Effect of Ratio Composition of White Cement and Portland Cement on the Degree of Whiteness and Metal Content

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Abstract

White cement is the cement that consumers use to make exterior and interior decorations of homes and buildings without reducing the quality of the compressive strength of the cement so that it can increase the selling value and beauty of the building. The company "X" is the only white cement producer in Indonesia, strives continuously to improve its quality in terms of its production process to produce products that are acceptable in the market. This study aims to create a standard series of testing the value of the degree of whiteness and see the difference and the relationship of each tool. The method for making the standard series is by using two types of cement, white cement with a ratio of 100% by weight of 600g used up to 10% by weight of 600g of white cement used and gray cement Ordinary Portland Cement (OPC) with a ratio of 100 % by weight of 600g used up to 10% by weight of 600g of gray cement. This test showed that the degree of whiteness decreased in the three tools, this is proportional to the use of the higher percentage of Ordinary Portland Cement (OPC) gray cement. The results of the comparison of the three tools obtained a linear regression value (r) which is close to 1 so that it can be said that the three tools have an interrelated relationship so that the value generated from one tool can be equated with other tools.

Abstrak

Semen putih adalah semen yang digunakan konsumen untuk membuat dekorasi eksterior dan interior rumah dan bangunan tanpa mengurangi kualitas kuat tekan semen sehingga dapat meningkatkan nilai jual dan keindahan bangunan. Perusahaan "X" merupakan satu-satunya produsen semen putih di Indonesia, terus berupaya meningkatkan kualitas dalam proses produksinya untuk menghasilkan produk yang dapat diterima pasar. Penelitian ini bertujuan untuk membuat rangkaian standar pengujian nilai derajat keputihan dan melihat perbedaan serta hubungan masing-masing alat. Cara pembuatan seri standar adalah dengan menggunakan dua jenis semen yaitu semen putih dengan perbandingan 100% berat 600g yang digunakan sampai dengan 10% dari berat 600g semen putih dan semen abu-abu dengan rasio 100% berat 600g digunakan hingga 10% berat 600g semen abu-abu. Pengujian ini menunjukkan bahwa derajat keputihan menurun pada ketiga alat, hal ini sebanding dengan penggunaan semen abu-abu yang lebih tinggi. Hasil perbandingan ketiga alat tersebut diperoleh nilai regresi linier (r) mendekati 1 sehingga dapat dikatakan ketiga alat tersebut memiliki hubungan yang saling berkaitan dan nilai yang dihasilkan dari satu alat dapat disamakan dengan alat yang lain.

Kata kunci : *White Cement, Whiteness, Standard Series*

INTRODUCTION

Since the early 1950s, cement output has expanded dramatically all across the world, particularly in emerging countries [1]. This industry is regarded as one of the most energy-intensive sectors [2]. The ettringites are formed in the early stages of Portland cement hydration by the reaction of the aluminate phases, calcium sulfate and water. Sulfate, carbonate and hydroxide ettringites are known and the compositions of their solid solutions have been investigated [3]. White cement is a key ingredient in architectural and decorative concrete. By using it, in particular,the resulting concrete not only becomes an expressive material that having an infinite range ofcolour tones, intensifies one of its aesthetic qualities, but could also gain remarkable validity interms of structural qualities due to its high mechanical strength [4]. It was found by Lübeck et al. [5] that white concrete with 50% white Portland cement replaced by slag presented favorable compressive strength and the same white value compared to that with pure white Portland cement. In addition to slag, other solid waste powders such as rice husk were also used to prepare white concrete. It was demonstrated by Ferraro et al. [6] that off-white rice husk ash provided favorable white value and improved compressive strength and durability. In addition, Çolak [7] evaluated the usage of limestone powder in white concrete and found the decreased wear resistance of white concrete with limestone powder. The production of cement uses a lot of resources and energy, thus there is a lot of interest in it as a potential way to recycle a lot of solid waste and lower the pace at which solid waste is produced [8]. It is predicted that the manufacture of cement clinker will utilize between 5.0 percent and 10.0 percent of the yearly world greenhouse gases [9,10]. One ton of cement clinker produces about the same amount of CO2 emissions [11].

The cement industry is an industry that is developing quite rapidly due to the many developments in Indonesia. Therefore, The company “X” is one of the largest cement producers in Indonesia carries out various innovations in the cement manufacturing process, one of which is by making white cement products. Consumers use the white cement to make exterior and interior decorations for homes and buildings without reducing the compressive strength of the cement. To guarantee the quality of the products produced, the industry is required to have quality control and quality assurance so that the products produced comply with the specified quality requirements so that customer satisfaction can be met. The quality Assurance and Research Division (QARD) is one of the technical support divisions at The company “X”, the company is responsible for the quality of products resulting from development and research, quality assurance, and research conducted. The development carried out is the testing process of raw materials, alternative materials, auxiliary materials, intermediate materials, semi-products, and final products carried out by the QA Department.

