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Strength and Water Absorption of Concrete Containing Metakaolin and Nylon Fiber

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Abstract: The released of carbon dioxide during the manufacturing of cement is one of the factors that contributes various parties to participate in improving the performance of concrete. The aims of this study is to enhance the performance of existing concrete with the use of metakaolin (MK) and nylon (N) fibers in compressive, splitting tensile, flexural strength and water absorption rate. This study was conducted by comparing the results of control concrete samples with the concrete samples that use metakaolin by 5% and 10% by volume of cement and added with nylon fibers at 0.5% and 1.0%. Compressive, splitting tensile, flexural and water absorption tests were conducted to determine the strength of concrete and the concrete ability to absorb water. From this study it was found that the optimum percentage of metakaolin and nylon fiber was at 5% and 0.5%, which recorded at the highest strength when both materials were used in concrete with strength of 41.4MPa. At the end of this study, it shows that the compressive, splitting tensile, flexural strength and the rate of water absorption are influenced by the percentage of metakaolin and nylon fiber used in concrete mix.

Keywords: Metakaolin, nylon fibers, compressive strength, splitting tensile strength, flexural strength, water absorption

1. Introduction

Construction and infrastructure industries in Malaysia are increasingly developing and expanding from year to year with various types of construction in terms of appearance and shape. Designed and constructed project should be in good condition, safe and have longer lifetime periods. Concrete as a major component in the construction industry as building materials still undergoes the process of enhancement. Therefore, stronger and steadier concrete can be produced (Basant et al., 2017). High demand for concrete has resulted in higher demand for cement from every corner of the world. This is because the features found on the concrete are able to meet the required criteria to ensure that it is suitable for use in any situation. However, cement production is a major contributor to emissions of carbon dioxide and other harmful gases in the environment (Surendra and Rajendra, 2016). Release of these gases is caused by calcium carbonate and fuel combustion (Jaishankar and Rao, 2016). In addition, large amounts of energy also needed to produce cement (Anbarasan and Venkatesan, 2015). Therefore, the production of concrete more environmentally friendly with

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the use of pozzolan material is needed. The use of pozzolan materials in producing concrete is considered efficient because it can reduce the consumption of cement, in addition able to improve the strength and durability of concrete (Aiswarya et al., 2013). One of the pozzolana which has been widely used is metakaolin obtained by calcining kaolinitic clay (Farhan and Gul, 2017). Metakaolin can be produced from a variety of primary and secondary sources containing kaolinite which used in making porcelain. The use of metakaolin has gained attention because the particle size of the material itself is finer than cement particles and able to fill the pores of the concrete.

Purpose of adding metakaolin in concrete is to reduce the consumption of cement in the concrete mixture. During the cement production process, cement contributed to the production of carbon dioxide gas, which may result in air pollution. Therefore, the use of metakaolin to replace part of cement in the concrete mix could reduce air pollution caused by carbon dioxide. Furthermore, pozzolonic materials such as metakaolin increases the mechanical properties of the concrete (Sawant and Ghugal, 2014). Concrete made of Portland cement is quite strong in compression but weak in tension and tends to be fragile (Banthia, 2012). The weakness of concrete in tension can be overcome by the use of sufficient amount of nylon fibers. Synthetic fibers are often used in various applications because of its high strength and durability and uncontrolled disposal which poses a serious threat to the environment. Results of studies have found that the use of nylon fiber in the concrete is able to improve the quality of concrete as well as to reduce the problem of marine pollution (Swami and Gupta, 2016).

1.1 Metakaolin in concrete

Metakaolin is a pozzolanic material produced from selected kaolin after improvements, according to certain conditions. It is an effective pozzolan and reacts well with excess calcium hydroxide resulting from the hydration of the OPC (Ordinary Portland Cement) through pozzolanic reactions to produce calcium silicate hydrate and calcium alumina silicate hydrate. Metakaolin is white and fine clay containing high silica content. It is produced by heating the kaolin, which is one of the natural minerals of clay at 650-900^{o}C (John, 2013). During the hydration process of cement, water reacts with Portland cement and forms calcium-silicate-hydrate (CSH). This reaction also resulting the formation of calcium hydroxide (lime). Lime is weak in concrete, thereby reducing the effect of CSH. When metakaolin is added to the concrete, it reacts with free lime to form an extra CSH material which causes concrete to be stronger and more durable (John, 2013).

Dubey, Chandak and Yadav (2015) conducted a study on the use of metakaolin in concrete aimed at studying the properties of concrete with different replacement of the metakaolin in M25 grade concrete. The mixture is classified as M1, M2, M3, and M4 with a percentage of 0%, 5%, 10% and 15% of the cement mass and then cured for 28 days. Results showed that concrete strength increased by 21.3 % when cement was replaced by metakaolin at 10%. While the compressive strength for the percentage of metakaolin by 5% and 15% each increased by 14% and 5.5 % respectively. The strength of concrete containing metakaolin of 10% is the highest since the mixture ratio of materials used at 10% is appropriate and it affects the strength of the concrete. This proves that the strength of concrete containing metakaolin increased by optimum usage compared to conventional concrete.

