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Compressive Strength and Emission Temperature of Concrete Containing Varying Percentage of Metakaolin and Superplasticizer

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Abstract: In the building sector, concrete is the most often utilized material. However, a rise in the production of such concrete may result in an increase in carbon dioxide pollution released into the atmosphere, which was harm the environment. As a result, alternative materials such as cement, fine aggregates, and coarse aggregates must be discovered in order to effectively overcome the negative impacts of the concrete manufacturing process and produce high strength concrete utilizing such alternative materials. As a result, the purpose of this research is to investigate the usage of Metakaolin as a cementitious additive and Superplasticizer. The particle size analysis, workability, compressive strength, and emission temperature of high-strength concrete containing Metakaolin and Superplasticizer were investigated in this study. In this investigation, metakaolin was employed as a partial replacement of cement with percentages of 5%, 10%, and 15%, while separate doses of Superplasticizer (1.5%) and 2%) used as a chemical admixture were carried out with w/c 0.27. All of the concrete cubes and prisms were cured in water for 7 and 28 days, respectively. The cube specimen of 100mmx100mmx100mm was utilized to test compressive strength, while the prism specimen of 510mmx100mmx100mm was tested on emission temperature concrete every hour for 7 days. According to the test results, the best percentage for use in concrete mixture in terms of compressive strength and emission temperature are 15% Metakaolin and 1.5 % Superplasticiser.

Keywords: Metakaolin, Supplementary Cementitious, Emission Temperature

1. Introduction

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Demand for cement is directly proportional to economic growth, and many developing countries are striving for rapid infrastructure development, and this explains why cement production is increasing rapidly. This is because cement is the main building material for housing and infrastructure development, as well as the gateway to economic development [1].According to Devi [2] also, the concrete industry is considered to be one of the main contributors to the causes of global warming, due mostly to the usage of Portland cement as a binder.

Actions have been taken to develop alternatives to Portland cement in order to minimize the environmental effect of the concrete industry. Geopolymers, innovative ecologically friendly inorganic binders produced from alkaline solutions that activate the alumina silicate of the source material, such as Metakaolin, fly ash, and slag, have received a lot of interest in recent years as a viable alternative to Portland cement. Geopolymer binders reduce greenhouse gas (CO_2) emissions and energy demands during manufacturing by making optimal use of industrial by-products [2].As a result, additional alternative materials need be studied and explored in order to reduce the use of cement, avoid the extinction of natural resource materials, fulfill the demand for concrete, and support sustainability in the construction field while conserving the environment. The construction industry must begin to highlight the usage and deployment of sustainable building materials systems that are generally available and easily accessible without damaging the ecosystem by taking viable remedies to these environmental problems seriously today. The focus of this study will be on Metakaolin, an alternative material to cement that will be utilized in the production of concrete. This study will also investigate at the compressive strength and emission temperature of concrete with varying percentages of Metakaolin and Superplasticiser to create high strength concrete.

This is from previous studies that have been done; it is proven that there are many benefits with the application of Metakaolin as an additional cementitious material in the production of concrete. According to Wang [3], mineral additive cement, such as fly ash, silica fume, and thermally activated kaolin, commonly known as Metakaolin, has been implemented to enhance the properties of concrete. Metakaolin also consumes less energy to produce than cement, which has gained increasing attention in usage for SCM in recent years because to environmental concerns and diminishing supply capacity of fly ash and silica fume. Metakaolin products are dominated by alumina (Al_2O_3) and silica (SiO_2), both of which have active pozzolanic characteristics. The pozzolanic reaction of Metakaolin with portlandite ($Ca(OH)_2$) results in considerable composition changes in the calcium silicate hydrate (CSH) gel, resulting in strong Al absorption and low Ca content in the development of a new gel known as CASH, which has a low Ca/(Al + Si) ratio but a high Al/Ca ratio. According to Shafiq [4], around 11.2 million metric tons of kaolin deposits have been discovered in Malaysia's states of Perak, Johor, Kelantan, Selangor, Pahang, and Sarawak. In 2007, over 30 operational kaolin mines produced 5, 87,508 metric tons of kaolin, up 72 percent over 2006. As a matter of fact of the availability of kaolin resources, Malaysia can also take advantage of the opportunity to produce eco-concrete by using metakaolin substance as a pozzolanic material in the production of concrete, as other countries have done, and hence promoting and improving sustainability in the construction sector.