To produce quality white cement products that consumers accept, the company must keep the results of its products reasonable because the quality of a production is a factor that forms the basis for consumers to make choices about a product. Given the importance of maintaining quality, a method or method is needed to maintain product quality, one of which is the analysis of production results. Analysis of production results is an activity to improve the quality of production. In this analysis of production results, it is discussed how a product complies with predetermined standards and the quality of the product can be accounted for to consumers whether the production results meet the targets set through the production process. Because in the process of making white cement, the most important thing is to see the value of the degree of whiteness, so there needs to be continuous checking. The checks were carried out in the plant five laboratories and checked in the QARD laboratory.

Along with the development of the times the Romans improved the cement-making process from initially only using gypsum calcined after which it was added with limestone and materials

from volcanoes to produce a better quality cement and is often known as a pozzolan. However, Portland cement has long been discovered, namely in the 5th century by the Egyptians to be used to make pyramids by calcining pure plaster after several centuries later the material was named Caementum which means binder.

RESEARCH METHOD

In conducting this research, to make it more focused, it is carried out in a research methodology so that the objectives of this study are as expected. Research methodology is a scientific process or method to obtain data for research purposes. The methodology is also a theoretical analysis of a method or method carried out. The method used in this research is the testing method using a Kett meter to get a new standard in testing the degree of whiteness on cement as well as a method of testing the chemical content contained in cement because if it passes a predetermined standard, it will be very influential in determining the value of whiteness in cement.

Instrument and Material

The material used in this study is white cement (White Cement) and Gray Ordinary Portland Cement (OPC) produced by the company. In comparison, the tools used in this research are the white color test equipment on cement, namely the Kett Meter C-100 tool found in laboratory 29 (QARD), the Kett Meter C-130 tool, and the Hunter Lab located in the Plant 5 laboratory of the company. Chemical content test equipment to see the chemical content contained in cement is by using XRF (X-Ray Fluorescence).

Process Procedure

The sample used for this study is a cement sample. White cement and gray cement Ordinary Portland Cement (OPC) produced by company “X”. After each 6 kg cement sample is taken, each cement's fineness test (Blaine) is carried out to see the difference between the two types of cement. After the fineness test (Blaine) was carried out, a comparison was made between Ordinary Portland Cement (OPC) gray cement and white cement. The comparison is 100% - 10% cement gray Ordinary Portland Cement (OPC) and 100% - 10% white cement (white cement) with a weighing weight of 600 g then enters the the homogenization process to get a homogeneous cement sample, homogenization is carried out using a turbule tool for 1 hour after making sure the sample is perfectly homogenized, then a whiteness test is carried out on the cement sample that has been made in each of these comparisons, which results in 11 samples. cement, then to see the value of the degree of white color contained in the sample, a test carried out using three tools, namely the Kett Meter C-100, Kett Meter C 130 and Hunter Lab, then the chemical content test is carried out using an XRF (X-Ray Fluorescence) tool) to see the minor and major oxides in the cement sample that has been compared. After getting the results of the tests carried out, then further analysis and discussion of the results obtained so that conclusions can be drawn by from the research.