Vipat and Kulkarni (2016) carry out studies on the use of metakaolin as partial cement replacement to improve the properties of concrete. Three levels of metakaolin replacement were used in this study, which is 10%, 15% and 20% of cement volume. Properties of concrete were measured by compression strength, tensile strength and concrete bond strength. Finding from this study shows that the use of metakaolin in M25 grade concrete can reduce the workability of concrete to form a honeycomb structure. The optimum compressive strength is at 15% when metakaolin is used at different levels of 10%, 15% and 20% by cement volume. However, compressive strength decreased at 20% of the metakaolin cement replacement level. In addition to compressive strength, the use of metakaolin also can increase the tensile strength and concrete bonds.

Namartha and Felixkala (2016) conducted a study using metakaolin at 5%, 10%, 15%, and 20% as partial cement replacement material. Result shows that the strength of concrete containing metakaolin was higher than the control concrete mix. Hence, cement replacement at 15% better than other mixtures with a maximum compressive strength of 72.7 MPa for M60 grade and concrete are cured for 28 days. After 28 days, strength of the concrete containing 5% of metakaolin increased to 4.36 %. While the usage of metakaolin at 10%, 15% and 20% increase by 13.73%, 17.45% and 12.44% respectively. Metakaolin can increase the compression strength and tensile strength up to 15% of its replacement rate. When cement is replaced by metakaolin at 20%, concrete strength tends to decrease compared to other percentage of metakaolin replacement. From the results of this study, it proves the use of metakaolin as partial cement material can produce stronger and better concrete.

Ogale and Shinde (2016) investigate the effects of metakaolin and fly ash when it is used as partial cement replacement by maintaining the water cement ratio of the concrete mix of M20. Concrete mixes using different metakaolin percentages of 0%, 5%, 10%, 15% and 20% of the weight of the concrete are curing for 7 and 28 days that will give maximum compressive strength. Finding shows that the compressive strength of concrete at 7 and 28 days are the best when metakaolin and fly ash are mixed at 10 percent for both materials (10% metakaolin + 10 fly ash). The use of metakaolin at an optimum of 10% encourages an increase in compressive strength at 7 days, which is 18.09% and 18.64% at 28 days when compared with control concrete.

1.2 Nylon fiber in concrete

Fiber reinforced concrete (FRC) is a mixture of cement and small fibers that are distributed randomly in concrete. A small number of fibers are distributed at random during concrete mixing, thereby enhancing the concrete properties of all directions. The mix has been successfully used in construction with excellent tensile strength and flexibility as well as good resistance and permeability resistance. Steel fiber can increase the strength of the structure to reduce the use of large and heavy steel reinforcement. Concrete resistance can be improved to reduce the crack width on concrete. Synthetic fibers such as polypropylene and nylon are used to improve concrete compression strength. Synthetic fibers are not used to replace the main reinforcement such as steel reinforced because these fibers have very little strength compared to the strength of steel reinforcement. Synthetic fiber, usually used only on concrete as secondary reinforcement (Rai and Joshi, 2014).

Swami and Gupta (2016) report that nylon fibers are widely used in various applications due to its high strength and durability. Nylon fiber was used in this study as an alternative and efforts to reduce pollution problems as well as improve workability, compressive strength and concrete tensile strength. The results of this study found that a mixture of nylon fibers of 1% to 1.5% in concrete led to isolation and lump in the concrete as well as resulting nylon fibers are not well-distributed in the concrete. Compression tests on the M20 and M30 concrete containing nylon fibers on day 7 and 28 showed that the strength is increased. It starts to decrease when the nylon fiber content exceeds 1% due to the workability of concrete is decreased as the nylon fibers are not well distributed and cause the presence of more pores in the concrete. Whereas, the tensile strength of concrete containing nylon fibers is found to increase by 60% to 70%, which allows it to be applied in any case.

According to Saxena et al. (2015) concrete is a relatively fragile material, with relatively low tensile strength and capacity. Typically, steel reinforcement will be used to increase concrete tensile strength. Therefore, study was conducted to study the characteristics of concrete strength by adding a different percentage of the nylon fiber in the concrete mixture. The aims of this study is investigates the compressive strength, tensile strength and bending of the concrete. Test was carried out for concrete, which had been cured for 7, 14 and 28 days. Samples were compared to ordinary concrete, which containing different percentages of fly ash with different proportion of nylon fibers. Results showed that conventional concrete replaced with fly ash by 10%, 20% and 30% and combined with nylon fibers with 0.2, 0.25, and 0.3% increased concrete strength.

