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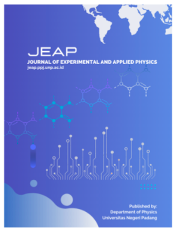

Consistency of Magnetic Susceptibility Values in Raw Mix 2 using Bartington Magnetic Susceptibility Meter Sensor Type B

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Abstract: The process of making cement goes through quite long stages, one of the processes is grinding at the Raw Mill. Raw Mill is divided into two large groups, Horizontal Mill and Vertical Mill, in Horizontal Factory. The milling result at the Horizontal Mill is Raw Mix 2 and quality testing will be carried out. In quality testing, testing is usually carried out on chemical parameters and there is no testing based on physical parameters. By looking for the magnetic susceptibility score of raw cement samples in Raw Mix 2 using the Bartington Magnetic Susceptibility Meter Type B sensor, you can see the consistency of magnetic minerals in raw cement in Raw Mix 2. Samples were taken from the Padang Semen Factory every hour of every day from February 1 to February 10, 2022, the samples were then measured using the Bartington Magnetic Susceptibility Meter Type B Sensor. The measurement results showed that the magnetic susceptibility value of Raw Mix 2 ranged from 79.8 x$10^{-8}m^3$/kg to 206.9 x$10^{-8}m^3$/kg, and standard deviation calculations were used. The data is interpreted into a graph and it shown that the magnetic susceptibility value of Raw Mix 2 obtained can be said to be consistent and of good quality. The magnetic properties of Raw Mix 2 obtained according on the magnetic susceptibility score obtained are antiferromagnetic. The grain type in Raw Mix 2 was found to have almost no superparamagnetic grains or contained less than 10% superparamagnetic grains.

Keywords: Bartington, Cement, Rock Magnetism, Magnetic Susceptibility

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1. Introduction

Cement is an important material used in construction. When mixed with water, cement will harden and become water tight. It is very useful in various construction projects, such as making concrete. Cement is produced in almost all countries because of its important role in infrastructure development [1]. The ingredients for making cement include materials of raw and auxiliary. The components of the raw materials include limestone (CaO) (± 80%), Silica (SiO_2) (± 10 %), clay (Al_2O_3) (± 8%), and iron sand (Fe_2O_3) (± 2%), while for materials of Auxiliary include Gypsum (Ca(SO_4). $2H_2O$), Pozzolan and Limestone (High Grade) [2]. So cement as a hydraulic adhesive is produced by grinding clinker which consists of calcium silicates as the main ingredient and will have adhesive properties when it reacts with water [3].

The process of making cement goes through quite long stages, one of the processes is grinding in a Raw Mill. Raw Mill is divided into two large groups: Horizontal Mill and Vertical Mill. The difference between the two types of Raw Mill lies in the main components in the grinding unit. Horizontal Mill contains grinding balls that function to reduce the size of the material [4]. In the Horizontal Mill, the material to be ground is introduced simultaneously with a flow of hot air originating from the suspension preheater which is pulled by the mill fan, so that in the Horizontal Mill, apart from the grinding process, there is also a drying process. The drying medium is hot air originating from hot Kiln exhaust gas with a temperature of 220℃-300℃[5]. The results of grinding at the Horizontal Mill are Raw Mix 2 and quality testing will be carried out. This aims to maintain the quality of cement and ensure that the buildings and structures built using this cement are the best [6].

The physical and chemical properties of each type of cement have different characteristics which must meet chemical and physical requirements. To ensure the quality of Portland cement, chemical and physical requirements must be continuously observed. These quality requirements include the compound content in Portland cement, cement fineness, residue, loss of flare, and others. In quality testing, testing is usually carried out on the chemical parameters contained in the results and processes. Testing chemical parameters on cement is very important in determining its quality [7]. Some parameters commonly used to test cement quality are Lime Saturation Factor (LSF), Silica Modulus (SIM), Alumina Modulus (ALM) [8], Residue On 90 microns, and Residue On 180 microns, in percentage. Raw Mix 2 is one of the results of the process that must be passed, so Quality Control and Quality Assurance need to be co because conducted Quality Control and Quality Assurance are mostly conducted based on chemical parameters and properties, even though cement contains magnetic minerals in the form of iron sand amounting to ± 2% [2]. Therefore, it is necessary to carry out Quality Control and Quality Assurance based on magnetic properties, especially in Raw Mix 2.