Portland cement can be replaced with 20% Metakaolin to attain maximum strength. According to studies, the strength values of 20P800 were 7% and 23% higher than the control mortar after 3 and 7 days, respectively [5]. According to the findings of a study conducted by Said et al (2011), the addition of MK increased compressive strength by 20%. When compared to the reference combination, adding 30% MK reduces compressive strength. When it comes to generating compressive strength at various ages, a combination of 10% MK produces the best results.When Metakaolin clay is used instead of cement, the Compressive Strength of Metakaolin concrete is increased by 5% to 15%. After 28 days, the greatest compressive strength was 31.65 MPa (a 15.43 % increase above control) with 15% cement replacement [12]. According to Said [4], the compressive strength improved dramatically over the course of 28 days. Beyond normal concrete strength for 28 days, partial replacement of up to 20% for both samples varies from 1% to 15% at 56 days and 5% to 31% at 90 days of curing.

The mechanical properties of high-strength concrete including Metakaolin have improved, with a maximum replacement rate of 10- 15%; however, the increase in compressive and splitting tensile strength outweighs the increase in bending strength [7]. According to Said [4], high initial compressive strength, splitting tensile strength, and bending strength were achieved using 5–20 % Metakaolin as a cementitious material. Using up to 15% Metakaolin as a supplementary cementitious material is the best way to take advantage of the increased initial compressive strength, according to the compressive strength. Alimrani[8] found that using Metakaolin with a 6% supplementation provided the highest compressive strength of concrete at ambient temperature, reaching 93.9MPa. MK replacement 9 % demonstrated the best thermal conductivity in concrete compressive strength.The compressive strength of the plain mortar specimens (without calcined kaolin minerals) was 62 MPa after 28 days, but the compressive strength of the mortars ranged from 49.6 to 66.6 MPa, depending on the type of Metakaolin used and the calcination temperature [9].

According to Alonge[10], when it refers to the influence of addition dose on concrete compressive strength, Superplasticizer additives behave differently. These Superplasticizer chemicals will improve compressive strength in people of all ages. Because the addition of SP to the concrete mix will supply extra water, the hydration process will not only be unaffected, but will be accelerated by the addition of water from cement particle deflocculation. Excessive amounts of Superplasticizer produce bleeding and segregation, which affects the cohesion and homogeneity of the concrete. As a result, if the dose utilized is more than the recommended dose, the compressive strength will be reduced. It is possible to see a difference in compressive strength with a difference in Superplasticizer dose in concrete. The compressive strength of concrete including Superplasticizer exceeds 8 N/mm^2, 10 N/mm^2, and 11 N/mm^2 for all dosages when the compressive strength raising efficiency is examined, and this value is greater than the control compressive strength. Based on the highest ultimate strength shown at 28 days of age, the optimum Superplasticizer dose is determined. The addition should be used at a rate of 1000 ml per 100kg of cement. Compressive strength is reduced by doses less than or more than this optimum value.

The aim of this research is to analyze the compressive strength and emission temperature of concrete with varying percentages of Metakaolin and Superplasticiser.

2. Materials and Methods

2.1 Materials

The material used in this study were included Ordinary Portland Cement, fine aggregate, coarse aggregate, Metakaolin, Superplasticiser, and water. The Particle size analyzer was studied for Ordinary Portland Cement and the specific surface area as shown in Table 1. The river sand retained at sieve no 4 as fine aggregate and coarse aggregate retained at sieve no 2 was used. Figure 1 shows the gradation curve of fine aggregate and coarse aggregate. Coarse aggregate will be left to dry in an open area to ensure that the aggregate does not moisturize or water, hence preventing the inclusion of water content in the water ratio for concrete mix design in this study. While the application of fine aggregate in this study is comparable to that of coarse aggregates, fine aggregate is not dried for as long. Dynamon NRG 1030 is the type of Superplasticiser that will be utilized in this study's concrete mix. Tap water (UTHM laboratory) treated by Syarikat Air Johor (SAJ) would be utilized in the high-strength concrete production process.

Table 1: Particle size analysis and specific surface area of metakaolin and cement

Sample	Diameter at 10% (mµ)	Diameter at 30% (mµ)	Diameter at 60% (mµ)	Specific surface area (cm^2/g)
Metakaolin	0.78	1.69	3.98	5267.03
Cement	1.94	8.08	18.52	16156.31