Concrete contains glass fiber and MK are some of the previous research that aims to create new high quality concrete to be used in the construction industry. Study showed that by adding 0.1% - 0.8% of glass fiber in concrete it reduces the compression strength of concrete. The compression strength reduces due to higher porosity in concrete resulted from the addition of fiber in concrete, but in the splitting tensile test shows that the tensile strength increases up to 16.6% (Sivakumar et al., 2017). There is also a study that shows an increases of concrete strength in the presence of pozzolanic material. Hydration reaction between MK and cement increases the mechanical properties of concrete and responsible towards the strength of concrete (Güneyisi et al., 2014).

As the addition of fiber in concrete, there’s some part of concrete that will be weak as the presence of fiber that led to the porosity of the concrete, thus the MK filled up the gap between concrete and the fiber (Rashiddadash et al., 2014). By using MK in concrete also will reduce the CO_2 emitted during the production process of the MK by 20% compared to the CO_2 emission during production of cement and this will ensure cleaner air and environmental friendly (Badogiannis et al., 2015).

2. Materials

This study uses the ordinary Portland cement produced by Tasek Corporation Berhad and metakaolin KM10CL were purchased from Kaolin (Malaysia) Sdn Bhd. Meanwhile, nylon fiber was purchased from a factory in Kulim, Kedah with a diameter of 0.35 mm and 12 LB tensile strength were cut to two inches long and were used in this study. Fig 1 shows the MK and nylon fiber used in this study.

Fig. 1- (a) Metakaolin ; (b) Nylon fiber

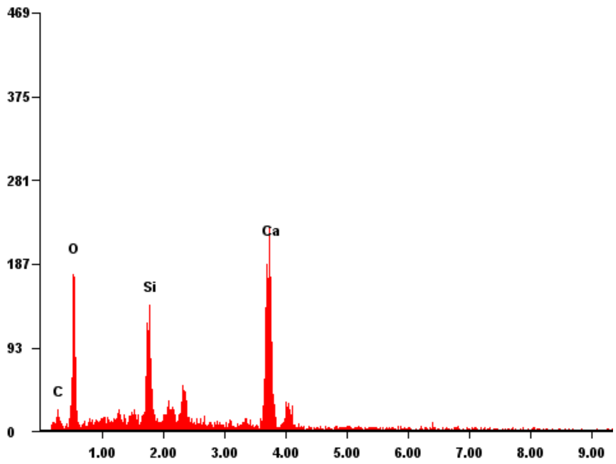
X-ray fluorescence (XRF), RIX 3000 was used for quantitative determination of chemical compositions in OPC and MK according to BS EN ISO 12677. Table 1 presents the chemical compounds and composition of OPC and MK used in this study from XRF analyses. It shows that the chemical compositions of OPC and MK were different within the type of chemical compounds present in OPC and MK. The two major compositions of OPC are Silicon dioxide

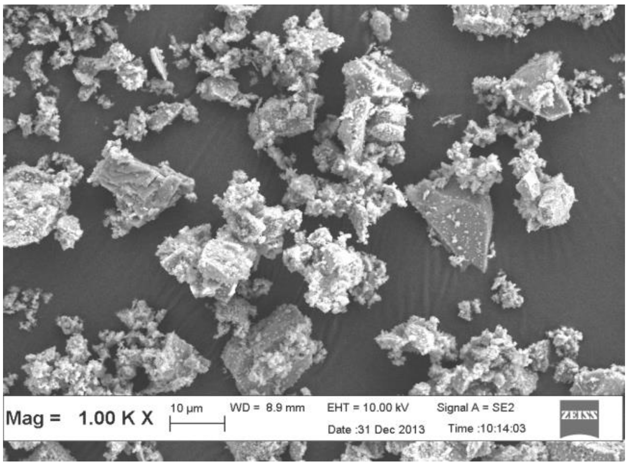
(SiO_2) and Calcium oxide (CaO) and the major compositions of MK are Silicon dioxide (SiO_2) and Aluminium oxide (Al_2O_3). The following section elaborates the present compounds in OPC and MK and its effects.

Table 1-Chemical compositions of cementitious material from XRF analysis.

	Chemical composition (%)	
	OPC	**MK**
Silicon dioxide (SiO_2)	20.63	55.04
Aluminum oxide (Al_2O_3)	4.71	44.10
Iron oxide (Fe_2O_3)	3.52	0.60
Calcium oxide (CaO)	60.98	0.02
Magnesium oxide (MgO)	0.98	0.2
Sodium oxide (Na_2O)	0.06	-
Sulfur trioxide (SO_3)	4.97	-
Loss of ignition (LOI)	2.38	0.50
SiO_2+Al_2O_3+Fe_2O_3	28.86	99.74

