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Influence of Mineral Admixtures on the Mechanical Properties of Fresh and Hardened Concrete

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Abstract **– This research aims to investigate the effect of introducing different mineral admixtures on the mechanical properties of concrete. The research is focused on optimizing the properties of fresh and hardened concrete, looking in particular at how factors such as slump, unit weight, air entrancement, compressive strength, tensile strength, flexural strength and modulus of elasticity are affected by different mineral admixtures in a concrete mix. Different mineral admixtures are used, namely silica fume, limestone and ultra-fine gypsum, and for the tests each mineral admixture replaced 25 % of the cement. The paper also compares the performance of the fresh and hardened properties of concrete.**

Keywords **– Air entrainment, compressive strength, flexural strength, modulus of elasticity, tensile strength, unit weight, workability.**

I. Introduction

In general, concrete is the most widely used material in the construction industry. It is easy to place, lower in cost than other materials, its ingredients are widely available, and it has good compressive strength. The ability of concrete to withstand the long term effects of load, time and environment depends mainly on how the engineering and microstructure properties of the material are constituted initially and how they are allowed to develop with age. However, some disadvantages of using concrete are that it is brittle and has low tensile stress. For years, researchers have been trying to find more effective ways of decreasing these disadvantages and making the use of concrete more efficient by using admixtures.

Mehta [1] defines admixtures as materials other than water, aggregates and hydraulic cement that are used as ingredients of concrete or mortar and are added to the batch immediately before or during mixing. The mixing of mineral and chemical admixtures in concrete can bring improvement in the engineering properties of hardened and fresh concrete such as tensile and flexural strengths, elastic modulus, workability and durability [2]. Cement is generally replaced partially by mineral admixtures, and the specific effects of admixtures generally vary with the mix proportion, ambient conditions and the dosage that is added. In particular, two types of admixtures – mineral and chemical – are widely used in construction industries. Three mineral admixtures were examined in this research, namely: limestone, silica fume and ultra-fine gypsum.

II. Materials and Methods

A. Materials

The sieve analysis test is used to determine the grading of the fine aggregates, and for this research three types of fine aggregate mix were tested, shown in Table I as X, Y and Z. The fine red sand aggregate is soft and relatively small in size, while the grey coarse sand is large in size.

Figure 1 demonstrates the sieve analysis results for the three types of fine aggregate mix, X, Y and Z, using sieve sizes of 10 mm, 5 mm, 2.36 mm, 1.18 mm, 0.6 mm, 0.3 mm and 0.15 mm. It can be seen that the sieve analysis results for the fine aggregates provide an indication of the best well graded mixture, especially using 50 % fine and coarse sand mixture at this stage, which contains particles of different sizes, while the 100 % grey coarse sand showed the lowest degree of gradation; this is known as being poorly graded. A well graded aggregate is more compacted than a poorly graded aggregate, while the poorly graded aggregate has better drainage than the well graded aggregate because its contains more void spaces. However, for this research a well graded aggregate was preferred as its particles are more compacted and there is a degree of gradation between particle sizes. The selected materials used for this research are normal Ordinary Portland Cement CEM I, 10 mm limestone coarse aggregate and 50 % grey and fine sand mixed together as fine aggregates. The mineral admixtures used were silica fume, limestone, and ultra-fine gypsum. Details of the chemical compositions of the admixtures are given in Table II.

TABLE I
Sieving Analysis of Fine Aggregates

Code	Sand Type
X	50 % Fine Red Sand, 50 % Grey Coarse Sand
Y	100 % Fine Red Sand
Z	100 % Grey Coarse Sand

TABLE II
Properties of Mineral Admixtures, [3]

Materials	Silica Fume	Limestone	Ultra-Fine Gypsum
SiO_2	94.69	2.61	–
Al_2O_3	0.16	0.93	–
Fe_2O_3	0.06	0.38	–
CaO	0.43	52.58	–
MgO	0.21	0.05	–
SO_3	–	0.12	–
I.L	3.22	43.03	–
$CaSO_4$	–	–	96.0
S	–	–	17
C	–	–	21