Iron sand is a magnetic mineral found in nature. Iron sand contains magnetic minerals that are used in industrial products such as steel and dry ink [9], dye [10], and cement [11]. The magnetic mineral content of iron sand can be determined from the magnetic susceptibility value using the method by rock magnetism. The magnetic method is a geophysical method that investigates the material's magnetic characteristics. Magnetic susceptibility is the magnetic property used in the Rock Magnetism Method to quantify the amount of magnetic minerals present in a material [12].

Magnetic mineral measurements can be carried out using rock magnetic methods, especially magnetic susceptibility parameters. This method is reasonably easy to use, quick to produce results, safe for the sample, and reasonably priced [13]. The magnetic properties of rocks can be determined using the method of rock magnetism based on the magnetic susceptibility value [14]. The magnetic properties of rocks are influenced by their mineral content. Whether the magnetization of a rock is stable or not depends very much on the type of mineral and its size. According to their properties regarding the influence of magnetism, these magnetic materials can be classified into 5 materials, consist of diamagnetic, paramagnetic, ferromagnetic, antiferromagnetic, and ferrimagnetic [15]. The Magnetic Susceptibility score can reveal the properties of magnetic and magnetic minerals type contained in the material. The relationship between magnetic susceptibility values and magnetic rock types can be seen in the Hunt Table, 1995[16].

The magnetic susceptibility of rocks and minerals is strongly connected. Each mineral and rock has a magnetic susceptibility score which is a characteristic of the rock and mineral. The score of magnetic susceptibility is very dependent on the elements that make up a material so based on this value information can be obtained regarding the minerals present in the substance [17]. The magnetic susceptibility score for each material is different, this depends on the type of material. This magnetic susceptibility will determine the magnetic properties of each material. The score of susceptibility in rocks is greater if the rock contains more and more magnetic minerals. The type of magnetic mineral and its concentration in the rock greatly influence the magnetic susceptibility value. The variation in values in sample measurements indicates that there are several kinds of magnetic minerals present in every sample [18]. The Fe element is related to magnetic susceptibility, the higher the Fe concentration, the higher the magnetic susceptibility. The factors influencing magnetic susceptibility are the concentration of magnetic minerals, the composition of the magnetic minerals, the size and shape of the grains, and the domain [19].

This research aims to see the consistency according on the magnetic susceptibility score. To see the consistency of the magnetic susceptibility score of Raw Mix 2, it is necessary to analyze the magnetic susceptibility of Raw Mix 2 using the Bartington Magnetic Susceptibility Meter Sensor Type B.

2. Materials and Method

Samples were taken according to procedures at PT. Semen Padang, starting with determining the point and taking samples. The sampling points shown in Figure 1.

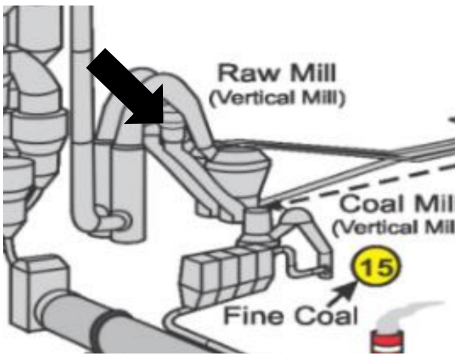

Figure 1. Sampling point of raw mix 2

Figure 1 shows the raw cement sampling point for Raw Mix 2, samples will be taken at the Horizontal Mill. Samples are taken once every hour, then put into plastic samples, then taken and prepared at the Geophysics Laboratory, Department of Physics, Faculty of Mathematics and Natural Sciences, Padang State University. Next, put the sample into the holder and label the holder with a code (sample name, month, year, and time of sampling), for example: RX2 220222 12. The total number of samples is 65 holders whose mass is measured using an Ohauss balance and the magnetic susceptibility value is measured using Bartington Magnetic Susceptibility Meter Sensor

Type B in the Geophysics Laboratory, Physics Department, Faculty of Mathematics and Natural Sciences, Padang State University. MS2B is shown in Figure 2.

Figure 2. Bartington magnetic susceptibility meter sensor type B.