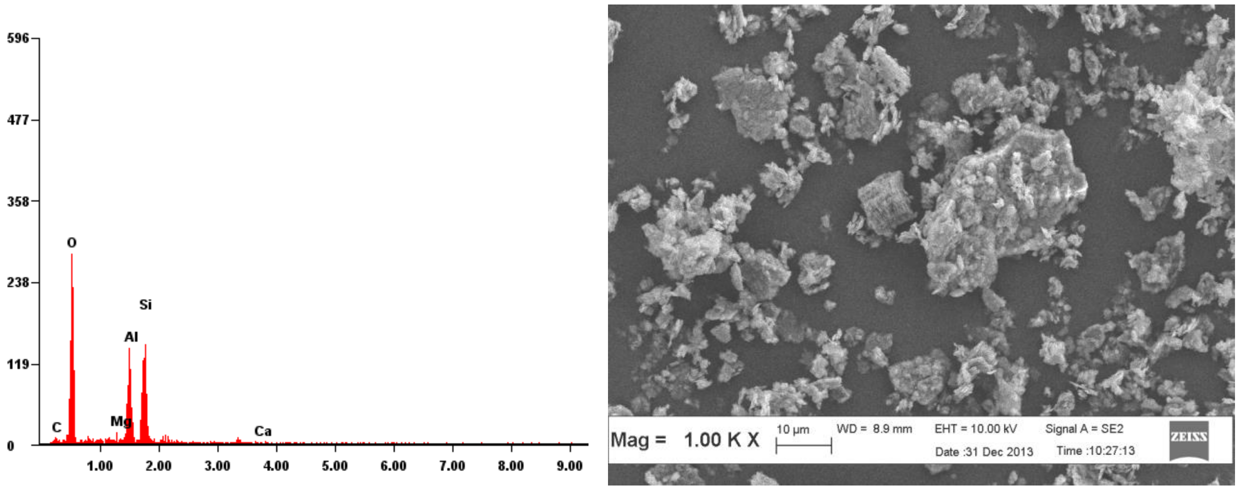
Morphology of OPC and MK is shown in Fig 2 and Fig 3. Dispersed particles in the form of agglomerations and irregular shape of OPC and agglomerated and crushed state form of MK can be notified by Scanning Electron Microscope (SEM) images. The element of calcium (Ca) and silica (Si) was identified by Energy Dispersive X-ray Spectroscopy (EDX) in both materials which contribute to the strength properties of the binder. MK has a higher alumina content compared to OPC which affect the early strength of the binder. DOE (Department of Environment) mix design method was used with a mix ratio of 1:1.6: 3.2 and W/C of 0.6 subsequently to maintain the slump value of 70-90 mm. Table 2 shows the mix proportion of this study.





Element	*Wt%*
C K	04.09
O K	29.67
SiK	11.19
CaK	55.06

Fig 2-Composition and particle morphology of OPC



Element	*Wt%*
C K	04.50
O K	43.05
MgK	01.30
AlK	21.73
SiK	29.42
CaK	00.00

Fig 3-Composition and particle morphology of MK

Table 2- Mix proportion

Mix	**C (%)**	**CA (%)**	**FA (%)**	**MK (%)**	**N (%)**
1	100	100	100	-	-
2	95	100	100	5	-
3	90	100	100	10	-
4	100	100	100	-	0.5
5	100	100	100	-	1.0
6	95	100	100	5	0.5
7	90	100	100	10	0.5
8	95	100	100	5	1.0
9	90	100	100	10	1.0

C: cement, CA: coarse aggregate, FA: fine aggregate, MK: metakoalin, N: nylon fiber.

2.1 Compressive strength test

Compression test was aimed to determine the strength of the concrete. It is determined by using the compression test machine provided in University Tun Hussein Onn Malaysia laboratory. Before a compressive test is carried out, 100 mm x 100 mm x 100 mm cube mould is used to prepare the concrete samples. Concrete mixture was poured into a mould by 2 layers and each layer were compacted by using the tamping rod to prevent the presence of air bubbles in concrete cubes. After 24 hours, the concretes were separated from the mould and immersed in water tank for curing purposes. Concrete samples were tested in the 7th and 28th day of curing. The compressive strength can be calculated as follows:

$$Fcu = \frac{P\max}{Area} \tag{1}$$

2.2 Water absorption test

Water absorption tests were performed to determine the rate of water absorption of the concrete samples under certain conditions. There were a few factors that may affect the water absorption rate, which include the use of additional materials, temperature and concrete exposure duration. For water absorption tests, the samples that have been cured for 7 and 28 days were dried in the oven for 24 hours and let it cool before weighed. Subsequently, the samples are immersed in water for a period of 24 hours. After 24 hours, the samples were taken out from the water tank and dried using a dry towel before it was weighed. Percentage of water absorption can be calculated using the formula below:

$$Absorption\% = \frac{(Wet - Dry)concrete, kg}{Dry, concrete, kg} \tag{2}$$

2.3 Splitting tensile test

Splitting tensile test was conducted to achieve the objective of this study with cylinder sample sizing 150 mm diameter and 300 mm height based on BS EN 12390-6:2000. Samples were tested in the 7th and 28th day of curing.