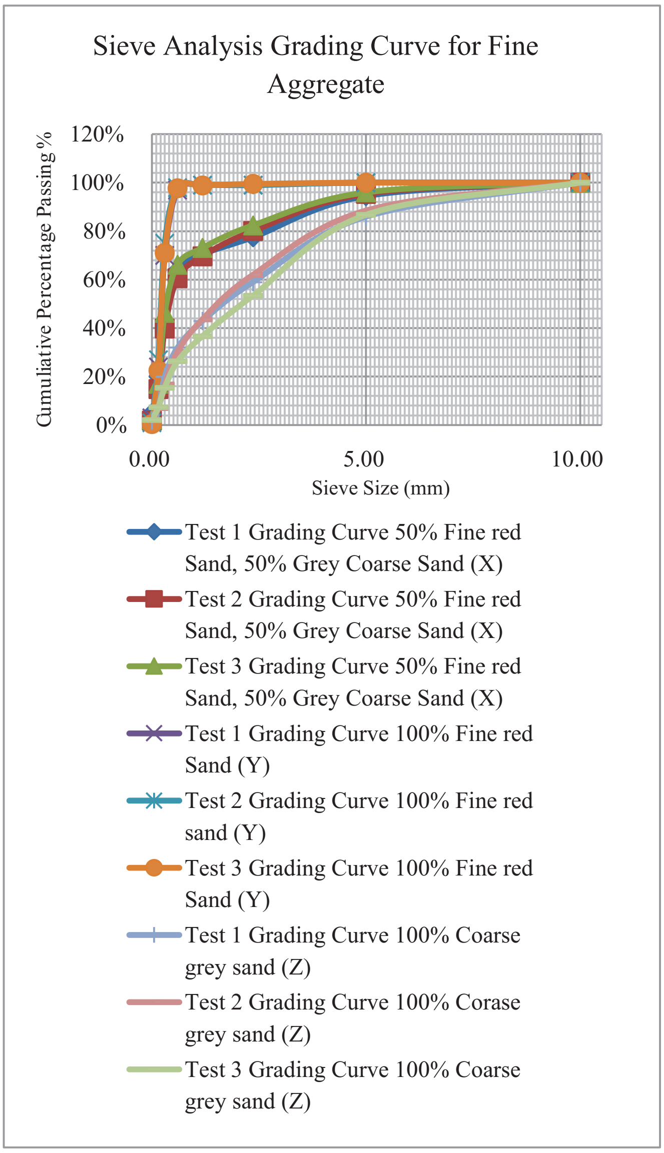

Fig. 1. Sieve analysis of fine aggregate.

Table III shows the concrete mix compositions that have been used in this research. The study was conducted using three different mineral admixtures, namely silica fume, limestone and ultra-fine gypsum, and for the tests each mineral admixture replaced 25 % of the cement. The particle size of the three admixtures are: Silica Fume 0.15 m, Limestone 1–3 um, and Ultra Fine Gypsum 0.12 um.

B. Methods

The concrete mixing throughout the research was carried out in a laboratory at a temperature of 20 °C. Both coarse and fine aggregates were stored in dry conditions, and normal tap water was weighed and added to the mixture. All materials were mixed in a concrete mixer with a maximum capacity of 0.06 m^3. In order to obtain a good concrete mix, the following procedure was adopted.

TABLE III

Concrete Mix Compositions

	Control Mix	**Silica Fume**	**Limestone**	**Ultra Fine Gypsum**
C (kg/m^3)	19	14.25	14.25	14.25
FA (kg/m^3)	33	33	33	33
CA (kg/m^3)	56	56	56	56
Water (kg/m^3)	15	15	15	15
W/C Ratio	0.78	0.78	0.78	0.78
Admixture (kg/m^3)	0	4.75	4.75	4.75

** where C is cement, FA fine aggregate, CA Coarse aggregate.

A mixture of fine aggregates consisting of 50 % coarse grey sand and 50 % fine red sand was added with a quarter of the water content. This helped to allow the fine aggregates to absorb water. After 60 seconds of mixing, the 10 mm limestone coarse aggregate was added to the mixture with another quarter of the water content for another 60 seconds. Afterwards, the cement, including the cement replacement materials, was added with the remaining half of the water content for 60 seconds. The high range water reducer was then added to maintain the content of the water and to ensure full distribution of particles. Finally, the mixing continued for another 180 seconds.

Mixing was continued until a uniform concrete mixture was achieved and a well compacted material was obtained. After mixing, casting was performed into two layers for each mix and the mixes were vibrated to remove the air content from the concrete. For each of the concrete mixes, the concrete was cast three times in cubes, steel prisms and steel cylindrical moulds.

After casting, the concrete was left to dry for 24 hours at a laboratory room temperature of 20 °C before re-moulding. The cubes, prisms and cylindrical samples were then kept continuously in water at 20 °C and tested after 28 days to determine their mechanical properties.