Figure 2 is a tool used to measure magnetic susceptibility values. Measurements of magnetic susceptibility values were carried out at two different frequencies, this is because the nature of SP granules is sensitive to changes in frequency. There are two frequencies at which magnetic susceptibility measurements can be performed, namely at Low Field Magnetic Susceptibility (χ_{LF}) at a small frequency of 470 Hz and High Field Magnetic Susceptibility (χ_{HF}) at a high frequency of 4700 Hz. The variation between low and high frequency magnetic susceptibility is called the Frequency Dependent Susceptibility parameter (χ_{FD}) which can be used to trace dominant magnetic mineral sources [20]. According on whether a material contains Superparamagnetic grains in a material, the value (χ_{FD}) is classified into 4 groups as shown in Table 1.

Table 1. Classification (χ_{FD}) of Superparamagnetic Grains.

χ_{FD}	Percentage	Information
Low χ_{FD} %	< 2 %	There are almost no SP grains
Medium χ_{FD} %	2 – 10 %	A mixture of SP and coarse granules, or SP granules <0.05 μm
High χ_{FD} %	10 – 14 %	Almost all SP items
Very high χ_{FD} %	> 14 %	Incorrect measurements, anisotropy, weak samples or contamination

[19]

From Table 1 value (χ_{FD}) is classified into 4 groups, namely low, medium, high, and very high. Values (χ_{FD}) with a percentage below two percent did not find superparamagnetic grains. Superparamagnetic granules are magnetic nanoparticles contained in ferrimagnetic or ferromagnetic particles. The highest frequency-dependent susceptibility value with a percentage of more than 14% means that the measurement is wrong, anisotropic, and the sample is weak or contaminated.

Measurements were conducted at 3 times for all sample at Low Field Magnetic Susceptibility (χ_{LF}) and three times at High Field Magnetic Susceptibility (χ_{HF}), to obtain an average magnetic susceptibility value and record the magnetic susceptibility score results displayed on the monitor screen in Microsoft Excel. The comparison of measurements at two frequencies is called Frequency Dependent Susceptibility (χ_{FD}) which is written in Equation 1:

$$(\chi_{FD})\% = (\chi_{LF} - \chi_{HF}) / \chi_{LF} \times 100\% \quad (1)$$

The average magnetic susceptibility value for each parameter (χ_{LF}, χ_{HF}, χ_{FD}) is calculated and entered into Table 3. The magnetic susceptibility value obtained first looks for the Minimum, Maximum, and Average values for each parameter (χ_{LF}, χ_{HF}, χ_{FD}). It is shown in Table 4. This value will later be used as a new reference standard based on the magnetic susceptibility score. The consistency of the magnetic susceptibility score of raw cement is in the range of values according to the following equation:

$$\chi = \bar{\chi} \pm 3\sigma \quad (2)$$

Furthermore, the magnetic susceptibility values (χ_{LF}) are grouped based on the Hunt Table, 1995[16] to determine the magnetic properties contained in the raw cement material in Raw Mix 2. Magnetic properties consist of Diamagnetic, Paramagnetic, Ferromagnetic, Antiferromagnetic, and Ferrimagnetic. The properties of magnetic contained in the raw cement samples in Raw Mix 2 are seen in Table 6. Based on equation 1, the (χ_{FD}) value of the raw cement sample in Raw Mix 2 is shown, then the (χ_{FD}) value is grouped based on the Dearing Table, 1999[19]. The Superparamagnetic (SP) grain content in the Raw Mix 2 raw cement sample is shown in Table 7.

3. Results and Discussion

The magnetic susceptibility score measurement of raw cement in Raw Mix 2 was measured utilized the Bartington Magnetic Susceptibility Meter Sensor Type B at the Geophysics Laboratory, Department of Physics, Faculty of Mathematics and Natural Sciences, Padang State University. Samples are taken every hour and every day from February 1, 2022 to February 10, 2022, totaling 65 samples. The measurements began with measuring the magnetic susceptibility value which was carried out repeatedly three times on each sample. Then the average value of these repeated measurements is determined. Measurements are carried out in two ways, namely Low Field Magnetic Susceptibility measurements (χ_{LF}) and High Field Magnetic Susceptibility (χ_{HF}). The average value of these two measurements is plotted in a table. Mark (χ_{FD}) is obtained from equation 1. The measuring the average magnetic susceptibility score results are shown in Table 2.

Table 2. Measurement Results of Average Susceptibility Values in Raw Mix 2.