2.4 Flexural strength test

Beam samples with a size of 100 mm × 100 mm × 500 mm were used to test the flexural strength of concrete based on BS EN 12390-5:2000. The samples were tested in the 7th and 28th day of curing. Fig 4 shows the setting up of 3 point load flexural test on the concrete sample in this study.

Fig. 4-Flexural strength test setting up with 3-point load

3. Results and discussions

Result of the test conducted were discussed in this section. To achieve the objective of this study four important tests were conducted which are the compression strength test, water absorption test, splitting tensile and flexural strength test. Tests were conducted on the concrete samples that contains MK and nylon fiber. Compression test and splitting tensile test were conducted by using compression machine while the flexural strength were conducted using 3 point load test. Total sample was 54 for compression, splitting tensile test, water absorption and flexural strength test. Total sample prepared and tested in this study were 216 samples.

3.1 Compression strength test results

Result of this test shows that the compressive strength of concrete on the 7th and 28th day of curing were varied based on the material used to produce the concrete samples. Results of this test can be seen in Table 3 below:

Table 3- Compression Strength Test Results

Sample	Average Strength on day-7 (MPa)	Average Strength on day-28 (MPa)
C 0%	33.5	40.4
MK 5%	37.7	44.6
MK 10%	34.2	43.2
N 0.5%	29.0	36.2
N 1.0 %	27.8	31.6
MK 5% + N 0.5%	32.3	41.4
MK 10% + N 0.5%	28.7	34.7
MK 5% + N 1.0%	23.2	26.9
MK 10% + N 1.0%	26.3	31.7

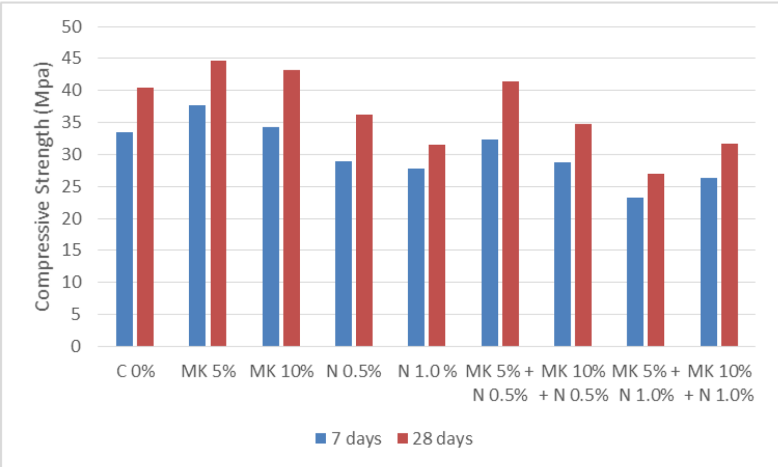


Fig. 5- Compression strength test results

Through Table 3 and Fig 5, it can be concluded that the compressive strength of concrete for each type of the samples increased directly with concrete ages. Only four samples successfully exceeded the target mean strength of 40 MPa on the 28^{th} day of curing ages, which are C 0%, MK 5%, MK 10%, and MK5% + N0.5% respectively with strengths of 40.4, 44.6, 43.2 and 41.4 MPa. Compressive strength of the concrete was influenced by the presence of metakaolin that reacted with cement during the hydration process to produce excess calcium silicate hydrate and calcium alumina silicate hydrate which led to increase the concrete compressive strength. For the rest of the sample shows that the strength was less than the targeted strength in this study especially when nylon fibers are used. The strength of concrete decreased when nylon fibers were added into the mix which encourage the formation of pores in the concrete resulting less concrete density and concrete strength. The following subsection will explain the contribution of pores in reducing concrete strength subjected to the nylon fiber in concrete.

3.2 Water absorption test results

Concrete curing is a process to prevent the moisture content in concrete mixes evaporates rapidly before reaching the concrete maturity which can affect the concrete strength. Therefore, the hardened concrete should be immersed in water for curing purposes until it reaches a certain period of time. In this study, the concrete has been immersed for 7 and 28 days. Table 4 below shows water absorption rates on day 7 and 28.

Table 4- Water Absorption Test Results

Sample	Water Absorption Rate (%)	
	7 days	28 days
C 0%	6.53	5.29
MK 5%	6.28	4.89
MK 10%	5.80	4.8
N 0.5%	7.95	5.99
N 1.0 %	8.92	6.13
MK 5% + N 0.5%	7.64	5.56
MK 10% + N 0.5%	6.51	4.59
MK 5% + N 1.0%	7.62	5.71
MK 10% + N 1.0%	6.94	6.10