For testing the properties of the hardened concrete, BS EN 12390-3:2009 was used to determine the compressive strength, BS 12390-6:2009 to determine the tensile strength, BS 12390-5:2009 to determine the flexural strength, and BS 1881-121:1983 to determine the elastic modulus of the concrete. For testing the fresh properties of the concrete, the BS EN 12350-2:2009 slump test was used to determine the workability of fresh concrete, BS EN 12350-6:2000 was used to determine the unit weight of fresh concrete, and BS EN 12350-7:2009 was used to determine the air entrainment of fresh concrete. Each test was performed and repeated three times.

III. RESULTS AND DISCUSSION

A. Influence of the Mineral Admixtures on the Fresh Properties of Concrete

1. Workability

The slump test results in Fig. 2 show that the total slump values for all mixtures ranged on average from 74 mm to 76.5 mm, and the concrete mixture containing limestone achieved the highest slump value of 76.5 on average, while concrete containing silica fume exhibited the lowest slump value. The use of silica fume resulted in improved workability and a reduction in the slump value, which also meant there was a lower water demand needed to reach the given slump, when compared with mixing concrete with different mineral admixtures. The improved workability was not as noticeable when mixing concrete with limestone (LS) and ultra-fine gypsum (UFG). Different slump behaviours of the concrete were mainly observed when silica fume was mixed because it contains very small fine particles. This leads silica fume particles to absorb less water as more particles are added hence reducing the slump value of fresh concrete [4]. Moreover, the slump test suggests that in the mixture containing LS, there is a further increase in the slump flow values compared with concrete containing the other mineral admixtures. This may be explained by the increased particle size and surface area of the LS which, in turn, increases the water absorption and hence increases the slump value [5]. Mixing concrete with ultra-fine gypsum achieved an average value of 75.5 mm which is in the range required to produce a higher concrete strength product according to BS EN 206-1:2000. In general, mineral admixtures, due to their variable sources and procedures, vary significantly in chemical compositions as well as interactions with cement and, therefore, produce different concrete slump results as shown in the figure below.

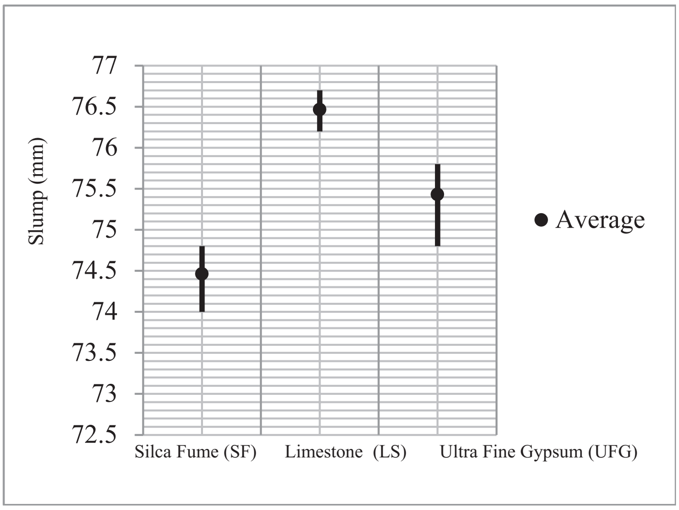

Fig. 2. Effect of mineral admixtures on workability.

2. Unit Weight

The mean values of the unit weight when concrete is mixed with different mineral admixtures (silica fume, limestone, and ultra-fine gypsum) are shown in Fig. 3. The unit weights of most concrete mixes with silica fume (SF) showed a unit weight varying from 2,400 kg/m^3 to 2,411 kg/m^3, whereas most of the concrete mixes with LS showed a unit weight varying from 2,388 kg/m^3 to 2,394 kg/m^3. Being lighter in weight, it is expected that the UFG will have the lowest unit weight as was the case in this investigation. The unit weight for this mixture ranged from 2,357 kg/m^3 to 2,363 kg/m^3. As a result, mixes made from this type of mixture will be more suitable for use in the reduction of dead loads on structural buildings. When comparing results with the concrete control mixture of 2,400 kg/m^3, the partial replacement of cement by the mineral admixtures made little difference to the concrete unit weight, and the addition of SF increased the unit weight most. The reduction in the unit weight when the limestone and UFG were used may be attributed to their weights, as they partially replaced the cement and are lighter that cement in weight, which has a significant effect on concrete density. According to the concrete specification standard BS EN 206-1, concrete is considered to be lightweight if its density does not exceed 2,200 kg/m^3, and is considered to be normal concrete if its density value is between 2,300 kg/m^3 and 2,400 kg/m^3. It can be noticed from Fig. 3 that all concrete mixtures lay within the corresponding range of the normal concrete category.