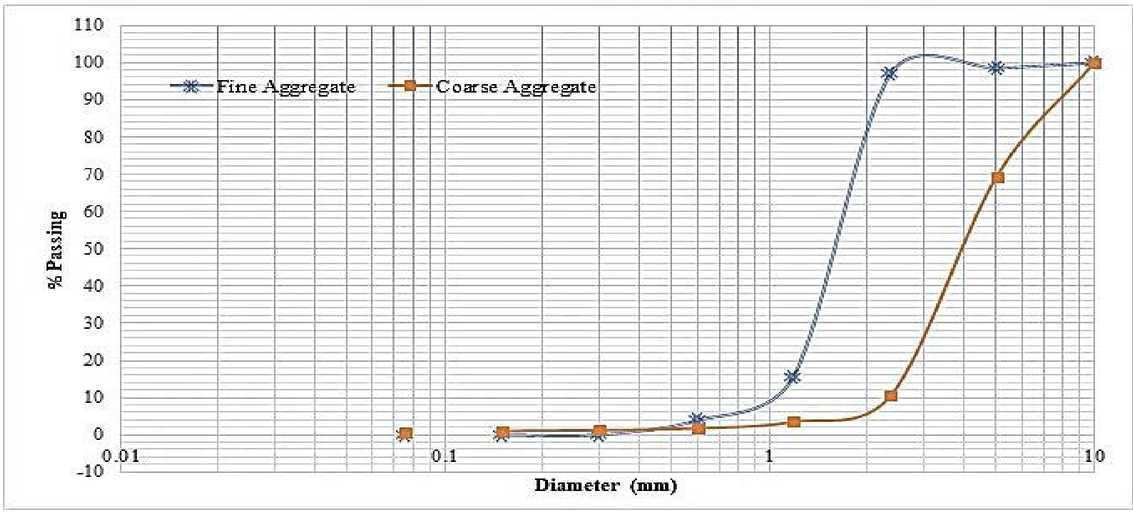

Figure 1: Gradation curve of fine aggregate and coarse aggregate

2.2 Mix Proportion

The metakaolin mixture design proportions employed in this investigation vary in percentages. In this investigation, multiple percentages of metakaolin will be used, including 5%, 10%, and 15%, with superplasticiser contents of 1.5% and 2% for each concrete mix. Table 2 shows design mix which used 1.5% and 2% Superplasticiser with 5%, 10%, and 15% Metakaolin. In this investigation, the design ratios were 1: 1.35: 1.85 (cement: sand: aggregate), and 0.27 for the water-cement ratio.

Table 2: Design mix for 1.5% and 2 % superplasticiser with 5%, 10%, and 15% metakaolin

Mix	Cement (kg)	Calcined Kaolin (kg)	Sand (kg)	Coarse Aggregate (kg)	Water (kg)	Superplasticizer (2%)(kg)	Superplasticizer (1.5%)(kg)
OPC	19.8	0	26.71	37.22	5.35	0.4	0.3
OPC+5MK	18.81	0.99	26.71	37.22	5.35	0.4	0.3
OPC+10MK	17.82	1.98	26.71	37.22	5.35	0.4	0.3
OPC+15MK	16.83	2.97	26.71	37.22	5.35	0.4	0.3

2.3 Methods

a. Compressive Strength

The compressive strength of concrete was tested on 100mm x 100mm x 100mm cubes in accordance with BS EN 12390-3: 2019. After 7 and 28 days of curing in water, these test specimens will be placed through compression test equipment, and the failure load of the specimens will be recorded, and the compressive strength of each specimen in MPa units. The compressive strength was calculated using the average of three specimens at each age of testing.

b. Emission Temperature

The emission temperature of concrete was tested 510mm x 100mm x 100mm prism specimen according with BS -130: 2013 (Testing concrete: A Method for Temperature- Method during of concrete specimens).To determine the emission temperature of concrete, a thermocouple sensor will be used in the experiment. The concrete temperature sensor in the investigation will be placed at the chosen site at the concrete that will be tested. The temperature sensor (probe) is installed 50mm deep into the concrete at the face of a vertical surface. The emission temperature value of concrete (prism) utilizing thermal couple will be monitored every 1 hour period for 7 days in this investigation. Figure 2 show the thermocouple was used test the emission temperature of concrete.

Figure 2: Thermocouple

c. Slump Test

The slump test is carried out in accordance with BS EN 12350-2: 2000 (Fresh Concrete Test-Part 2: Slump Test), in which fresh concrete that has been ready to be mixed is compacted into the mould in the form of a frustum cone, and when the cone is withdrawn upwards, the distance the concrete has slumped provides a measure of the consistency of the concrete. The required range of concrete fresh slump values is 150 +/- 25.

d. Slump Flow Test

The slump flow test is carried out in accordance with BS EN 12350-5: 2000(Testing Fresh Concrete- Part5: Flow Table test). This test assesses the consistency of fresh concrete by monitoring the spread of concrete on a jolted flat plate. The required range of concrete fresh flow values is 450 +/- 25.

3. Results and Discussion

3.1 Workability of Fresh Concrete

The results data of slump test and slump flow test of fresh concrete with different percentage of Metakaolin and Superplasticiser, and the control sample showed in Figure 3 and 4.