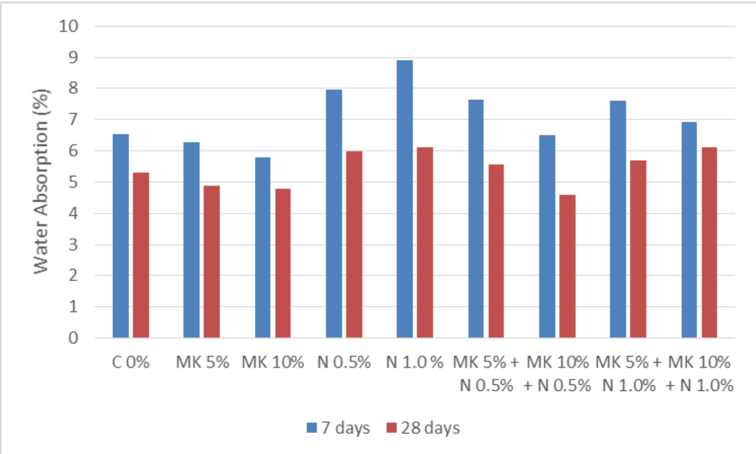


Fig. 6- Water Absorption Test Results

From Table 4 and Fig 6 above, it can be seen that concrete containing nylon fibers, especially nylon fibers with 1.0% are more likely to absorb water than concrete containing metakaolin only. This is resulting from the use of these nylon fibers where it encourages the presence of pores in the concrete. Meanwhile, for concrete containing 10% metakaolin is the least water absorbing on the 7th day and 28th day. This is due to the characteristics of the metakaolin itself, which acts as filler to fill the empty pores in the concrete thus reducing the percentage of water absorption. Nylon fibers have caused the presence of the pores in the concrete, which leads to increased water absorption rate. On the other hand, the water absorption rate will decrease when metakaolin are used in concrete.

Concrete strength had increased to 44.6 MPa when 5% of cement volume has been replaced by metakaolin. Strength of the concrete containing 10% of metakaolin decreases compared to the concrete containing 5% of metakaolin in concrete after 7 days of curing. However, both consumption of metakaolin percentage exceeded the target mean strength of this study. Thus, the authors agree with John (2013); Dubey, Chandak and Yadav (2015); Vipat and Kulkarni (2016); Namartha and Felixkala (2016) & Ogale and Shinde (2016), replacement of cement with metakaolin increase the compressive strength of the concrete. However, authors disagree with Swami and Gupta (2016) which stated that the inclusion of nylon fiber in concrete will increase the compressive strength of the concrete compared to conventional concrete. This study shows that the use of nylon fiber in concrete samples does not give positive influenced to the strengths and even caused higher water absorption rates. This is because of presence of nylon in concrete increases pores in concrete due to unwell distribution of nylon fiber in concrete mixes. Authors also agree with Saxena et al. (2015), the use of pozzolan material increases the compressive strength of the fiber concrete. The use of both metakaolin and nylon fiber shows that, the strength of concrete increased when MK 5% was used with nylon fibers at 0.5%. This proves that by introducing MK in concrete containing nylon fiber can improve the durability of concrete. Meanwhile, the increase in the water absorption rate shows that the concrete has a high number of pores that can affect the concrete strength. The highest increment of compressive strength of the concrete (44.6 MPa) when 5% of metakaolin were used.

3.3 Splitting tensile test results

Table 5 shows the splitting tensile results of prepared samples containing metakaolin and nylon fiber on day 7 and 28.

Table 5- Splitting tensile result

Sample	Average Splitting Tensile Strength (MPa)	
	7 days	28 days
C 0%	2.76	3.1
MK5%	2.98	3.67
MK10%	2.12	2.23
N0.5%	2.74	3.1
N1.0%	2.27	2.69
MK5% + N0.5%	2.8	3.1
MK10% + N0.5%	3.14	3.28
MK5% + N1.0%	2.4	3.33
MK10% + N1.0%	2.34	2.96

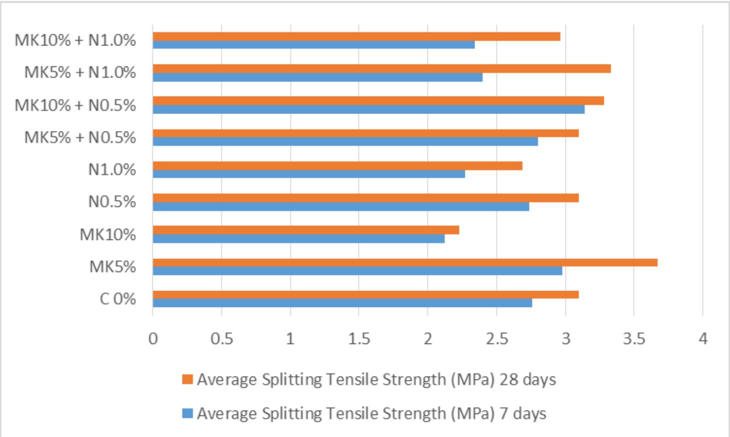


Fig 7-Splitting Tensile result

From Table 5 and Fig 7 above shows that the splitting tensile strength of MK5% increased about 18% compared to the control at 28 days age. This shows that the particles of the MK were very fine and fills the pores of the concrete and increases the bond between the aggregate and the binder matrix, thus increases the strength of concrete (Shafiq et al., 2015). Meanwhile, for MK10%, splitting tensile strength reduces about 28% compared to the control at 28 days age. This shows that the high replacement amount of MK will decrease the tensile strength of the concrete. Thus, the authors agree with Vipat and Kulkarni (2016) & Namartha and Felixkala (2016), replacement of cement with MK will increase the tensile strength of the concrete, however it will reduce the tensile strength of the concrete when the level of replacement exceeds 10%.

