the overall hypothesis test (F Test) and individual hypothesis test (t-test). Decision making used in hypothesis testing is if the significance value is <0.05 so that it accepts H_0. H_0 is the influence of the independent variable on the dependent variable. **Table 5** shows the results of estimation of PCC compressive strength models 3rd, 7th and 28th days.

Table 5. Estimation Results of The Model.

Compressive Strength	Model Estimation	Results
3rd Day	Model Coefficient	It has a positive effect: sieving on 45 µm, LOI, interaction between Blaine and SO3, the interaction between Blaine and sieving on 45 µm, the interaction between Blaine and BTL, the interaction between SO3 and LOI, the interaction between sieving on 45 µm and LOI and the interaction between sieving on 45 µm and BTL.
		Has a negative influence: Blaine, SO3, BTL, the interaction between Blaine and LOI, the interaction between SO3 and sieving on 45 µm, the interaction between SO3 and BTL, and the interaction between LOI and BTL.
	F Test	Blaine, SO3, sieving on 45 µm, LOI and BTL simultaneously have significant influence and coefficient value.
	t-Test	Significant factors influence: interaction of factor SO3 and sieving on 45 µm
7th Day	Model Coefficient	Has a positive effect: Blaine, SO3, and sieving on 45 µm
		Has a negative influence: LOI and BTL
	F Test	Blaine, SO3, sieving on 45 µm, LOI and BTL simultaneously have significant influence and coefficient value.
	t-Test	Significant factors influence: Blaine, sieving on 45 µm, LOI and BTL

Table 5. Estimation Result s of The Model (Cont.).

Compressive Strength	Model Estimation	Results
28th Day	Model Coefficient	Has a positive effect: Blaine, SO3, and sieving on 45 µm. Has a negative influence: LOI and BTL.
	F Test	Blaine, SO3, sieving on 45 µm, LOI and BTL simultaneously have significant influence and coefficient value.
	t-Test	Significant factors influence: Blaine and LOI

Significant factors that influence each compressive strength are based on the characteristics of PCC. PCC is more efficient in using clinker, and there are additional materials that can improve better quality. At compressive strength 3 and seven days is the initial compressive strength achieved from cement as a reference to the final compressive strength (compressive strength 28 days) achieved by cement. At 28 days compressive strength, significant factors that influence are Blaine and LOI, where Blaine is the smoothness of cement extending the cement surface while LOI can describe the amount of limestone material added in cement. Limestone has fine characteristics which can close the cavities in cement. Therefore the final compressive strength of Blaine and LOI has a significant effect.

3.2. Calculate of Optimal Value Factors Affecting the Strength of Presses 3rd, 7th and 28th Days of PCC Products

Optimization of factor values that affect the compressive strength of 3rd, 7th and 28th days of PCC was obtained by giving treatments to the compressive strength of 3rd, 7th and 28th days of PCC based on the range of factors influencing compressive strength. **Figure 2** is a range of factor values that affect the compressive strength of 3rd, 7th and 28th days of PCC based on PT Semen Padang recommendations.

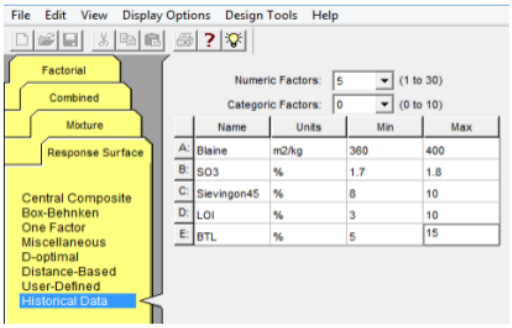

Figure 2. The range of Factors Affecting the Strengths Press 3rd, 7th and 28th days of PCC Products.

Optimization phase by using Design Expert 7 software with a range of compressive strength to be achieved, namely:

a. 3 days compressive strength is 150 - 190 kg/cm^2.
b. 7 days compressive strength is 220-260 kg/cm^2.
c. 28-day compressive strength is 320-360 kg/cm^2.