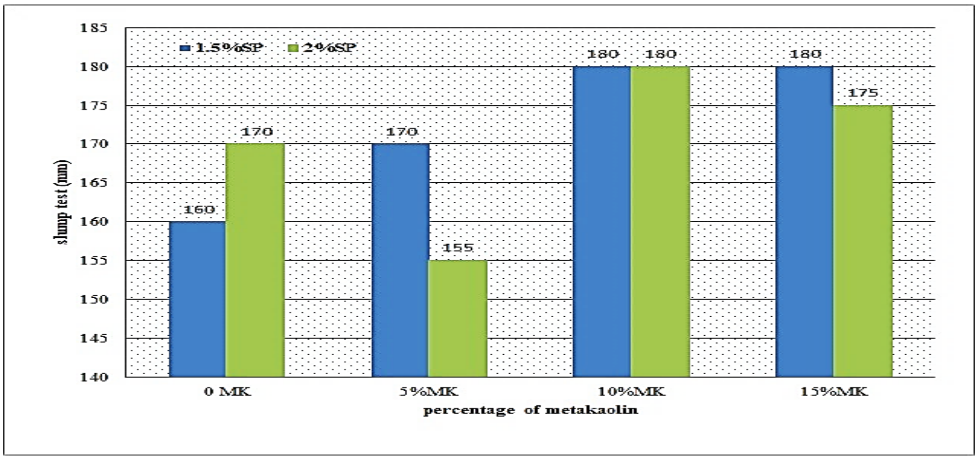

Figure 3: Slump test of Metakaolin concrete and control mix

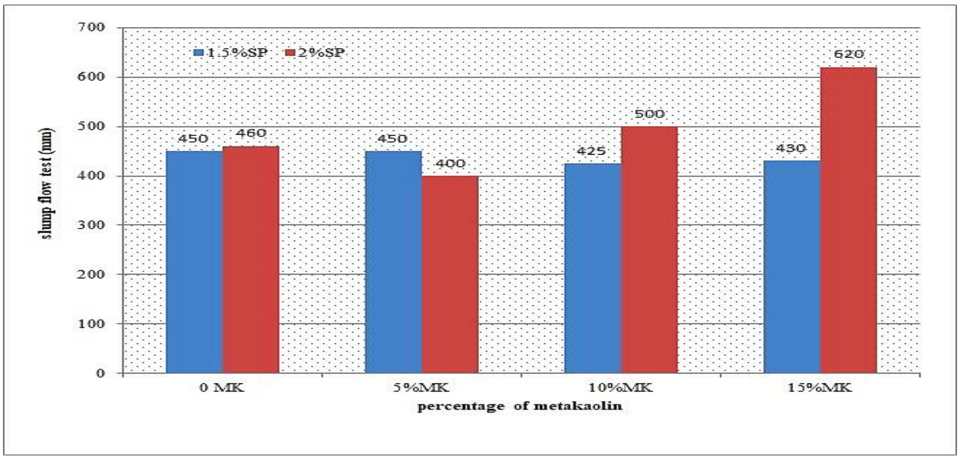

Figure 4: Slump flow test of Metakaolin concrete and control mix

Based on results in the Figure3, it identify that fresh concrete slump test was increase when increase utilization dosage of metakaolin with 1.5% superplasticiser whichmarked160mm (0%MK), 170mm (5%MK), 180mm (10%MK), and 180mm (15%MK). While the fresh concrete results with 2% of superplasticiser showed that 10% and 15% of metakaolin give highest slump which is 180mm and 175mm.