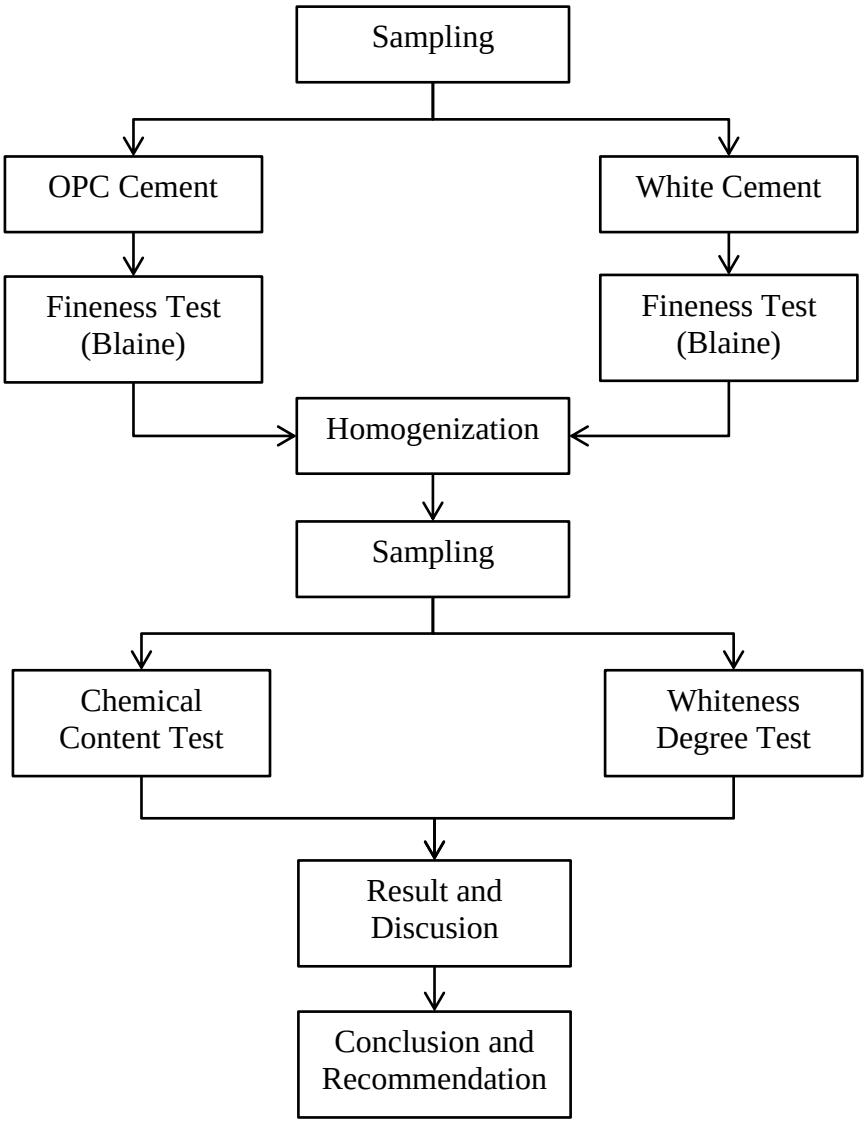

Figure 1. Research Scheme

Chemical Content Testing in Cement

This method needs to be done to see what chemical content is contained in cement so that it can be known the chemical content that affects the whiteness of cement.

Whiteness Test Method

This method needs to be done to see the value of the degree of whiteness in the cement produced so that it can be seen that it has reached the set target.

Table 1. Degree of White Color Relationship with Filter

Filter Color	Whiteness Degree Value (whiteness)
Red	79,6 ± 0,1
Blue	86,6 ± 0,1
Green	86,7 ± 0,1

Experimental Design

The experimental design carried out in this study using the linearity test, which is one of the statistical tests that aims to determine whether a variable has a linear relationship or not significantly, the relationship can be seen with the correlation coefficient (r) close to 1.00 so that if the correlation coefficient is close to 1.00 it can be said good linearity and there is a relationship between following variables. The correction factor that can be generated with the following equation:

$$Y = a\,(x) + b$$

Where,
Y = Correction factor
a = Slope
b = Intercept
x = White color degree percentage

To see the level of precision produced on each of these test equipment, it is necessary to carry out a precision test that aims to show the closeness of a series of measurements obtained from homogeneous samples. In the precision test carried out, namely by taking the value of the degree of whiteness (whiteness) 7 times repetition with the same sample.

$$\%\text{RSD} = \frac{\text{SD}}{\text{X}} \times 100\%$$

$$\text{CV}_{\text{Horwitz}} = 2^{(1-0.5\log c)}$$

Where,
C = Fraction of analyte concentration in the sample
RSD = Relatife Standar Deviation
SD = Standard Deviation
X = Average Result

To see the level of precision on the three test equipment, whether it is included or not, what must be seen from the %RSD generated from these calculations. If $\%\text{RSD}_{\text{result}} < \%\text{RSD}_{\text{constant}}$, then the precision level of each tool is declared precision and if $\%\text{RSD}_{\text{result}} > \%\text{RSD}_{\text{constant}}$, then the precision level of the tool cannot be declared precision.

RESULT AND DISCUSSION

Whiteness Cement Test Results

A whiteness test is carried out to determine the degree of white value contained in the cement that wants to be standardized. In this test, it is done by mixing gray Ordinary Portland Cement (OPC) and white cement (white cement) at a ratio of 10% to 100%, and then the homogenization process is carried out using a Turbula tool for 1 hour so that the mixture can be perfectly homogenized. After each sample is perfectly homogenized, testing is carried out with the three tools, namely the Kett Meter C-100, Kett Meter C-130, and Hunter Lab, so that they can find out the percentage of white color degrees produced on each of these tools is. Then the results obtained from testing the degree of whiteness (whiteness) are as follows.
In Figure 2, it can be seen that there is a difference in the white color value of the three tools because the research carried out was to make a standard series with a percentage ratio of white cement (white cement) and gray Ordinary Portland Cement (OPC) then mixed (homogenized) so that the results The degree of whiteness (whiteness) on each tool tends to decrease because the use of the percentage of gray cement (gray) is getting higher so that the value of the degree of whiteness (whiteness) obtained from each tool is getting lower.