Selection of the optimal value generated is based on the desirability value that is close to or equal to 1[11]. As well as selecting the optimal value on the compressive strength of 3rd, 7th and 28th days of PCC with minimum Blaine and SO3 values and maximum sieving on 45 µm, LOI and BTL. Optimal values of compressive strength 3rd, 7th and 28th days of PCC in **Table 6**.

Table 6. Optimal Value Factors Affecting the Strength of Presses 3rd, 7th and 28th Days of PCC Products.

Compressive Strength	Optimal Value Factors Affecting Press Strength	
3rd Day	Blaine	379 m^2/kg
	SO_3	1.72 %
	Sieving on 45 μm	8.78 %
	LOI	5.40 %
	BTL	7.75 %
	Compressive Strength	174.846 kg/cm^2
7th Day	Blaine	389 m^2/kg
	SO_3	1.72 %
	Sieving on 45 μm	9.47 %
	LOI	4.17 %
	BTL	10.98 %
	Compressive Strength	244.869 kg/cm^2
28th Day	Blaine	388 m^2/kg
	SO_3	1.78 %
	Sieving on 45 μm	8.49 %
	LOI	4.20 %
	BTL	8.18 %
	Compressive Strength	344.308 kg/cm^2

The optimal value of each factor on compressive strength 3rd, 7th and 28th days compared to obtain to obtain optimal 3-day compressive strength does not require high Blaine value, whereas to obtain 7th and 28th days compressive strength PCC requires high Blaine value. Whereas to get the optimal compressive strength 3rd and 7th days, the maximum SO3 value is not needed, whereas to get 28 days compressive strength, SO3 is needed which is close to the maximum value. Obtaining a 3rd-day compressive strength required a 45 µm sieving on the value that was not too high and not too low, whereas for obtaining an optimal 7th-day compressive strength, higher sieving on the value of 45 µm and sieving value were needed. On 45 µm lower than the value of sieving on 45 µm on compressive strength 3 and 7 days of PCC cement. Low LOI values are required for PCC compressive strengths 7th and 28th days, whereas a high LOI value is needed to form a 3rd-day compressive strength of PCC. If the BTL value at each compressive strength is compared, a low BTL value is needed to form a 3rd-day compressive strength of PCC, while a high BTL value is required for 7th-day compressive strength. The medium BTL value from the limit is needed to form a 28th-day compressive strength of PCC.

4. Conclusion

The conclusions are significant and optimal values of factors that affect the compressive strength of 3rd, 7th and 28th days of PCC. In the 3rd day compressive strength are interaction of SO3 factor and sieving on 45 µm, with optimal values are Blaine: 379 m^2/kg, SO_3: 1.72 %, Sieving on 45 μm: 8.78 %, LOI: 5.40 %, BTL: 7.75% and compressive strength is 174,846 kg/cm^2. The 7th day compressive strength, the significant factors are Blaine, sieving on 45 µm, LOI and BTL, with optimal value are *Blaine*: 389 m^2/kg, SO_3: 1.72 %, Sieving on 45 μm: 9.47 %, LOI: 4.17 %, BTL: 10.98 % and compressive strength is 244,869 kg /cm^2. Significant factors in 28th day compressive strength are Blaine and LOI, while the optimal values are *Blaine*: 388 m^2/kg, SO_3: 1.78 %, Sieving on 45 μm: 8.49 %, LOI: 4.20 % and BTL: 8.18 %, with an optimal 28-day compressive strength of 344,308 kg /cm^2.

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Optimization of significant factors of cement compressive strength at PT Semen Padang