When the nylon is added into the concrete, the strength of concrete become decreased. Higher porous concrete resulted from the addition of fiber in the concrete and reduced the bonding strength between the concrete particles. As the addition of nylon and MK in the sample of MK5%+N0.5%, it shows an increase of strength about 15% compared to the concrete contains nylon fiber 1%, the pores of concrete were being covered by the fined particle of MK and it's increased the bond of its particle and increased the strength of concrete (Barbhuiya et al., 2015).

3.4 Flexural strength test results

Fig 8 and 9 shows the deflection data analysis results obtained from the 3-point load test for 7 and 28 days' age samples. From this data, the maximum load and deflection of each sample can be identified and from this data also the flexural strength were being calculated.

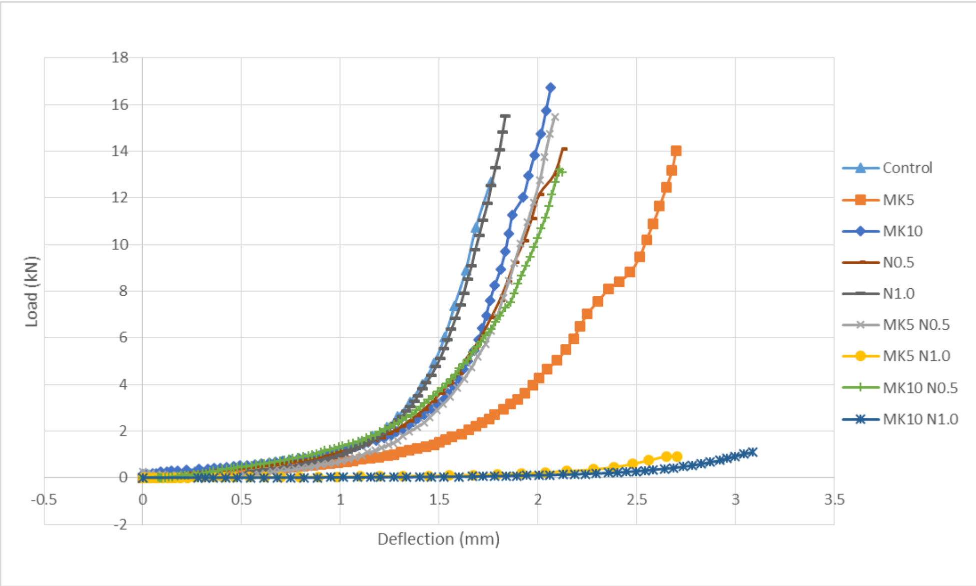


Fig 8- Deflection analysis result for 7 days' age samples

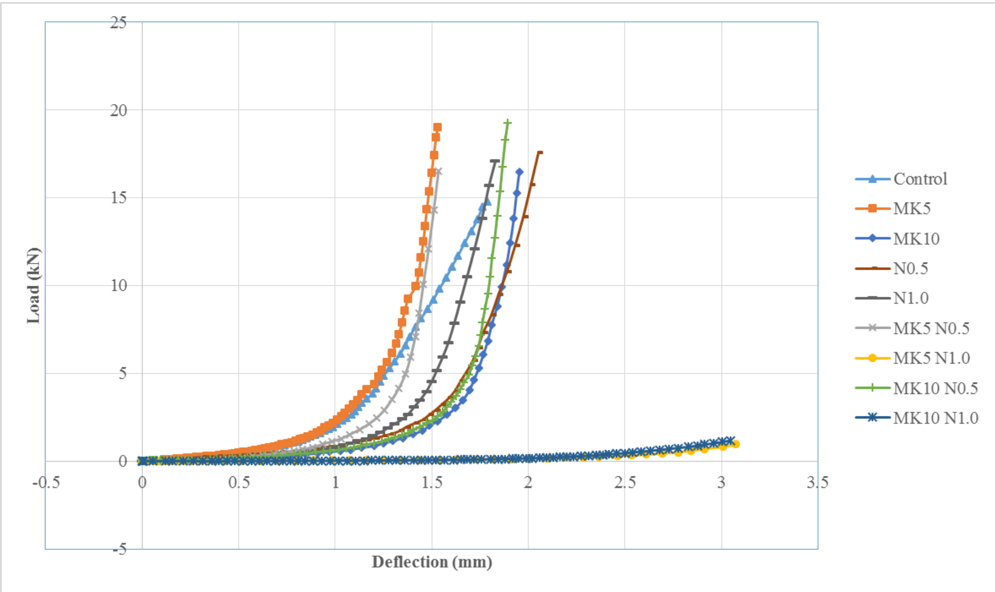


Fig 9- Deflection analysis result for 28 days' age samples

Based on the Fig 8 above it is found that on the 7th day's age of the samples, MK 10% can withstand a higher load compared with the control sample while MK5% shows high load and higher deflection reading. Based on the graph, it is also found that the addition of fibers in concrete mixtures can increase the bending strength of concrete compared to non-fiber concrete. From Fig 9 it shows that the capability of samples with fiber to withstand load founded to be decreased compared to the control sample. According to Sivakumar et al. (2017), the production of pores resulted from the addition of fibers in concrete causes the bonding between the binder and aggregate become weaker. This effect can be reduced by introducing MK into the concrete (Rashiddadash et al., 2014). By doing that the pores were filled with fine particles of the MK and improve the concrete durability. Fig 9 above also shows that the concrete beam containing MK and fibers had a positive effect compared with concrete containing only fiber. Table 6 shows the overall results of the flexural strength test for the concrete samples after curing for 7 days and 28 days.

Table 6-Flexural Strength Result

Sample	Flexural Strength (Mpa) 7 days	28 days
C 0%	7.61	8.88
MK5%	8.4	11.41