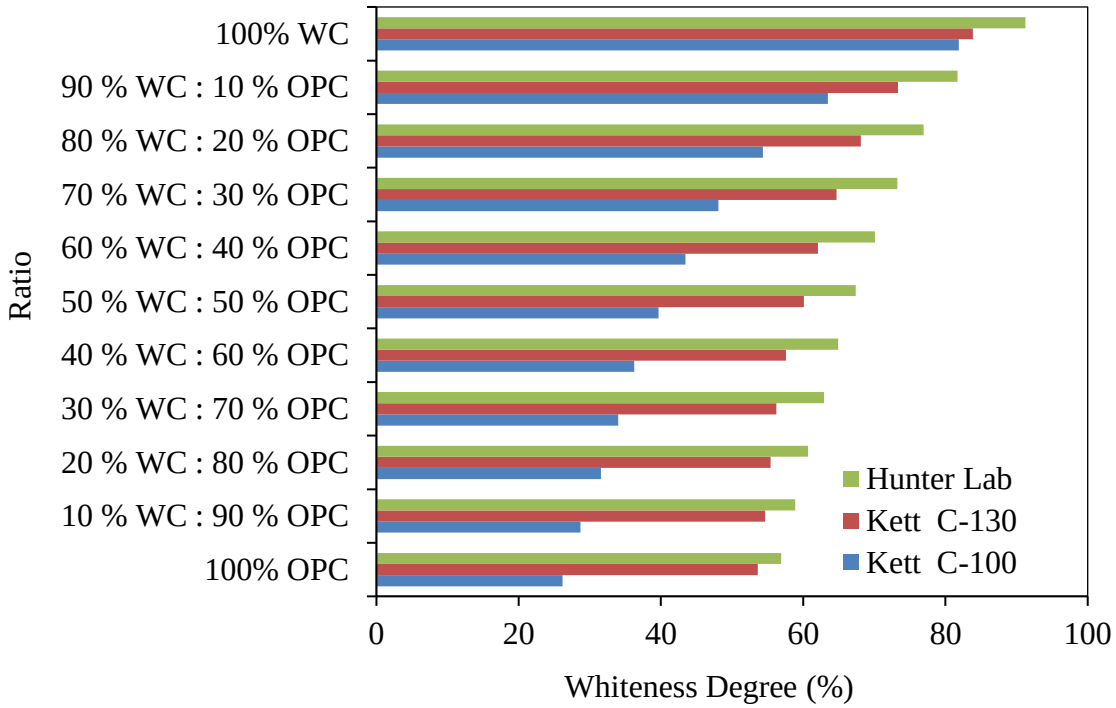

Figure 2. Result Graph of Whiteness Cement Test

The working principle of each of these tools is almost the same, namely the principle of reflecting light that is fired at the sample being tested and then forwarded to a photodiode (sensor) as a catcher of the reflected light. So if the percentage of gray cement Ordinary Portland Cement (OPC) is greater, then the light reflected by the sample to the sensor is less because the amount of light absorbed by the sample is different from the sample with a small percentage of gray cement, the sample reflects more light, which is fired into the sample and then forwarded to the sensor. Then the light is absorbed by the sample. so that it will get a more excellent whiteness value.

Comparison Results Between Kett meter C-100 and C-130

The difference between the three white degree test instruments, a comparison of the white degree test results data on the three tools is carried out, which shows how big the difference is between these tools and the relationship between the white degree test tools. This test is carried out by looking at the difference between the test equipment being compared and a linearity test to see the relationship between the test equipment so that the tool can be said to be the same in the value it produces.

It can be seen that the difference in the comparison results in figure 3 between the Kett Meter C-100 and the Kett Meter C-130. There is a more significant difference in the use of white cement (White Cement) which is getting lower because in each tool, there are differences in the specifications of the tool. If using the Kett Meter C-100 tool, the light that is shot into the sample and reflected by the sample before hitting the sensor, two lenses are used, namely a blue lens and a green lens. The results are then the results of the white color degrees from each lens are averaged while if using a tool The Kett meter C-130 only uses a blue light as a light source to be fired at the sample and then reflected by the sample to the sensor and the white degree value of the sample being tested will come out.