P Fithri, D Meilani, N T Putri and F H Chotimah

Industrial Engineering Department, Universitas Andalas, Padang, Indonesia

E-mail: primafithri@eng.unand.ac.id

Abstract. The quality measurement of cement production is focussed on five factors, namely: Blaine fineness (Blaine), SO3 content (SO3), Sieving on 45 µm (Sieve), Loss on ignition value (LOI) and Biomass-to-liquid value (BTL). They were measured when cement was 3rd, 7th and 28th days old. This study analyzed the effect of significant influence using multiple regression analysis and the optimal value of the five factors that affect compressive strength using the Response Surface Method (RSM). The results obtained for Portland Composite Cement(PCC)significant factor for 3rd day: Blaine: 379 m2/kg; SO_3: 1.72%; Sieving on 45 µm: 8.78%; LOI: 5.40% and BTL: 7.75%. For 7th day compressive strength: Blaine: 389 m2/kg; SO_3: 1.72%; sieving on 45 µm: 9.47%; LOI: 4.17% and BTL: 10.98%. For 28th day compressive strength: Blaine: 388 m2/kg, SO_3: 1.78%, sieving on 45 µm: 8.49%, LOI: 4.20% and BTL: 8.18%.

1. Introduction

The cement industry is one industry that is experiencing rapid development due to increasing infrastructure development. PT Semen Padang is the cement companies located at Padang City, West Sumatra. One of the products produced every day by the company is Portland Composite Cement (PCC). PCC is the cement that is currently widely produced because PCC uses a small amount of clinker and the addition of an objective material to increase the compressive strength of PCC. So that PCC can minimize environmental impacts and be more economical. The main thing that consumers concern is quality [1]–[4]. If the product quality is good, it can increase customer satisfied, and customers will always use the product. So that, to reach that goal, quality must concern to its product and also service [5]. Therefore, every company needs to carry out quality control to maintain the quality of products produced so that consumers do not switch to similar products produced by competing companies and can compete globally, both nationally and internationally.

The parameters of cement quality regarding consumers are based on the compressive strength produced by cement. Testing of compressive strength of cement was carried out when cement was 3rd, 7th, 28th days old. Testing the compressive strength of cement at the age of 3rd and 7th days was done to obtain the initial compressive strength of cement as the prediction of the final compressive strength produced later. While testing the compressive strength of cement at 28th days was done to obtain the final compressive strength of cement. PT Semen Padang controls the quality of the compressive strength of cement at compressive strengths 3rd, 7th and 28th days. The better the compressive strength produced by cement, the higher the ability of cement to hold a load so that the resulting infrastructure is stronger and durable. The compressive strength of cement is influenced by several

main factors, namely the amount of SO_3, the percentage of Dissolved Parts (BTL), the percentage of Loss On Ignition (LOI), Blaine and sieve on 45 μm [6]. Blaine, sieve on 45 μm, SO_3, LOI, and BTL, can be used to determine the amount of material in cement making. In controlling cement quality, PT Semen Padang sets quality standards for each of the factors that affect cement and cement compressive strength.

PT Semen Padang's quality control system is using a trial and error system based on a range of quality standards. PT Semen Padang has not received optimal value for each of the factors that affect the compressive strength of 3rd, 7th and 28th days of PCC. PT Semen Padang also does not know among the factors that affect the compressive strength that most significantly influences the compressive strength of PCC. As a result of not getting optimal value from the factors that affect the compressive strength, the number of additional material in cement production has not been fixed and the compressive strength of 3rd, 7th and 28th days of PCC have fluctuated.

Fluctuating compressive strength values will affect the product price and quality of PCC products. Based on these problems, the company needs to know the significant factors that influence the compressive strength of 3rd, 7th and 28th days of PCC products as a reference in controlling the quality and optimal value of these factors.

2. Method

Data processing in this study is grouped based on the objectives to be achieved; there are knowing the significant factors that affect the compressive strength of 3rd, 7th and 28th days of PCC products and measuring affects the compressive strength of 3rd, 7th and 28th days of PCC products to produce strong optimal press. The first goal was achieved by using multiple regression analysis methods. The initial step taken was the determination of the independent and dependent variables, the independent variables used are Blaine, SO3, sieving on 45 μm, LOI and BTL and the dependent variables used are compressive strength 3rd, 7th and 28th days. After that, designed the compressive strength model, the selection of the model based on the value of the largest R-Square and a signature model with the tools used are Design Expert 7. The selected model was tested for classical assumptions as validation of the model. If the model fulfilled the classical assumption test, the model is estimated with the output in the form of model coefficients, model coefficient tests and significant factors that affect compressive strength.