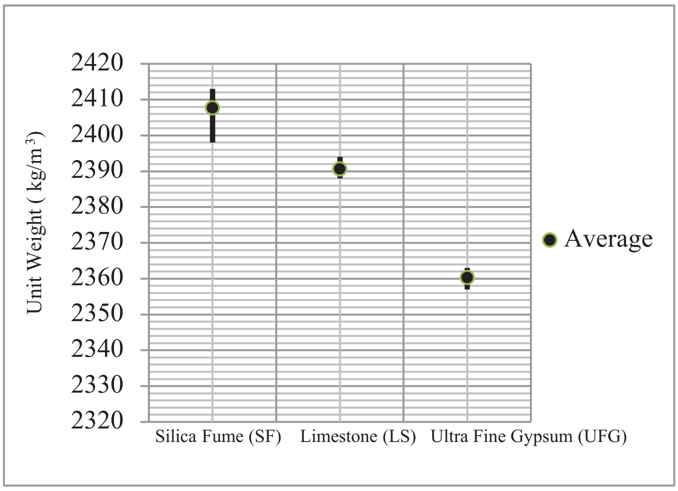

Fig. 3. Effect of mineral admixtures on unit weight.

3. Air Entrainment

Because the use of mineral admixtures has become common practice, engineers are concerned about the effect of these admixtures on the concrete air void system. The effect of mineral admixtures on the entrapped air in concrete is shown in Fig. 4. Based on the presented data, it seems that the air content of the mineral admixture concrete mixes ranged from 6.5 % to 7 %. The concrete mixtures were designed to be non-air entrained. The air content indicated that the incorporation of LS in the concrete generated the highest air content – an average of 6.8 % – while mixing UFG resulted in the lowest air content – 6.5 %. A small amount of reduction in the air entrapped occurs due to the influence of the fine particles of the mineral admixtures when they partially replace cement [6]. Using the same figure, all mixtures seem to fall into the normal concrete category where the total air void in normal concrete is between 4 % and 8 % by volume. Wering [7] indicates that using SF reduces the content of air in concrete. Samuel [8] assessed the influence of LS on air content, and found that using LS reduces the air entrapped in concrete. In contrast, reducing the air content in concrete is necessary as it improves concrete's resistance to freezing and thawing and workability, while it reduces concrete permeability and segregation. Therefore, the addition of mineral admixtures allowed less air to be entrapped in the concrete.

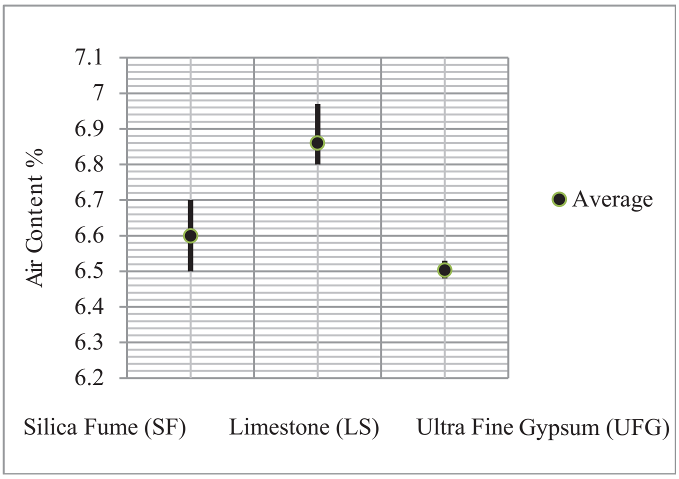

Fig. 4. Effect of mineral admixtures on air entrainment.

4. Correlation between the Air Content and Unit Weight

Based on the test results in Fig. 5, a mathematical model was developed using graphical methods to quantify the effect of the mineral admixtures on the relationship between the air entrainment and unit weight of the fresh properties of concrete. Examining the validity of the results, there seemed to be a strong correlation between two concrete admixtures – LS and UFG – as found from R^2 coefficient values which were 0.6 and 0.5, respectively. The lower value for the R^2 coefficient for SF is most likely to have been caused by imperfection in the pressure added when measuring the air content and rounding values to the nearest 0.5 % for air content values.