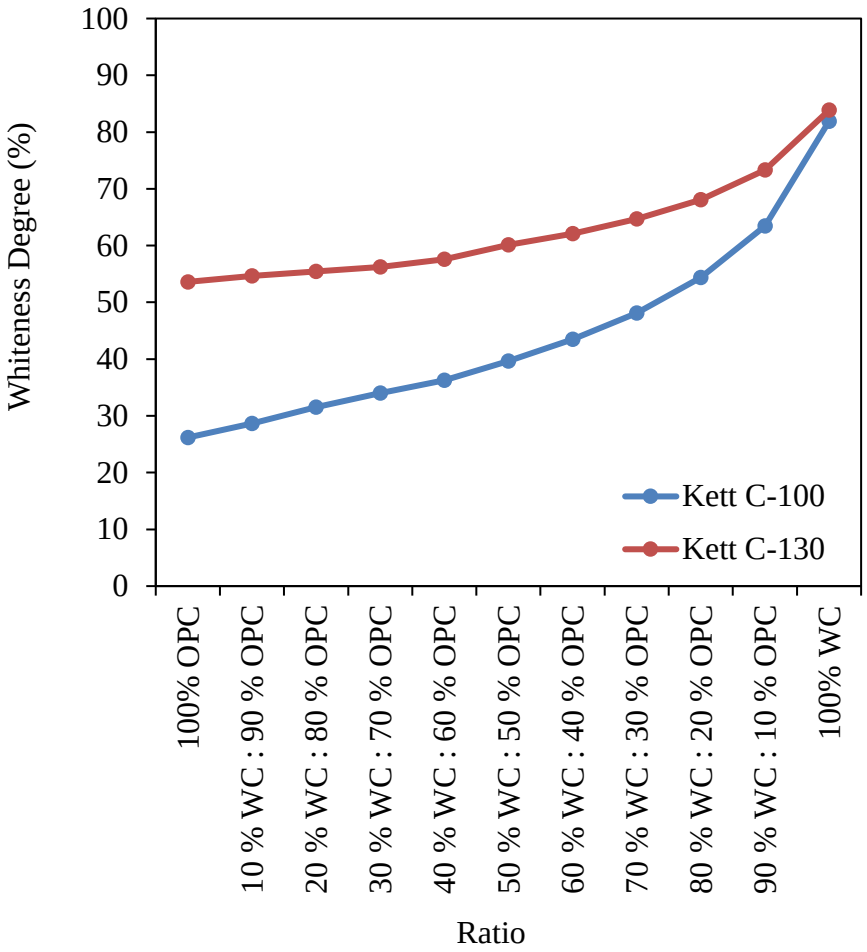

Figure 3. Curve comparison of Kett meter C-100 and C-130

Figure 3 shows a linear curve is obtained from the linearity test between the comparison of the Kett meter C-100 and the Kett meter C-130 with a linear regression value (r) of 0.9986, and the correction factor is (y = 0.5537x + 38.152) with a value of a = 0.5537 and b = 38.152. In the resulting data, a value (r) is obtained which is close to 1 so it can be said that there is a relationship between the Kett Meter C-100 and the Kett Meter C-130 so that if a sample test is carried out on the Kett Meter C-100 tool, the resulting value will be considered the same as the value. Which is generated from the Kett Meter C-130 tool by using the correcting factor obtained from the linearity test so that we already know the value generated from the Kett Meter C-130 tool without re-testing the tool.

Comparison Results Between Kett meter C-100 and Hunter lab

In figure 4, it can be seen that there are differences between the comparisons of the C-100 Kett meter and the Hunter Lab because in each of these tools, there are differences in the specifications of the tool. If using the Kett Meter C-100, the light is fired into the sample and reflected by the sample. In the sample before hitting the sensor, there are two lenses used, namely a blue lens and a green lens, then the results are then the results of the white color degrees from each lens are averaged, while the use of the Hunter Lab tool is the working principle uses calculations from the L A B, CIE L*a*b system or CIELAB is a scale of colors that is uniform in the color dimension. This system is implemented in the form of color dimensions.

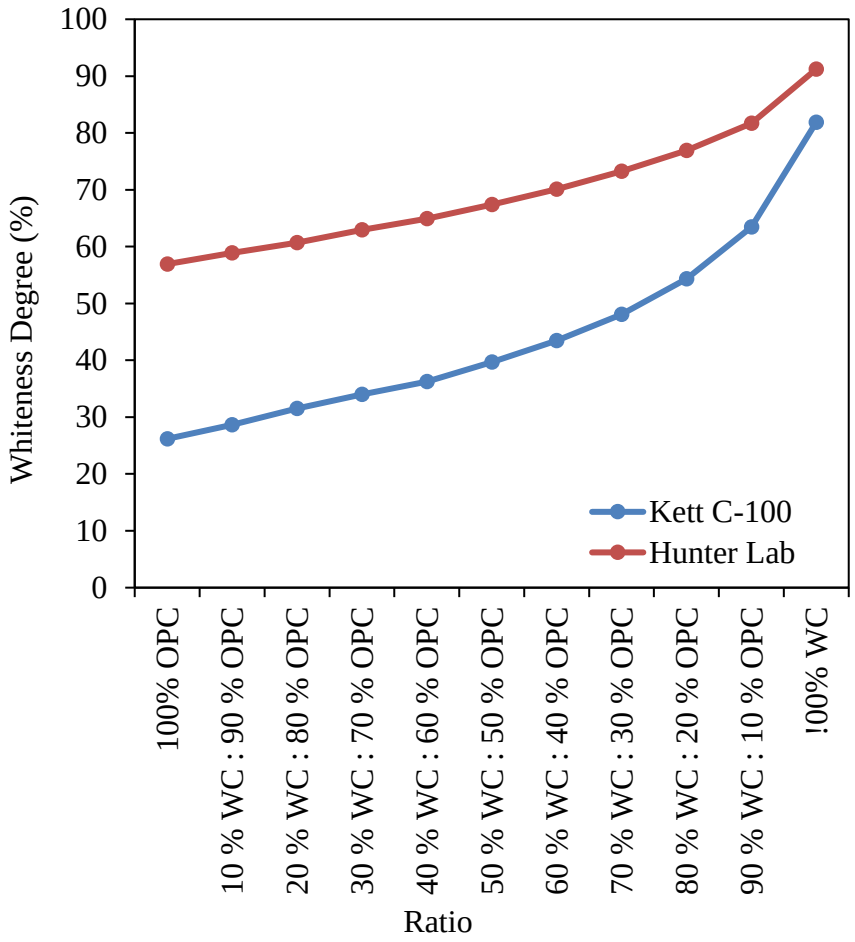

Figure 4. Comparison graph between the Kett Meter C-100 and Hunter Lab

Figure 4 shows a linear curve from linearity testing in the comparison of the Kett meter C-100 with Hunter with a linear regression value (r) of 0.9948 and a correction factor (y = 0.6232x + 41.915) is obtained with a value of a = 0.6232 and b = 41,915 In the resulting data, a value (r) is obtained which is close to 1 so that it can be said that there is a relationship between the Kett Meter C-100 and the Hunter Lab so that if a sample test is carried out on the Kett Meter C-100 tool, the resulting value will be considered the same as the value which is generated from the Hunter Lab tool by using the correcting factor obtained from the linearity test so that we already know the value generated from the Hunter Lab tool without the need to retest the tool.