No	Sample Name	Magnetic Susceptibility Value			No	Sample Name	Magnetic Susceptibility Value		
		χ_{LF}	χ_{HF}	χ_{FD}%			χ_{LF}	χ_{HF}	χ_{FD}%
1.	RX2 010222 02	191.2	189.9	0.7	35.	RX2 040222 15	120.3	118.9	1,2
2.	RX2 010222 03	180.2	178.7	0.8	36.	RX2 040222 16	125.1	123.8	1.0
3.	RX2 010222 04	175.7	175.1	0.4	37.	RX2 040222 19	121.3	121.0	0.3

No	Sample Name	Magnetic Susceptibility Value			No	Sample Name	Magnetic Susceptibility Value		
		χ_{LF}	χ_{HF}	$\chi_{FD}\%$			χ_{LF}	χ_{HF}	$\chi_{FD}\%$
4.	RX2 01022205	201.3	199.2	1.1	38.	RX2 07022216	119.2	119.0	0.2
5.	RX2 01022206	178.4	175.6	1.6	39.	RX2 07022217	124.4	123.6	0.3
6.	RX2 01022209	152.1	149.9	1.4	40.	RX2 07022218	118.7	117.5	1.0
7.	RX2 01022210	170.2	166.8	2.1	41.	RX2 07022220	121.4	121.4	0.0
8.	RX2 01022211	132.5	131.4	0.8	42.	RX2 07022221	108.9	107.4	1.4
9.	RX2 01022212	122.7	119.2	2.9	43.	RX2 07022222	132.7	131.4	1.0
10.	RX2 01022213	145.9	144.4	1.0	44.	RX2 08022209	131.7	131.1	0.5
11.	RX2 01022214	138.4	136.7	1,2	45.	RX2 08022210	130.9	130.8	0.1
12.	RX2 01022215	134.8	132.3	1.9	46.	RX2 08022211	144.1	143.7	0.3
13.	RX2 01022216	96.8	96.6	0.2	47.	RX2 08022214	133.7	131.7	1.5
14.	RX2 02022211	186.3	183.2	1.7	48.	RX2 08022215	121.1	121.0	0.1
15.	RX2 02022212	206.9	202.6	2.1	49.	RX2 08022216	108.5	108.3	0.1
16.	RX2 02022213	190.9	190.9	0.0	50.	RX2 08022220	142.3	139.5	2.0
17.	RX2 02022214	148.7	146.2	1.7	51.	RX2 08022221	150.9	148.5	1.4
18.	RX2 02022215	128.5	127.8	0.5	52.	RX2 08022222	151.3	150.6	0.5
19.	RX2 02022217	187.1	184.2	1.5	53.	RX2 09022208	132.9	132.1	0.6

No	Sample Name	Magnetic Susceptibility Value			No	Sample Name	Magnetic Susceptibility Value		
		χ_{LF}	χ_{HF}	$\chi_{FD}\%$			χ_{LF}	χ_{HF}	$\chi_{FD}\%$
20.	RX2 030222 10	133.2	130.0	2,2	54.	RX2 090222 09	131.9	129.3	2.0
21.	RX2 030222 12	131.2	129.1	1.6	55.	RX2 090222 10	159.0	156.4	1.6
22.	RX2 030222 14	110.7	110.6	0.1	56.	RX2 090222 11	126.1	125.9	0.1
23.	RX2 030222 15	108.2	107.8	0.4	57.	RX2 090222 12	94.0	92.8	1.3
24.	RX2 030222 16	79.8	79.4	0.5	58.	RX2 090222 13	121.6	120.4	1.0
25.	RX2 030222 17	121.8	120.4	1,2	59.	RX2 090222 14	136.2	134.9	1.0
26.	RX2 030222 18	123.3	119.6	3.0	60.	RX2 100222 08	155.4	153.9	1.0
27.	RX2 030222 20	121.2	119.2	1.7	61.	RX2 100222 09	158.8	156.1	1.7
28.	RX2 030222 21	126.4	124.4	1.6	62.	RX2 100222 11	150.8	149.7	0.7
29.	RX2 040222 08	115.7	114.2	1.3	63.	RX2 100222 12	145.8	144.8	0.7
30.	RX2 040222 09	126.0	124.1	1.5	64.	RX2 100222 13	140.4	139.8	0.4
31.	RX2 040222 10	116.4	114.4	1.7	65.	RX2 100222 15	145.8	144.1	1,2
32.	RX2 040222 11	119.5	117.8	1.4					
33.	RX2 040222 12	114.5	113.1	1,2					
34.	RX2 040222 14	117.0	115.6	1,2					

In Table 2 we can see the measuring the average magnetic susceptibility scores results in every hour and every day from 1 February - 10 February 2022 in the conditions of Low Field Magnetic

Susceptibility (χ_{LF}), High Field Magnetic Susceptibility (χ_{HF}), and Frequency Dependent Susceptibility (χ_{FD}). From the data obtained, the maximum, minimum, and average values per day will be found. It can be observed in Table 3.