From the Figure 4, it showed that utilization of 2% superplasticiser with varying percentage of metakaolin in fresh concrete mix give the increase slump flow values when increase dosage of metakaolin, which is 400mm (5%MK), 500mm(10%MK) and 620mm(15%MK). Meanwhile, control mix showed with highest slump flow than the concrete mix with 5% of metakaolin which is 460mm (0%MK).It is clear from Figures 3 and 4, that replacing cement with metakaolin will improves the workability of metakaolin concrete when compared to the control specimen (OPC concrete). This is because the specific surface area of Metakaolin powder is lower than that specific surface area of cement powder, which increases the workability of Metakaolin concrete. Because the specific surface area is smaller, the water demand will be lower, and the workability will be higher at the same water cement ration. This is explained by the fact that as particle size decreases, more water is required to facilitate particle movement with one another, resulting in an increase in viscosity. Meanwhile, some of the water is trapped in the agglomerate's pores and has no impact on flow ability. The main parameters influencing the flow values of all mixtures were discovered to be w/b, s/b, and SP/b. SP/b, on the other hand, is considered more important because it contributes to the flow value that can be achieved. This confirms previous findings on HCC mixed flow [11]. According to [11], utilizing of Metakaolin as supplementary material will improve the flow ability of concrete and cement mortar. Metakaolin will also improve the workability and fishing of concrete.From this study also, it identify that by utilize 2% dosage of Superplasticiser in to concrete mix with 15% of Metakaolin, the slump flow was larger which 620mm than the slump flow of control mix. Therefore, it’s identifying that 2% dosage of Superplasticiser in this study is high dosage to utilize in concrete mix with 15% of Metakaolin. This is due to Metakaolin's smaller specific surface area than cement. When the specific surface area of Metakaolin is small, the amount of water required in the concrete mix is reduced. As a result, 15% Metakaolin was used to replace the cement in the concrete mix, while 2% Superplasticiser provided high hydration and interrupted water flow in the concrete mix, causing bleeding and segregation. According to [10], if the dosages are increased beyond this point, the compressive strength will be reduced. This occurs because excessive SP dosage causes bleeding and segregation, which affects the concrete's cohesiveness and uniformity.

3.2 Compressive Strength

Compressive strength of concrete with varying percentage of Metakaolin and Superplastiser are shown in Table 4. These tests were performed on 7 days and 28 days. Figure 2 shows the analysis graph value of compressive strength for the various percentages of superplasticiser and metakaolin.

Table 3: Compressive strength of Metakaolin concrete with Superplasticiser

Age of test	0MK 1.5SP	5MK 1.5SP	10MK 1.5SP	15MK 1.5SP
Average cube compressive strength (Mpa)				
7 days(S1)	54.75	65.3	60.88	60.16
28 days(S1)	54.7	77	74.13	78.48
Age of test	0MK 2SP	5MK 2SP	10MK 2SP	15MK 2SP
Average cube compressive strength (Mpa)				
7 days(S2)	54.7	55.4	57.5	58.77
28 days(S2)	58	68.5	64.7	64.67

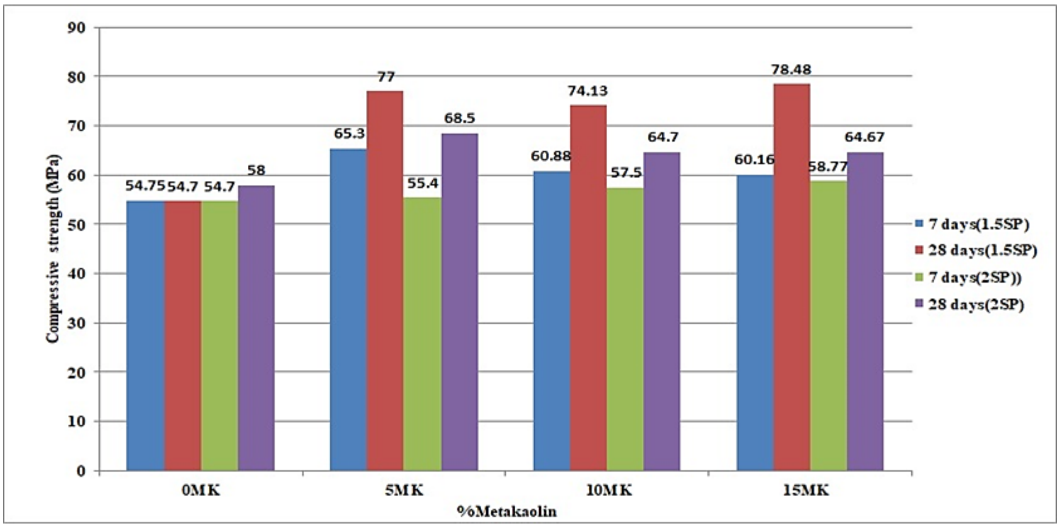

Figure 5: Compressive strength of concrete different percentage of Metakaolin and Superplasticiser