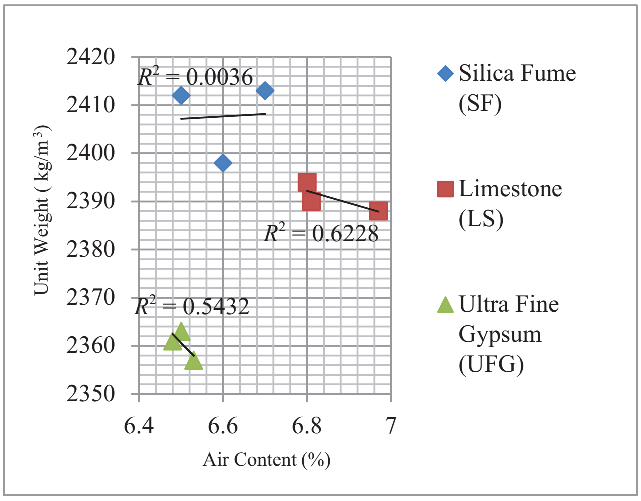

Fig. 5. Correlation between air entrainment and unit weight.

5. Correlation between Air Entrainment and Workability

The relationship between air entrainment and workability is presented in Fig. 6. No correlation was established between those two concrete properties as the R^2 values found were 0.5, 0.02 and 0.006 for SF, LS and UFG, respectively. However a linear relationship between the two concrete properties – air content and workability – was noticed, as the slump of the concrete increased with increased air content for all concrete mixes. Thus, it is more likely that the loss of slump in all mixes was a function of water–cement ratio rather than air content.

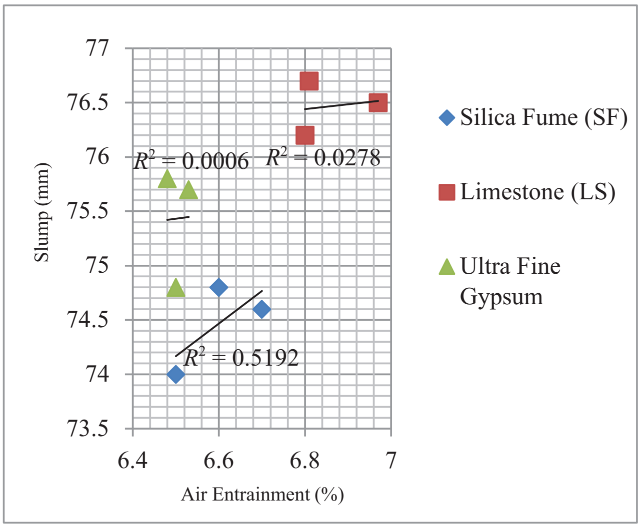

Fig. 6. Correlation between air entrainment and workability.

6. Correlation between the Workability and Unit Weight

On the other hand, as it can be seen from Fig. 7, a very strong correlation was found between the slump and unit weight values for all mixes. The presented sample indicates that there is a linear relationship between the slump and the unit weight of all concrete mixes, and the mathematical model confirms this as values of R^2 seem conclusive, ranging closely from 0.42 to 0.54. Therefore, the predicted values according to the graph and the experimental values are relatively close, which shows the accuracy of the values obtained from the tests, as well as the linear relationship between workability and unit weight.

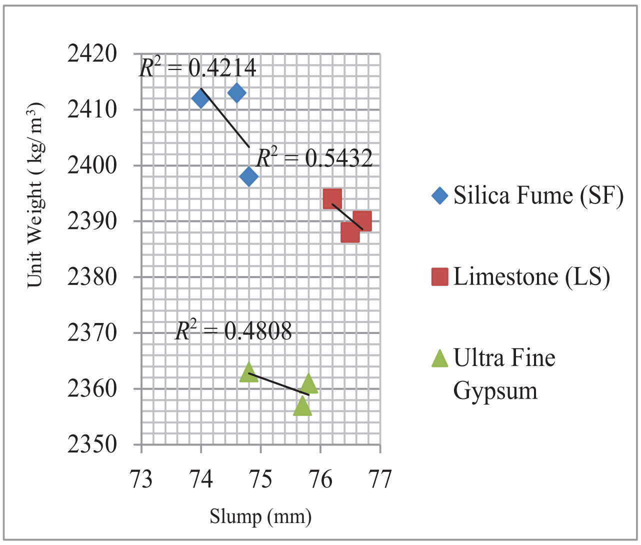

Fig. 7. Correlation between workability and unit weight.