Table 3. Maximum, Minimum and Average Values of Magnetic Susceptibility Measurement of Raw Cement in Raw Mix 2.

Date	**Maximum**			**Minimum**			**Average**		
	χ_{LF}	χ_{HF}	$\chi_{FD}\%$	χ_{LF}	χ_{HF}	$\chi_{FD}\%$	χ_{LF}	χ_{HF}	$\chi_{FD}\%$
February 1, 2022	201.3	199.2	2.9	96.8	96.6	0.2	155.4	153.5	1,2
February 2, 2022	206.9	202.6	2.1	128.5	127.8	0.0	174.7	172.5	1.3
February 3, 2022	133.2	130.0	3.0	79.8	79.4	0.1	117.3	115.6	1.35
February 4, 2022	126.0	124.1	1.7	114.5	113.1	0.3	119.5	118.1	1,2
February 7, 2022	132.7	131.4	1.4	108.9	107.4	0.0	120.9	120.05	0.64
February 8, 2022	151.3	150.6	2.0	108.5	108.3	0.1	134.9	133.9	0.7
February 9, 2022	159.0	156.4	2.0	94.0	92.8	0.1	128.8	127.4	1.08
February 10, 2022	158.8	156.1	1.7	140.4	139.8	0.4	149.5	148.07	0.95

From Table 3, the maximum, minimum, and average values per day are obtained. The highest small Field Magnetic Susceptibility (χ_{LF}) data is in sample RX2 020222 12, namely 206,9 x $10^{-8}m^3$/kg, and the highest High Field Magnetic Susceptibility (χ_{HF}) value is in the same sample, namely RX2 020222 12 which has a score of 202,6 x $10^{-8}m^3$/kg. Mark of Low Field Magnetic Susceptibility (χ_{LF}) the lowest was found in the sample RX2 030222 16, namely 79,8 x $10^{-8}m^3$/kg and the lowest was also found in the same sample RX2 030222 16, value are 79,4 x $10^{-8}m^3$/kg. The high susceptibility value of a sample is caused by a high magnetic mineral concentration, and samples with a low susceptibility score have a small magnetic mineral concentration. The maximum, minimum, and average Magnetic Susceptibility values per day from February 1 to February 10, 2022, are plotted into a graph, which shown in Figure 3.

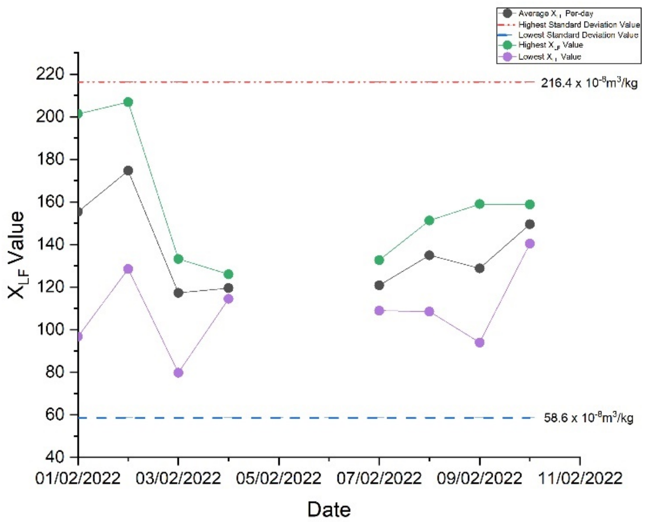

Figure 3. Minimum, maximum, and average magnetic susceptibility values every day from February 1 to February 10, 2022

Based on Figure 3 the value of each subject varies greatly per day, we can see the highest Low Field Magnetic Susceptibility value is on February 2, 2022, and the lowest is on February 3, 2022. High susceptibility scores are due to contamination while high magnetic susceptibility values indicate the presence of magnetic minerals in the material. To see the consistency of the magnetic susceptibility score of raw cement samples in Raw Mix 2, standard deviation calculations were used. First, we will look at the daily standard deviation to see that the data obtained can be said to be consistent. The standard deviation of the results from magnetic susceptibility measurements per day can be observed in Table 4.