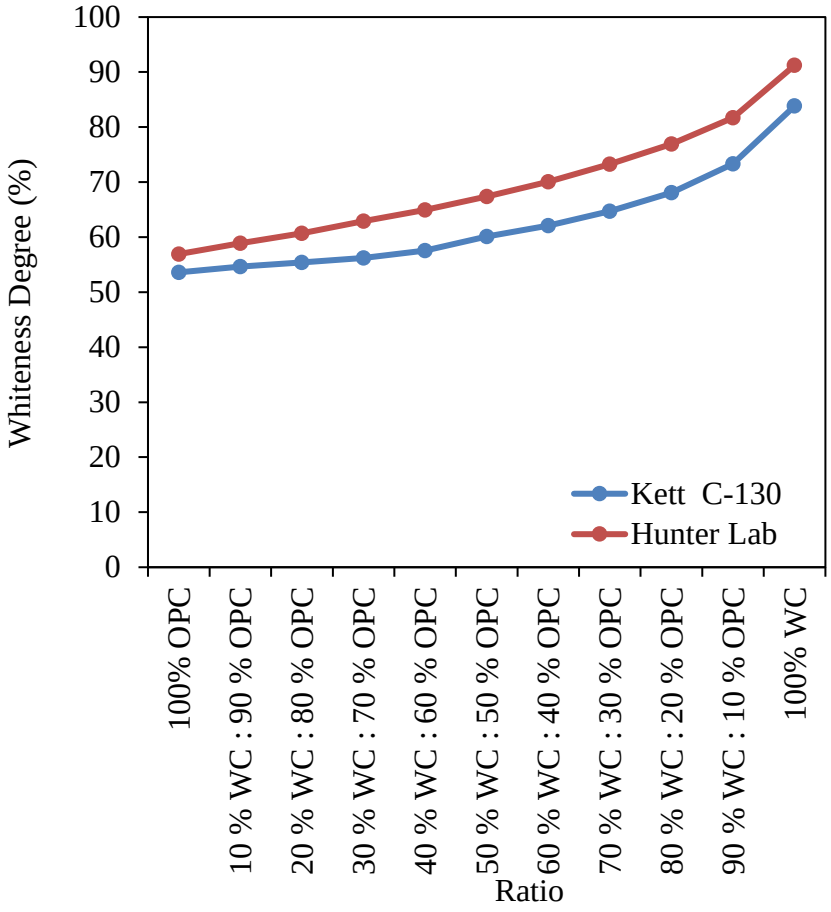

Figure 5. Comparison graph between the Kett Meter C-130 and Hunter Lab

In Figure 5, which is obtained from the results of the comparison between the C-130 Kett meter and the Hunter Lab, there are differences because in each of these tools there are differences in the specifications of the tool, the C-130 Kett Meter uses a blue light as a light source to be fired into the sample is then reflected by the sample to the sensor and the white degree value will come out of the sample being tested, whereas if using the Hunter Lab tool the working principle uses calculations from the LAB CIE system L*a*b* or CIELAB is a scale of uniform colors in color dimension. This system is implemented in the form of color dimensions.

In Figure 5, we get a linear curve from linearity testing in the comparison between the Kett meter C-130 and Hunter Lab with a linear regression value (r) of 0.9906 and a correction factor (y = 1.1191x - 0.6199) with a value of a = 1.1191 and b = 0.6199. In the data generated, a value (r) is obtained which is close to 1 so that it can be said that there is a relationship between the Kett Meter C-130 and the Hunter Lab so that if a sample test is carried out on the Kett Meter C-130 tool, the resulting value will be considered the same as the value obtained generated from the Hunter Lab tool by using the correction factor obtained from the linearity test so that we already know the value generated from the Hunter Lab tool without the need to retest the tool.

Precision Testing

The level of precision can be determined by testing the three white degree test instruments. A precision test was carried out on the data generated by each of these tools. This precision test is carried out by averaging the data from seven repetitions in each sample and then making a standard deviation for each sample so that the percentage of acceptance requirements from each sample is compared with the acceptance requirements of the company.

Table 1. Kett Meter Precision Test C-100

Repetition	100% WC	90% WC 10% OPC	80% WC 20% OPC	70% WC 30% OPC	60% WC 40% OPC	50% WC 50% OPC	40% WC 60% OPC	30% WC 70% OPC	20% WC 80% OPC	10% WC 90% OPC	100% OPC
1	81.95	63.30	54.50	48.05	42.50	39.85	36.50	34.45	31.80	28.65	26.15
2	81.85	63.45	54.50	48.15	43.85	39.85	35.50	33.05	31.80	29.10	26.45
3	81.95	63.30	54.05	48.05	42.50	39.10	36.50	34.45	31.30	29.10	26.15
4	81.95	63.45	53.90	48.05	43.85	39.85	35.70	34.45	31.80	27.80	26.15
5	81.95	63.45	54.50	48.05	43.85	39.30	36.50	32.80	31.00	29.10	26.15
6	81.95	63.75	54.50	48.15	43.85	39.85	36.50	34.45	31.30	29.10	26.05
7	81.65	63.45	54.50	48.05	43.85	39.85	36.50	34.45	31.80	27.80	26.15
Average	81.89	63.45	54.35	48.08	43.46	39.66	36.24	34.01	31.54	28.66	26.18
SD	0.11	0.15	0.26	0.05	0.66	0.32	0.44	0.75	0.34	0.61	0.13
%RSD	0.14	0.24	0.48	0.10	1.52	0.81	1.22	2.20	1.07	2.14	0.48
Acceptance Terms	%RSD < 3%										