B. Influence of the Mineral Admixtures on the Hardened Properties of Concrete

1. Compressive Strength

The compressive strength development for all concrete mixtures containing different mineral admixtures (SF, LS and UFG) is presented in Fig. 8. The compressive strength of concrete was calculated from the average of three specimens and was plotted as a function of mineral admixtures. For all mixtures, cement was partially replaced by 25 % of all mineral admixtures. It was also noticed that there was an increase in the compressive strength of concrete when the cement was partially replaced by SF achieving a strength of 49 MPa. The UFG achieved the second highest compressive strength, while the partial replacement of cement by LS reached a value of 45 MPa. It was found that there was a significant improvement in the compressive strength of concrete when mixing concrete with SF which had a higher compressive strength than that recorded for the concrete control mixture.

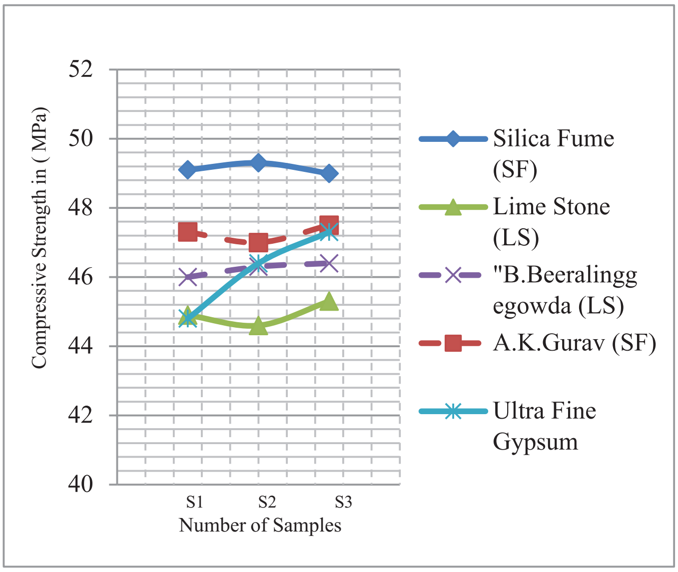

Fig. 8. Mineral admixture effect on concrete compressive strength.

The increase in strength was due to the cement that continued to hydrate. The mechanism of the mineral admixtures on concrete can be divided into two main categories: the interaction zone between the cement particles and admixtures, and the chemical reaction between the two substances. Therefore, the enhancement in the compressive strength of concrete when mixed with SF is due to the inclusion of the SF particles as they are very small and can act as filler which fills in voids in cement, resulting in a compacted system, hence increasing the compressive strength of the concrete. Furthermore, SF particles are very reactive pozzonlanic materials, and possess a high silicon dioxide content of around 91 %, which also, in return, increases the compressive strength of the concrete [9]. These factors make concrete containing SF stronger than the other mixes containing different mineral admixtures. Similar results were reported by Gurav A. K. [10] as shown in Fig. 8. The small change in the result between the authors' study and Gurav A. K. [10] is due to the difference between the parameters used between the two studies, such as water to cement ratio.

The UFG is fine powdered gypsum that is used mainly in agriculture to improve soil aggregation and permeability. This type of gypsum has a higher content of calcium and sulphur than most gypsum types and also contains smaller particles. Therefore, the enhancement in the compressive strength of concrete when mixed with UFG is due to the smaller particles of the materials that act as filler in the concrete, and also due to the reaction between the sulphate and the C-S-H of the cement. This reaction seems to increase the concrete strength as more C-S-H is produced, which, in turn, accelerates the concrete strength [11].

Using Fig. 8, the highest reduction in compressive strength was observed when using LS as a partial replacement for cement. LS is a type of sedimentary rock that consists mainly of calcium carbonates, $CaCO_3$. The incorporation of LS powder with Portland cement has many advantages for early compressive strength, due to the chemical reaction between calcium carbonate with the alumina phases of cement, which results in increased cement hydration and increased concrete strength [12]. However, LS is mainly used to speed up the hydration process, and does not usually achieve high strength after a long period such as 28 days [13]. As a result, LS recorded the lowest compressive strength value as can be seen from Fig. 8. Similar results were reported by Beeralingegowda, [14] as can be seen from Fig. 8.