Table 4. Standard Deviation Every Day.

Date	χ_{LF}	χ_{HF}	$\chi_{FD}\%$
February 1, 2022	30.29	30.16	0.75
February 2, 2022	29.66	28.93	0.8
February 3, 2022	16.33	15.47	0.94
February 4, 2022	4.07	4.15	0.41
February 7, 2022	7.79	7.89	0.55
February 8, 2022	14.05	13.53	0.72
February 9, 2022	19.42	19.02	0.62
February 10, 2022	6.83	6.26	0.45

The Table 4 shown that the standard deviation value for measuring the magnetic susceptibility of raw cement samples in Raw Mix 2 per day still varies. So the data obtained cannot be said to be consistent, to get the consistency value it is necessary to recalculate based on the overall susceptibility data. It can be observed in Table 5.

Table 5. Overall Magnetic Susceptibility Measurement Results of Raw Mix 2 Cement.

Parameter	χ_{LF}	χ_{HF}	$\chi_{FD}\%$
Maximum	206.9	202.6	3.0
Minimum	79.8	79.4	0.0
Standard Deviation	26.3	25.9	0.7
Average	137.5	136.0	1.1

Table 5 shown that the average magnetic susceptibility score of Raw Mix 2 is 137,5 x $10^{-8}m^3$/kg and the standard deviation value of Raw Mix 2 is 26,29 x $10^{-8}m^3$/kg. It can explain that the maximum and minimum magnetic susceptibility scores per day in the (χ_{LF}) and (χ_{FD}) states still vary as well as the average magnetic susceptibility value per day obtained in the (χ_{LF}) state still varies as well as in the (χ_{FD}) state so that the value obtained cannot be said that the value is consistent yet.

Measurement of magnetic susceptibility scores in the small Field Magnetic Susceptibility (χ_{LF}) state looks inconsistent for both hourly and daily data. This is also evidenced by the calculation of the standard deviation, as well as for the value of High Field Magnetic Susceptibility (χ_{HF}) and Frequency Dependent Susceptibility (χ_{FD}) is inconsistent for hourly and daily data. Therefore, to find a new reference standard, consistent data is needed so that the data used is the whole data. Statistically, it is stated that more samples are expected to give better results. That way, There is a good chance that the obtained mean and standard deviation will resemble the population mean and standard deviation. The standard deviation score is a number that is used to assess how closely the data in a sample matches the average score and to determine how distributed the data. Based on the overall standard score of the data, it can be obtained the consistency of the magnetic susceptibility value of raw cement in the range from 58,6 x $10^{-8}m^3/$kg up to 216,4 x $10^{-8}m^3/$kg, this is shown in Figure 2.

From the measurement results, the magnetic susceptibility socre of Raw Mix 2 is as explained in the Hunt Table, 1995[16]. The magnetic properties of Raw Mix 2 can be observed in Table 6.

Table 6. Magnetic Properties of Raw Mix 2 Cement.

Magnetic Susceptibility Value (x $10^{-8}m^3/$kg)	**Magnetic Properties**
79,8 x $10^{-8}m^3/$kg – 206,9 x $10^{-8}m^3/$kg	Antiferromagnetic

Table 6 shows the magnetic susceptibility value in Low Field Magnetic Susceptibility ranging from 206,9 x $10^{-8}m^3/$kg to 206,9 x $10^{-8}m^3/$kg. It can observe that the magnetic properties of raw cement in Raw Mix 2 are Antiferromagnetic. Antiferromagnetic materials have a small positive magnetic susceptibility value in the range (0-760) x $10^{-8}m^3/$kg.

Based on the measuring the magnetic susceptibility score results of Raw Mix 2 (Table 2), the value (χ_{FD}) of the Raw Mix 2 sample can be determined, then the value (χ_{FD}) is grouped based on the Dearing Table, 1999[19]. The classification of grain types in Raw Mix 2 can be observed in Table 7.

Table 7. Classification of Grain Types Contained in Raw Mix 2 Cement Samples.