From the tabulated results for 7days, its shows that an increase values of compressive strength with an increasing dosage metakaolin of 5%, 10% and 15% which marked at 55.4MPa, 57MPa and 58MPa respectively. However, a large dosage of Metakaolin, which was 15% with 2% Superplasticiser showed the best concrete compressive strength, compared the other concrete mix with Metakaolin and the control mix at 7days. But in 28days age of the concrete, it showed the decreased value of compressive strength when utilized an increase of Metakaolin dosage of 10% and 15% which marked at 64.7MPa and 64.67MPa respectively. However, the small dosages of Metakaolin which 5% give a best compressive strength value (68MPa) than other Metakaolin concrete mix at 28days.While utilizing 1.5%SP in Metakaolin concrete resulted in a high compressive strength when compared to the control mix, and this strength was able to meet the compressive strength requirements of this study. This is due to the fact that the higher the dose of Metakaolin used, the higher the compressive strength, which is 77MPa (5MK), 74.13MPa (10MK), and 78MPa (15MK). As a result, 1.5 % SP is preferable to 2 % SP for use in concrete mixes because it can enhance compressive strength. It has also been discovered that using a Superplasticiser in a concrete mix not only improves workability but also increases the compressive strength of the concrete when used at the proper dosage. According to [10] increased dosage of the Superplasticizer (SP) will increase compressive strength. Because the addition of SP provides more water for concrete mixing, not only will the hydration process be unaffected, but it will be accelerated by the additional water from cement particle deflocculation. As a result, increasing the dosage will increase the entrapped water and promote cement hydration. Though increasing the admixture dosage will improve compressive strength, there is still a limit to how much admixture can be used.

It was also discovered that the compressive strength of Metakaolin concrete will increase when compared to the control mixture, with a Metakaolin dose range of 5% to 15% with 1.5%SP. At the age of 28 days, Metakaolin concrete with 15% additional cement, i.e. Metakaolin, was successfully achieved with a maximum compressive strength of 78.48MPa. It goes same result from [12], that locally developed Metakaolin increases the compressive strength of Metakaolin concrete compared to a control mixture with substitution cement, with an inclusion range of 5% to 15%. At 15% cement replacement by developed Metakaolin, maximum compressive strength of 31.65 MPa (i.e. 15.43 percent higher than control) was achieved after 28 days (i.e. 15.43 percent higher than control).The filling effect of concrete compaction and the pozzolanic reaction of Metakaolin to concrete mix are the two most important aspects of this cementitious supplementary metakaolin to achieve good strength. According to [4], based on compressive strength, up to 15% Metakaolin can be used as a partial substitute for the optimal portion of high initial compressive strength cement.

3.3 Emission Temperature

Comparison of ambient temperature and concrete temperature were shown in Figures 6, 7, 8 and 9.While the graph of comparison emission temperature concrete with different percentage of Metakaolin and Superplasticiser shown in Figure 10 and 11.

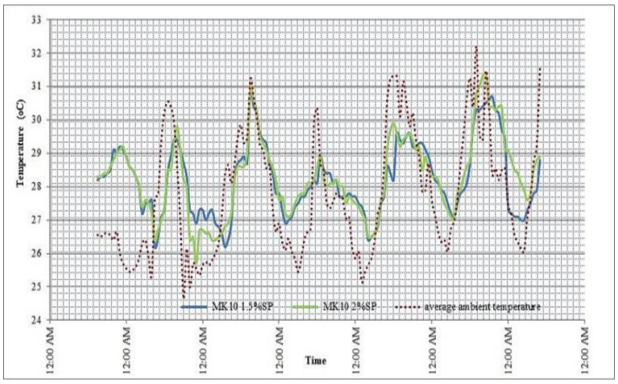

Figure 6: Emission temperature concrete by control sample by 1.5% and 2% SP with ambient temperature

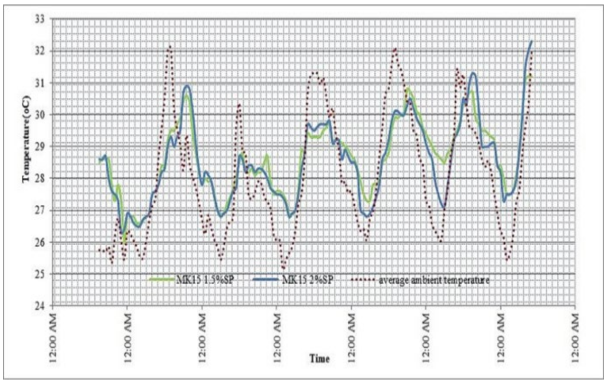

Figure 7: Emission temperature concrete by containing MK5% by 1.5%SP and 2%SP with ambient temperature

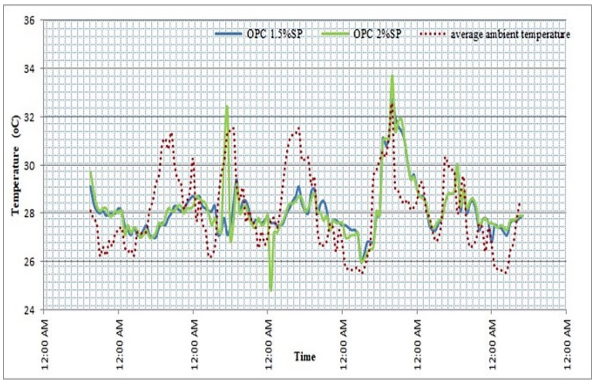

Figure 8: Emission temperature concrete by MK10% with 1.5% and 2% SP with ambient temperature