2. Tensile Strength

Fig. 9 shows the effect of the mineral admixtures on the tensile strength of the concrete. It clearly shows that the addition of SF achieved the highest tensile strength, followed by the incorporation of UFG and finally mixing LS with concrete. Furthermore, it indicates that the use of all mineral admixtures slightly improves the tensile strength of concrete and their effect on the tensile strength was relatively close. The trend in the strength gain was similar to the compressive strength, as the incorporation of mineral admixtures enhanced the concrete tensile strength but at a gradually smaller rate. The enhancement in the tensile strength of the concrete mixed with SF was due to initial filling of the voids by SF particles, which significantly enhanced the tensile strength [15]. Tensile strength results obtained by Katkhuda, H. [16] show the same trend as can be seen in Fig. 9. as the tensile strength values were relatively close to the author result. Srivastava [17] reports that the partial replacement of cement by SF enhances the compressive and tensile strengths of concrete. The results also show that mixing concrete with LS results in achieving an average tensile strength of 2.9 MPa. This maybe be attributed to the effect of the LS on the small voids that acts as a filler, also due to the high reactivity of the LS powder which contains a high content of calcium carbonate. Jayaraman [18] describes experimental work the result of which show the same trend as can be seen in Fig. 9. The UFG achieved a tensile strength of an average of 2.94 MPa, which is considered to be a promising result as it exceeded the result obtained for LS. Computing the percentage gains in the tensile strengths of the mineral admixtures with respect to the control mixtures, the values of the average tensile strength gains were 23 %, 20 % and 22 % for SF, LS and UFG, respectively.

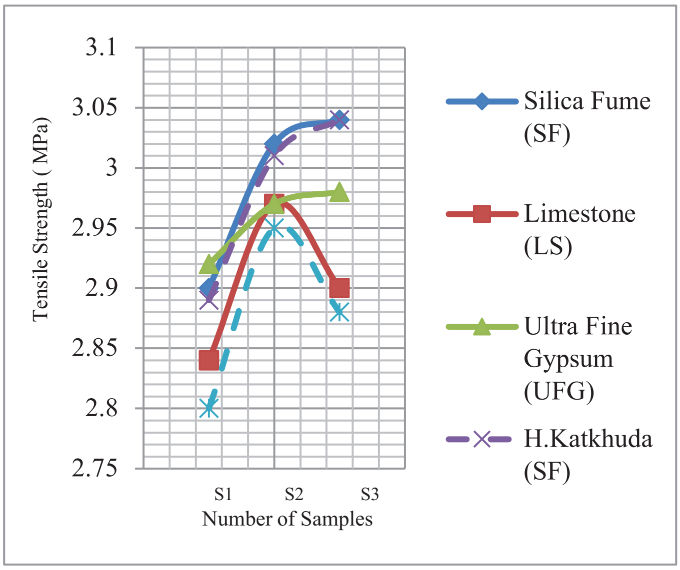

Fig. 9. Mineral admixture effect on concrete tensile strength.

3. Flexural Strength

The flexural strength of concrete reinforced with different mineral admixtures is summarized in Fig. 10. The modulus of rupture for all concrete mixes ranged from 1.2 to 1.9 MPa. Mixing concrete with SF achieved the highest flexural strength, while incorporating concrete with UFG recorded the lowest value. This trend in the strength gain is similar to results for the compressive strength and tensile strengths of concrete, as mixing SF with concrete influenced concrete and enhanced its strength the most. Results from Mydin [19] show that mixing SF leads to an increase in the flexural strength of concrete as shown in Fig. 10. However, the content of SF in their study was lower than the one analyzed in this study. As a result, the flexural strength value seems slightly less than for these authors' results. As shown in Fig. 10, the flexural strengths of cement blended with LS indicated a better strength gain in comparison with mixing concrete with UFG.

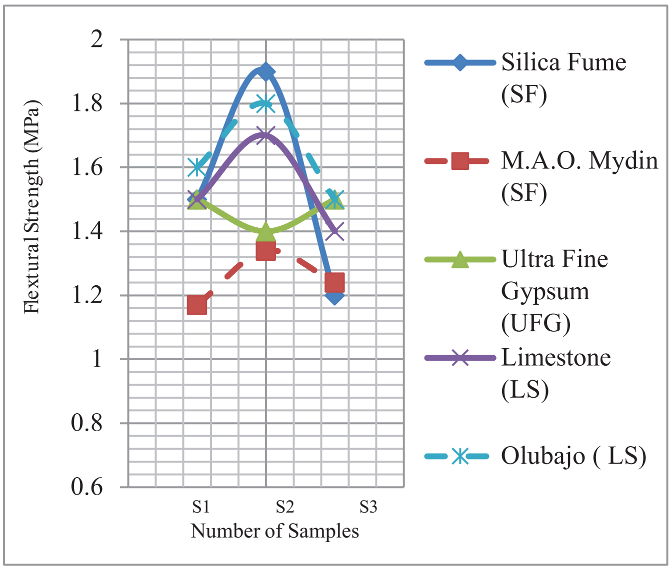

Fig. 10. Mineral admixture effect on concrete flexural strength.