Value Range χ_{FD} %	**Number of Samples**	**Information**
< 2%	58	Absent or containing less than 10% superparamagnetic grains
2-10%	7	Contains superparamagnetic grains from 10% -75% which is a fine and coarse SP grains mixture

Based on Table 7, it can be observed that the type of grain in Raw Mix 2 with a total sample of 65, 58 samples have an average value of χ_{FD} % < 2%. So it can be seen that the content of superparamagnetic grains contained in raw cement is absent or almost absent superparamagnetic grains, namely containing less than 10% superparamagnetic grains. 7 samples have χ_{FD} % values in the range of 2 - 10%. So it can be seen that the sample contains superparamagnetic grains between 10 - 75% which is a mixture of fine and coarse superparamagnetic grains. In Table 5, the average value of χ_{FD} % is obtained, namely the overall χ_{FD} % value is 1.1% or < 2%. This value indicates that the measured raw cement samples contain almost no superparamagnetic grains or contain small of 10% superparamagnetic grains. with a value of χ_{FD} % < 2% is 58, which means it does not exist or contains small of 10% superparamagnetic grain. The relationship between χ_{LF} and χ_{FD} % can be seen in the graph below.

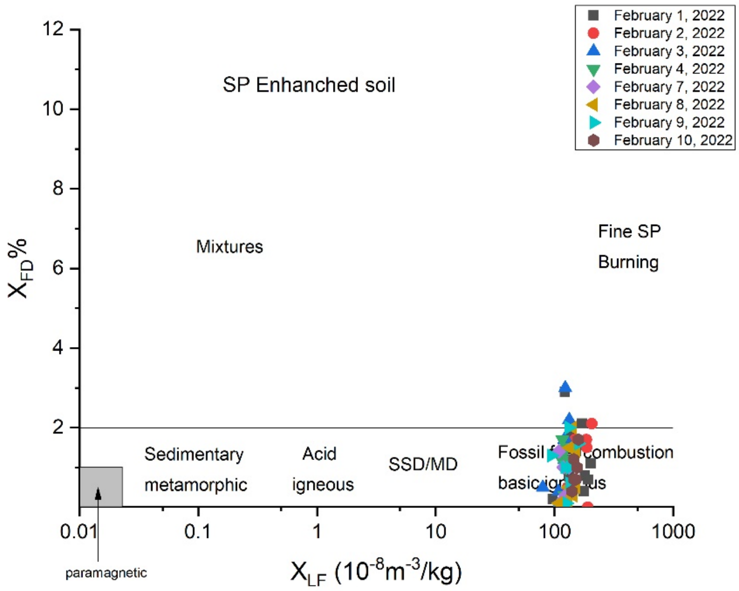

Figure 4. χ_{LF} and χ_{FD} % relationship graph

Based on Figure 4, the χ_{LF} graph ($10^{-8}m^3/kg$) for raw cement samples can be seen that the χ_{FD} % value obtained varies in the range of 0.0% - 3.0%. The properties of magnetic minerals are greatly impacted by the size of their magnetic grains. Magnetic grains are the most significant element within the magnetic field. Because it shows the same magnetic susceptibility value at small and big frequencies.

4. Conclusion

The magnetic susceptibility of raw cement in Raw Mix 2 from Padang Cement Plant every hour and every day from February 01 to February 10, 2022, varies with the highest value 206,9 x $10^{-8}m^3$/kg and the lowest value 79,8 x $10^{-8}m^3$/kg in the sample with an overall average of 137,5 x $10^{-8}m^3$/kg. The data obtained varies greatly, this is because the raw materials are taken from different places. By using equation 2 it can be stated that χ = 137,5 ± (3 * 26,3) x $10^{-8}m^3$/kg, so that a consistent magnetic susceptibility score of raw cement can be obtained in the range of 58,6 x $10^{-8}m^3$/kg up to 216,4 x $10^{-8}m^3$/kg. Based on the average value per day of Raw Mix 2 and interpreted into a graph, it was found that all Raw Mix 2 data that had been measured was consistent because there was no data that crossed the standard deviation line obtained using equation 2. This means that meanwhile, the measured Raw Mix 2 value can be said to be consistent and of good quality based on standard deviation calculations. This consistency value can be seen from the 65 samples, it would be better if more samples were obtained. The magnetic properties of raw cement in Raw Mix 2 are antiferromagnetic based on Hunt Table, 1995[16]. Based on Table 7, it can be observed that the type of grain in Raw Mix 2 with 58 samples has the value χ_{FD} % < 2% which means there is no or contains less than 10% superparamagnetic grains. While range (χ_{FD} %) 2 -

10% totaling 7 samples, which means they contain from 10% - 75% superparamagnetic grains, which are a mixture of fine and coarse superparamagnetic grains.

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