Table 2. Kett Meter Precision Test C-130

Repetition	100% WC	90% WC 10% OPC	80% WC 20% OPC	70% WC 30% OPC	60% WC 40% OPC	50% WC 50% OPC	40% WC 60% OPC	30% WC 70% OPC	20% WC 80% OPC	10% WC 90% OPC	100% OPC
1	83.90	73.60	67.80	64.10	61.50	60.40	57.40	56.60	55.50	54.90	53.80
2	83.90	73.00	67.60	64.70	62.00	60.10	57.80	56.20	55.10	54.70	53.60
3	83.80	73.50	68.30	65.30	62.10	59.90	57.70	56.50	55.00	54.40	53.60
4	83.90	72.80	68.60	64.60	62.50	60.30	57.60	56.40	55.50	54.80	53.70
5	83.90	72.90	68.20	64.70	62.10	60.00	57.20	55.80	55.80	54.60	53.60
6	83.70	73.80	67.80	64.90	62.00	59.80	57.90	55.90	55.50	54.70	53.30
7	83.80	73.60	68.40	64.60	62.30	60.20	57.30	56.30	55.60	54.50	53.60

Repetition	100% WC	90% WC 10% OPC	80% WC 20% OPC	70% WC 30% OPC	60% WC 40% OPC	50% WC 50% OPC	40% WC 60% OPC	30% WC 70% OPC	20% WC 80% OPC	10% WC 90% OPC	100% OPC
Average	83.84	73.31	68.10	64.70	62.07	60.10	57.56	56.24	55.43	54.66	53.60
SD	0.08	0.40	0.37	0.36	0.31	0.22	0.26	0.30	0.28	0.17	0.15
%RSD	0.09	0.55	0.54	0.56	0.50	0.36	0.46	0.53	0.51	0.31	0.28
Acceptance Terms	%RSD < 3%										

Tables 1, 2, and 3 show that the level of precision of the three tools obtained results that can still fall within the acceptable limits of the company, which is a maximum of 3%. So, the Kett meter C-100, Kett meter C-130, and Hunter lab can still be said to have a good level of precision because the percentage of RSD obtained from the three tools is still below the maximum limit given by the company.

Table 3. Hunter Lab Precision Test

Repetition	100% WC	90% WC 10% OPC	80% WC 20% OPC	70% WC 30% OPC	60% WC 40% OPC	50% WC 50% OPC	40% WC 60% OPC	30% WC 70% OPC	20% WC 80% OPC	10% WC 90% OPC	100% OPC
1	91.33	81.69	76.82	73.30	69.90	67.45	64.93	62.96	60.84	59.03	57.21
2	91.30	81.61	76.94	73.18	70.14	67.44	65.05	63.08	60.75	58.95	56.73
3	91.24	81.65	76.81	73.23	70.21	67.47	65.10	62.73	60.57	58.87	57.25
4	91.22	81.66	76.73	73.22	70.07	67.27	65.03	62.98	60.43	58.86	56.66
5	91.10	81.78	77.00	73.25	70.12	67.26	64.76	62.86	60.71	58.91	56.83
6	91.18	81.78	77.15	73.25	70.08	67.51	64.84	62.97	60.70	58.67	56.67
7	91.26	81.74	77.06	73.32	70.01	67.31	64.76	62.87	60.75	58.77	57.07
Average	91.23	81.70	76.93	73.25	70.08	67.39	64.93	62.92	60.68	58.87	56.92
SD	0.07	0.07	0.15	0.05	0.10	0.10	0.14	0.11	0.14	0.12	0.26
%RSD	0.08	0.09	0.20	0.07	0.14	0.15	0.22	0.18	0.23	0.20	0.45
Acceptance Terms	%RSD < 3%										

X-Ray Fuorescence Test

To determine the chemical content contained in cement, chemical content testing was carried out with an XRF (X-Ray fluorescence) tool to determine the major and minor oxides contained in the cement sample. In this case the major oxides include CaO, SiO_2, Al_2O_3, and Fe_2O_3, while the minor oxides include MgO, SO_3, Na_2O, and K_2O, the results are as follows:

Table 4. Chemical content test results on cement

Description	Chemical Parameter							
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	K_2O	F-CaO
100% WC	19.90	2.43	0.39	66.36	2.39	2.17	0.26	1.60
90 % WC : 10 % OPC	19.41	2.43	0.64	66.31	2.45	2.19	0.32	2.00
80 % WC : 20 % OPC	19.08	2.43	0.90	66.22	2.51	2.17	0.37	2.00
70 % WC : 30 % OPC	18.66	2.43	1.15	66.13	2.56	2.19	0.43	1.70
60 % WC : 40 % OPC	18.32	2.43	1.42	66.01	2.59	2.19	0.49	1.50
50 % WC : 50 % OPC	18.08	2.43	1.68	65.95	2.64	2.17	0.54	1.50
40 % WC : 60 % OPC	17.61	2.43	1.95	65.85	2.69	2.17	0.59	1.50
30 % WC : 70 % OPC	17.39	2.43	2.16	65.78	2.76	2.18	0.63	1.50
20 % WC : 80 % OPC	17.00	2.44	2.48	65.68	2.81	2.18	0.71	1.50
10 % WC : 90 % OPC	16.56	2.44	2.73	65.58	2.84	2.23	0.76	1.60
100% OPC	16.20	2.44	2.99	65.49	2.91	2.23	0.82	1.50

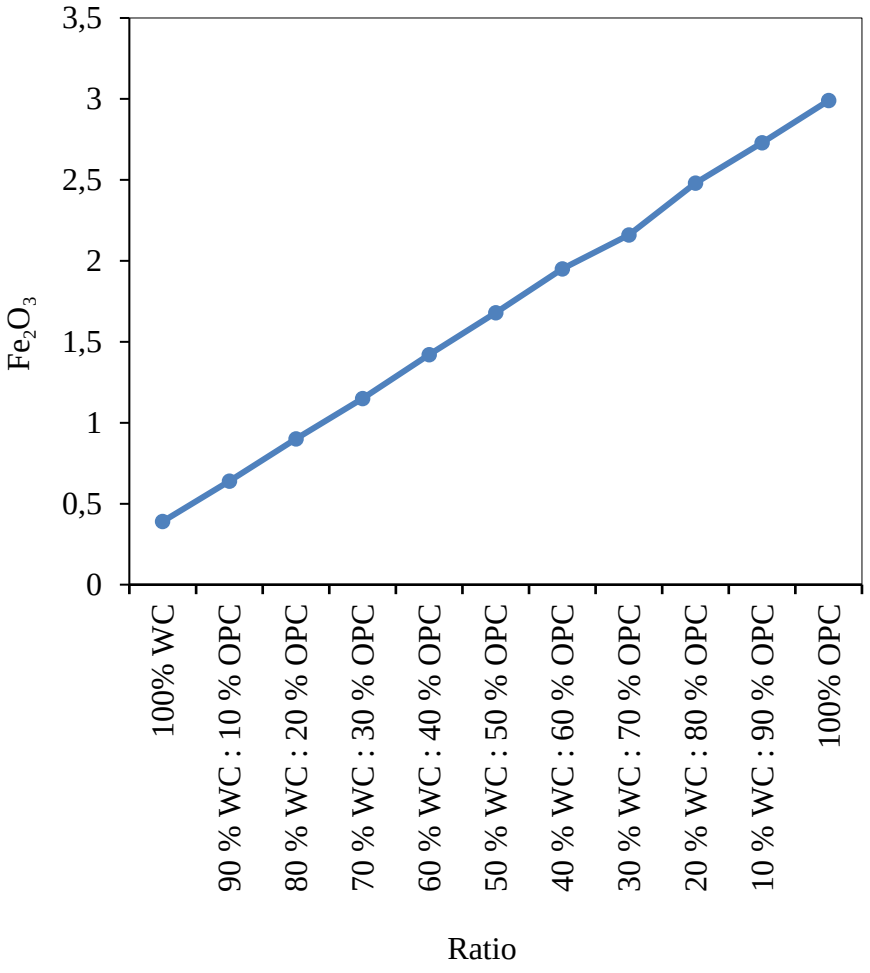

Figure 6. Level Test Graph of Fe_2O_3

In table 4, it is found that an important parameter that is very influential on the value of the degree of whiteness (whiteness) in testing the chemical content of cement is the content of Fe_2O_3 compounds. This is because the compound for the process of making white cement is very limited because it can affect the white colour produced from the cement. So from Figure 6 it can be seen that the higher the percentage of grey Ordinary Portland Cement (OPC) use, the higher the content of Fe_2O_3 compounds which make the cement have a low white colour value.

CONCLUSION

From the results of the discussion above, the following conclusions can be drawn:

1. The decrease in the value of the degree of whiteness generated from the Kett Meter C-100, Kett Meter C-130 and Hunter Lab tools is caused because the comparison made using Ordinary Portland Cement grey cement will increase so that it will greatly affect the value degree of white colour produced.
2. The results of the comparison of the three tools are found that there is a very related relationship between the three tools as seen from the value (r) obtained at 0.9986, 0.9948, and 0.9906, all of which are close to 1, so that the value generated from one tool can be generalized with other tools.
3. The increase in Fe_2O_3 compounds affects the whiteness value that is produced because the content of Fe_2O_3 contained in cement greatly affects the results of the colour of the cement, so the content of Fe_2O_3 compounds must be limited to as small as possible.

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