The compressive strength model in regression analysis was used as a model in obtaining optimal values. To get the optimal value, the factors that influence the strength of the measurement results are based on the results of PT Semen Padang. Determine optimal conditions for each independent variable by using Expert Design software 7. Selection of optimal values based on maximum desirability values (close to 1).

3. Result and Discussion

3.1. Analysis of Factors Affecting Compressive Strength 3rd, 7th and 28th days PCC Products

Analyses of factors affecting compressive strength use multiple regression method.

3.1.1. Design a PCC Cement Press Strength Model. Selection of the best model is obtained based on The recommendation of Design Expert 7. Software recommendations focus on the highest value of Adjusted R-Square and Predicted R-Square and the lowest PRESS (Prediction Error of Square) values of several models available in Fit Summary. The PCC cement compressive strength 3rd is obtained in the equation below.

$$\begin{aligned} Y = {} & 359.14233 - 1.19690\,X_1 - 55.65896\,X_2 + 8.97836\,X_3 + 44.70652\,X_4 - 38.29970\,X_5 + 0.59474\,X_1X_2 \\ & + 0.027746\,X_1X_3 - 0.15254\,X_1X_4 + 0.13773\,X_1X_5 - 12.580\,X_2X_3 + 8.07579\,X_2X_4 - 9.23518\,X_2X_5 \\ & + 0.29102\,X_3X_4 + 0.42686\,X_3X_5 - 0.85982\,X_4X_5 \end{aligned} \quad (1)$$

Information:
Y: compressive strength
X_1: Blaine
X_2: SO3
X3: sieving on 45 μm
X_4: LOI
X_5: BTL

The PCC cement compressive strength 7th is obtained in the equation below.

$$Y = 71.72916 + 0.46940\,X_1 + 11.14397\,X_2 + 2.07820\,X_3 - 4.41102\,X_4 - 2.72922\,X_5 \quad (2)$$

The PCC cement compressive strength 28th is obtained in the equation below.

$$Y = 160.24986 + 0.49244\,X_1 + 17.99002\,X_2 + 1.76364\,X_3 - 10.55869\,X_4 - 1.15262\,X_5 \quad (3)$$

3.1.2. Classic Assumption Test. Classic assumption test was done as a validation of the regression model. Classic assumption test was based on the type of model produced. If the model is linear, the classic assumption test is normality, linearity, multicollinearity, heteroscedasticity, and autocorrelation. While the nonlinear model, the classic assumption test is normality, heteroscedasticity, and autocorrelation. In this study, a linear model is found at compressive strength 7th and 28th days. A nonlinear model was found at 3rd days compressive strength. The following is a classic assumption test performed on the 7th day compressive strength of PCC products:

a. Normality Test
This test was carried out by making decisions based on the assumed probability distribution on the empirical distribution, with the hypothesis used as follows [7].
H_0: distribution residue has a normal distribution
H_1: spread residue does not have a normal distribution
Accept H_0 if the significance value> α (0.05)

Table 1. Normality Test for PCC Product 7-Day Strength Press Model.

Kolmogorov-Smirnov			Shapiro-Wilk		
Statistic	Df	Sig.	Statistic	df	Sig.
.077	101	.143	.986	101	.368

Based on the results of the normality test, the value of Sig = 0.143 is obtained. Because of the value of Sig> α, the decision taken is to accept H_0, which means the distribution ε has a normal distribution.

b. Linearity Test
Linearity test was carried out for each of the influencing factors (Blaine, SO3, sieving on 45 μm, LOI and BTL) on the 7th and 28th days compressive strength of PCC products. The significance level used is 0.05 with a hypothesis [8]:
H_0: the independent variable has a linear relationship with the dependent variable.
H_1: the independent variable does not have a linear relationship with the dependent variable.
Accept H_0 if the significance value> α (0.05). **Table 2** shows the results of the Linearity Test in Blaine with 3-Day Compressive Strength of PCC Products.

Table 2. Linearity Test in Blaine with 3-Day Compressive Strength of PCC Products.