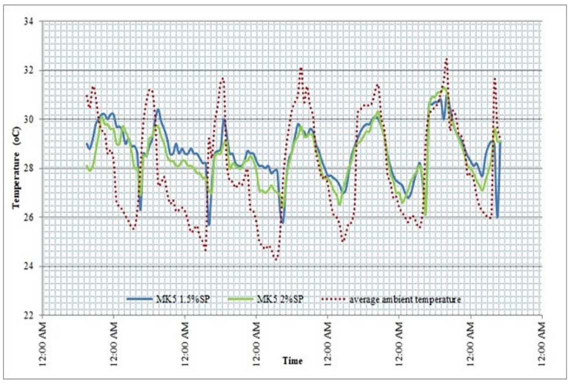

Figure 9: Emission temperature concrete by MK15% with 1.5% and 2% SP with ambient temperature

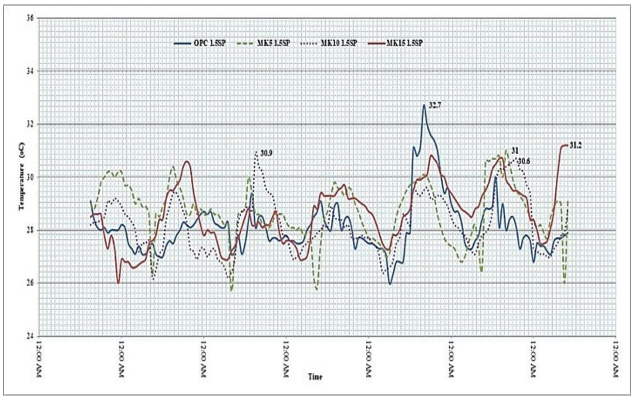

Figure 10: Differential of concrete temperature by varying percentage of MK with 1.5% of SP

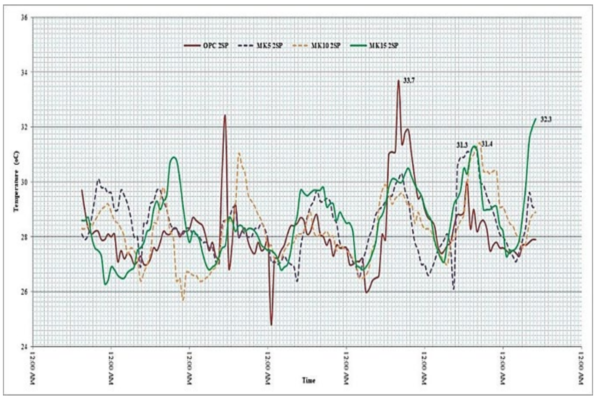

Figure 11: Differential of concrete temperature by varying percentage of MK with 2% of SP

The difference in concrete emission temperature in the presence of 1.5 % and 2 % Superplasticiser in concrete mix with different doses of Metakaolin mixture (5 %, 10 %, and 15 %) is shown in Figures 7 and 8. The graph analysis reveals that adding Metakaolin and Superplasticiser to the concrete mix affects the concrete's emission temperature. This is due to the discovery that the presence of cementitious supplementary material (Metakaolin) in the concrete mix causes the Metakaolin concrete to have a lower temperature than the concrete that does not contain the Metakaolin mixture.

In comparison to concrete containing Metakaolin, the result temperature value of OPC with 1.5 percent Superplasticiser shows the highest value, as shown in Figure 10. This is because the maximum emission temperature for OPC 1.5 % is 32.7 ℃, while the maximum emission temperatures for concrete MK5, MK10, and MK15 are 31 ° C, 30.7 ° C, and 32.2 ° C, respectively. The graph in Figure 11 also shows that utilising 2% Superplasticiser with various Metakaolin doses in the concrete mix gives the same comparison as Figure 4.15, where concrete that does not contain Metakaolin content (OPC 2 % SP) will give a temperature value that is higher than concrete that contains Metakaolin. Where it is discovered that concrete without Metakaolin (OPC 2%SP) can reach a maximum high temperature of 33.7 ºC, whereas concrete with Metakaolin can reach a maximum low temperature of 31.5 ºC (MK5), 31.3 ºC (MK10), and 32.3 ºC (MK15).