MK10%	10.04	9.92
N0.5%	8.45	10.54
N1.0%	8.88	10.25
MK5% + N0.5%	9.3	9.92
MK10% + N0.5%	7.85	11.55
MK5% + N1.0%	0.55	0.58
MK10% + N1.0%	0.66	0.7

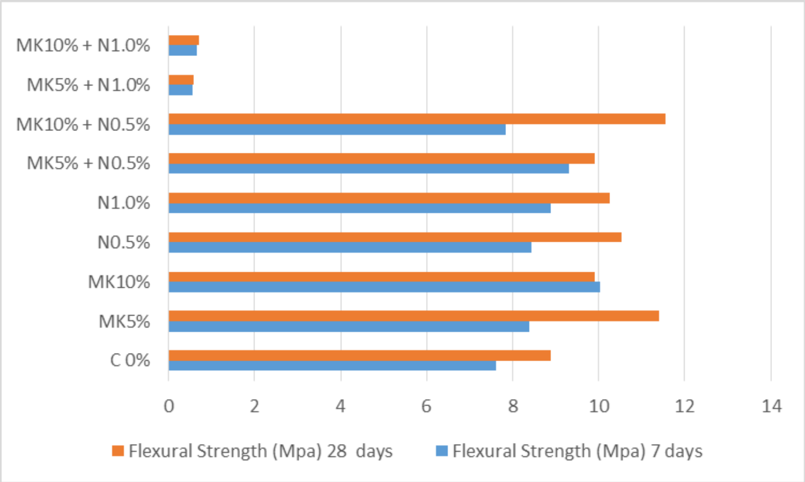


Fig. 10- Flexural Strength Result

From Table 6 and Fig 10, it's shown that the replacement with MK and the addition of nylon fiber affects the strength of the concrete. As the MK replaces the cement in the concrete it shows the positive result as the MK particles are very fine and the pore size of the concrete is becoming smaller and this will contribute to the bond of the particle as the particle will react each other to withstand the load (Williams et al., 2016). When nylon fiber was added by 0.5% the flexural strength increases about 18% compared to the control. The density of the concrete is lower and this will affect the bond strength between the particles between concrete (Saidani et al., 2016). Sample of MK10%+N0.5% shows increases of strength compared to the concrete contains fiber, it shows that the presence of MK in the concrete-fiber can overcome the weakness of the control, concrete-MK and also concrete-fiber samples. Presence of the fined particles of MK in the fiber concrete can fill the gap and the pores of the concrete particle thus increase the bond between the concrete (Williams et al., 2016). Presence of nylon fiber in concrete contributes to the change of concrete strength based on splitting tensile and flexural strength. Adding 0.5% and 1.0% of nylon fiber into the concrete shows that it prolongs the life span of the concrete. Furthermore, adding 1.0% of nylon in concrete reduces the strength of concrete, however it contributes to higher lengths of deflection of the concrete.

4. Conclusion

Presence of MK and nylon fiber in concrete had an effect on the mechanical properties of concrete, however, it can withstand higher load and higher length of deflection act on the concrete. Based on all of the tests conducted and the results that had been analyzed, the changes of pattern and the physical behavior that can be seen, the optimum use of metakaolin and nylon fibers in concrete is MK 5% and N 0.5% with the high compressive strength, lower water absorption and higher splitting tensile strength compared to concrete containing nylon fiber.

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