			Sum of Squares	df	Mean Square	F	Sig.
7 Days Press Strength Blaine	Between Groups	(Combined)	16948.412	41	413.376	1.288	.184
		Linearity	2309.090	1	2309.090	7.197	.009
		Deviation from Linearity	14639.321	40	365.983	1.141	.318
	Within Groups		18928.539	59	320.823		
	Total		35876.950	100			

c. Multicollinearity Test

Multicollinearity test is based on Variance Inflation Factor (VIF) and tolerance value; if the value of VIF value is <10 and the value of tolerance is> 0.1, then it can be said that the multicollinearity test is fulfilled [9]. Multicollinearity test of 7 days compressive strength model is VIF value <10 and tolerance value> 0.1.

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	Tolerance	VIF
Blaine	.866	1.154
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BTL	.863	1.159

[a] Dependent Variable: 7 Days Press Strength

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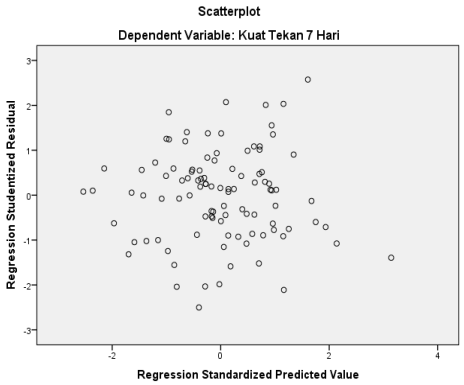
Heteroscedasticity test is fulfilled if there is no specific pattern on the Scatterplot graph or the resulting points spread above and below the zero on the Y-axis. Figure 2 is the result of heteroscedasticity test of 7 days PCC compressive strength model.



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Heteroscedasticity test results do not form a particular pattern and the resulting points spread above and below zero on the Y-axis.

e. Autocorrelation Test

Autocorrelation test using the Durbin-Watson method, with the decision-making criteria used [10]:

1) DW values below -2 mean positive autocorrelation.
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Table 4 is the result of autocorrelation test of PCC cement compressive strength 7 days.

Table 4. Autocorrelation test of 7-Day Compressive Strength Model.

Model	Durbin-Watson
	1.198

[b] Dependent Variable: 7 Days Press Strength

Classic assumption tests are carried out for each compressive strength model 3rd, 7th and 28th days PCC, with the same steps and the same decision making. The three models have been fulfilled by the classical assumption test.

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Table 5. Estimation Results of The Model.

Compressive Strength	Model Estimation	Results
3rd Day	Model Coefficient	It has a positive effect: sieving on 45 μm, LOI, interaction between Blaine and SO3, the interaction between Blaine and sieving on 45 μm, the interaction between Blaine and BTL, the interaction between SO3 and LOI, the interaction between sieving on 45 μm and LOI and the interaction between sieving on 45 μm and BTL.
		Has a negative influence: Blaine, SO3, BTL, the interaction between Blaine and LOI, the interaction between SO3 and sieving on 45 μm, the interaction between SO3 and BTL, and the interaction between LOI and BTL.
	F Test	Blaine, SO3, sieving on 45 μm, LOI and BTL simultaneously have significant influence and coefficient value.
	t-Test	Significant factors influence: interaction of factor SO3 and sieving on 45 μm
7th Day	Model Coefficient	Has a positive effect: Blaine, SO3, and sieving on 45 μm
		Has a negative influence: LOI and BTL
	F Test	Blaine, SO3, sieving on 45 μm, LOI and BTL simultaneously have significant influence and coefficient value.
	t-Test	Significant factors influence: Blaine, sieving on 45 μm, LOI and BTL

Table 5. Estimation Result s of The Model (Cont.).