The concrete will reach a high temperature at particular periods, according to the emission temperature analysis data of concrete with varied percentages of Metakaolin. Furthermore, it was discovered that the temperature of Metakaolin concrete will reach emission temperature in the time range of 3 to 4 hours from midday to dusk. This is because the temperature rises at that time, affecting the pozzolanic reaction of the Metakaolin in the concrete, causing the Metakaolin to create a high emission temperature. However, the temperature of the concrete will drop again when the ambient temperature drops, such as at night or during rain, but the temperature of the concrete Metakaolin remains high in comparison to the ambient temperature. This also demonstrates that the ambient temperature might aid in the reaction of the pozzolonic material in the concrete it see the comparison ambient temperature and concrete temperature in Figures 6, 7, 8 and 9.

The pozzolanic reaction in the concrete causes emission temperature Metakaolin concrete. When the pozzolanic interacts in the concrete to increase its strength, it generates heat. This is because it was discovered that when 15% MK is used in the concrete mix, Metakaolin emits a higher temperature than other MK doses. Emission temperature Metakaolin concrete is caused by the pozzolanic reaction in the concrete. Heat is generated when the pozzolanic reacts with the concrete to improve its strength. This is because it was observed that Metakaolin emits a greater temperature than other MK dosages when 15% MK is employed in the concrete mix.By substituting cement for pozzolanic activity, materials with pozzolanic activity can reduce hydration heat while increasing the heat generated during hydration due to the pozzolanic reaction. Pozzolans have been shown to improve cement durability, lower hydration heat, increase resistance to sulphate attack, and lower energy costs per unit of cement. The addition of Metakaolin with pozzolanic character to the PC (in the reaction with PC hydration products calcium silicates appear in the structure) has been proven in scientific research work by other scientists to speed up the binding time in the early stages of hydration [13].

Therefore it can be concluded that, excessive consumption of MK will increase high emissions. According to Kadri [14] due to the strong pozzolanic activity of MK, it produced a small heating increase when compared to a 100 percent Portland cement mortar. When it came to hydration heat, MK-blended mortar behaved more like SF than fly ash (FA). Because the samples had fixed large amounts of calcium ions (lime), both the SF and MK displayed pozzolanic activity after 2 h; however the FA, due to its lower activity early on, hardly showed any response with lime before day 28.

4. Conclusion

In this study, the effect of Metakaolin and Superplasticiser as partial substitution of cement in concrete mix on the compressive strength and emission temperature is investigated. For this purpose, concrete mixtures are prepared by adding different amount of Metakaloin and Superplasticier and the fresh and hardened properties of concrete mix incorporating these materials are investigated by several experiments. The results of the analysis of the test are described as follow:

a. Utilizing 1.5%SP in Metakaolin concrete resulted in a high compressive strength when compared to the control mix, and this strength was able to meet the compressive strength requirements of this study. This is due to the fact that the higher the dose of Metakaolin used, the higher the compressive strength, which is 77MPa (5MK), 74.13MPa (10MK), and 78MPa (15MK). As a result, 1.5 % SP is preferable to 2 % SP for use in concrete mixes because it can enhance compressive strength. Besides that, compressive strength of Metakaolin concrete will increase when compared to the control mixture, with a Metakaolin dose range of 5% to 15% MK with 1.5%SP. At the age of 28 days, Metakaolin concrete with 15% additional cement, i.e. Metakaolin, was successfully achieved with a maximum compressive strength of 78.48MPa.
b. The emission temperature value of the control mix including 1.5 and 2% Superplasticizer and different percentages of Metakaolin (5, 10, and 15%) is greater than that of the Metakaolin concrete.
c. For particle size analysis of Metakaolin and cement powder that was ha been analyses, it was identify that diameter of Metakaolin is smaller which is 3.98 mµ, while diameter of cement is larger which 18.52 mµ. The specific surface area of Metakaolin is also small, at 5267.03 cm^2/g, while the cement specific surface area is larger, at 15156.31cm^2/g.

d. For particle size distribution of fine aggregate and coarse aggregate, the largest of particle size was retained in 2.36mm sieve aperture and the maximum size is 0.15mm.Meanwhile the value of coarseness modulus of aggregate in this study is 0.894533. The largest particles size was retained in 10mm and the maximum size values is10mm.

Research on concrete containing Metakaolin as supplementary cementitous and Superplasticiser as chemical admixture, it offers a great deal of scope for future research. There are some limitations of this study and some recommendations for further studies are suggested, which listed as follow:

a. Use Thermocouple tools that auto-generate data to get more precise results for emission temperature.
b. Every layer when placed fresh concrete in mould must be compact and recommended there layers of full the mould.
c. Exploration of different percentage of Superplastiser as admixture and with other types of Superplasticiser.
d. Exploration of different size of coarse aggregate and fine aggregate.
e. Exploration more detail of characteristic of Metakaolin and Superplasticiser

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