Compressive Strength	Model Estimation	Results
28th Day	Model Coefficient	Has a positive effect: Blaine, SO3, and sieving on 45 µm. Has a negative influence: LOI and BTL.
	F Test	Blaine, SO3, sieving on 45 µm, LOI and BTL simultaneously have significant influence and coefficient value.
	t-Test	Significant factors influence: Blaine and LOI

Significant factors that influence each compressive strength are based on the characteristics of PCC. PCC is more efficient in using clinker, and there are additional materials that can improve better quality. At compressive strength 3 and seven days is the initial compressive strength achieved from cement as a reference to the final compressive strength (compressive strength 28 days) achieved by cement. At 28 days compressive strength, significant factors that influence are Blaine and LOI, where Blaine is the smoothness of cement extending the cement surface while LOI can describe the amount of limestone material added in cement. Limestone has fine characteristics which can close the cavities in cement. Therefore the final compressive strength of Blaine and LOI has a significant effect.

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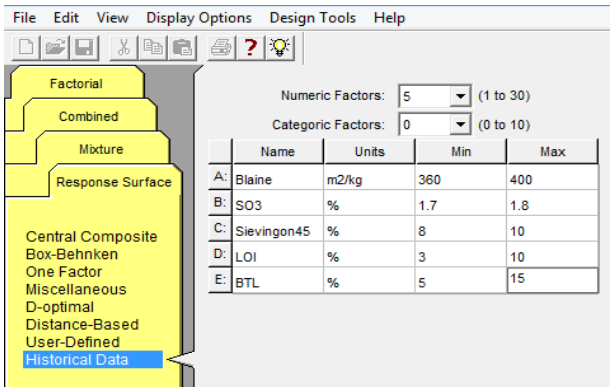

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Selection of the optimal value generated is based on the desirability value that is close to or equal to 1[11]. As well as selecting the optimal value on the compressive strength of 3rd, 7th and 28th days of PCC with minimum Blaine and SO3 values and maximum sieving on 45 µm, LOI and BTL. Optimal values of compressive strength 3rd, 7th and 28th days of PCC in **Table 6**.

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	BTL	8.18 %
	Compressive Strength	344.308 kg/cm^2

The optimal value of each factor on compressive strength 3rd, 7th and 28th days compared to obtain to obtain optimal 3-day compressive strength does not require high Blaine value, whereas to obtain 7th and 28th days compressive strength PCC requires high Blaine value. Whereas to get the optimal compressive strength 3rd and 7th days, the maximum SO3 value is not needed, whereas to get 28 days compressive strength, SO3 is needed which is close to the maximum value. Obtaining a 3rd-day compressive strength required a 45 μm sieving on the value that was not too high and not too low, whereas for obtaining an optimal 7th-day compressive strength, higher sieving on the value of 45 μm and sieving value were needed. On 45 μm lower than the value of sieving on 45 μm on compressive strength 3 and 7 days of PCC cement. Low LOI values are required for PCC compressive strengths 7th and 28th days, whereas a high LOI value is needed to form a 3rd-day compressive strength of PCC. If the BTL value at each compressive strength is compared, a low BTL value is needed to form a 3rd-day compressive strength of PCC, while a high BTL value is required for 7th-day compressive strength. The medium BTL value from the limit is needed to form a 28th-day compressive strength of PCC.

4. Conclusion

The conclusions are significant and optimal values of factors that affect the compressive strength of 3rd, 7th and 28th days of PCC. In the 3rd day compressive strength are interaction of SO3 factor and sieving on 45 μm, with optimal values are Blaine: 379 m^2/kg, SO_3: 1.72 %, Sieving on 45 μm: 8.78 %, LOI: 5.40 %, BTL: 7.75% and compressive strength is 174,846 kg/cm^2. The 7th day compressive strength, the significant factors are Blaine, sieving on 45 μm, LOI and BTL, with optimal value are *Blaine*: 389 m^2/kg, SO_3: 1.72 %, Sieving on 45 μm: 9.47 %, LOI: 4.17 %, BTL: 10.98 % and compressive strength is 244,869 kg /cm^2. Significant factors in 28th day compressive strength are Blaine and LOI, while the optimal values are *Blaine*: 388 m^2/kg, SO_3: 1.78 %, Sieving on 45 μm: 8.49 %, LOI: 4.20 % and BTL: 8.18 %, with an optimal 28-day compressive strength of 344,308 kg /cm^2.

5. References

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