This may be attributed to the effect of calcium carbonate within LS powder which prompts growth in the hydration process that leads to further increases in concrete strength [20]. Similar results were reported by Olubajo [21] for the flexural strength achieved by the replacement of cement by limestone. The small difference in the flexural strength value between the authors' study and the previous study are due to the differences in water-cement ratio, and due to the addition of bottom ash admixture to concrete by the previous author. When compared to the control mix, all specimens contained mineral admixtures which showed an increase in the flexural strength of 12 %, 11 % and 8 % for SF, LS, and UFG respectively. In other words, the flexural strength development of concrete was influenced by the addition of the mineral admixtures, and their relative effect on strength gain was equal or the same.

4. Modulus of Elasticity

The use of mineral admixtures in concrete has been on the rise and most concrete produced today will contain mineral admixtures as part of their mix design. Mineral admixtures change the microstructure of the concrete mix and have a significant effect on its strength. Fig. 11 shows the effect of SF, LS and UFG on the concrete modulus of elasticity. It is obvious that the modulus of elasticity increases in the following order for different mineral admixtures: SF, UFG and LS. This trend could be explained by the different rates of hydration of the mineral admixtures, the availability of water for hydration and the presence of water filled pores in the different mixes [22]. The adverse effect of the LS admixture on the concrete modulus of elasticity was pronounced to be the lowest when compared with the other mineral admixtures; however, this value was higher than the control mix concrete value. Unlike the hydration process in ordinary Portland cement, the hydration process in the blended cement was considerably more complex. It involved the reaction of the mineral additive in addition to the hydration of the Portland cement. The reaction starts when calcium hydroxide Ca(OH)2 is mixed with concrete to produce more C-S-H, which leads to an increase in the concrete strength. In addition, it was discovered that when the Portland cement is blended with a mineral admixture such as SF or LS, the structure of C-S-H, the principle strength-giving compound in the hardened concrete, changes to provide more strength [23]. The percentage increases in the static modulus of elasticity at 28 days of curing as measured relative to reference concrete for SF, LS and UFG were 41 %, 34 % and 40 %, respectively.

According to Almudaiheem [24], the change in the modulus of elasticity is attributed to irreversible changes in the structure of the hardened cement paste on first drying. Swamy [22] attributed this change in the modulus of elasticity to the removal of moisture from capillary channels, as a result of the effect of the hydration process of concrete. In this research it is believed that the change can be attributed to the different speeds of the hydration process. In addition, this change might be caused by the chemical reactions between the mineral admixtures and cement. However, whether the change of the modulus of elasticity caused by water drying is reversible or not, is another issue that could be discussed.

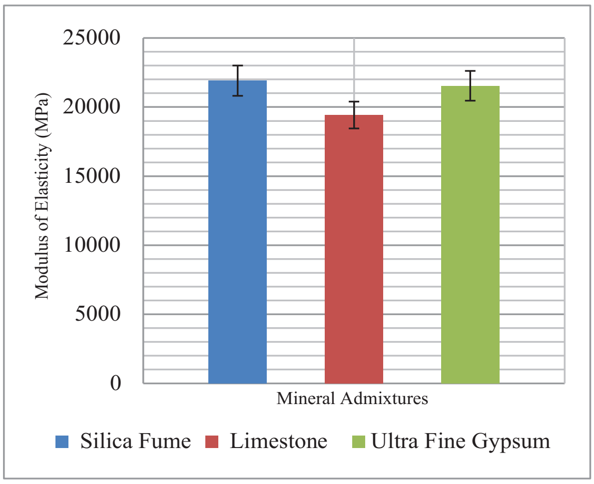

Fig. 11. Mineral admixture effect on concrete modulus of elasticity.

5. *Correlation between Compressive and Tensile Strength*

Fig. 12 shows the correlation between the influence of mineral admixtures on concrete compressive and tensile strengths. It can be seen that there exists a strong correlation between the two concrete admixtures – concrete SF and UFG – as found from the R^2 coefficient values which were 0.8 and 0.9, respectively. The lower value of the R^2 coefficient for LS was most likely caused by lower values of compressive and tensile strengths recorded for concrete when mixed with LS powder, compared to the values achieved by using SF and UFG.

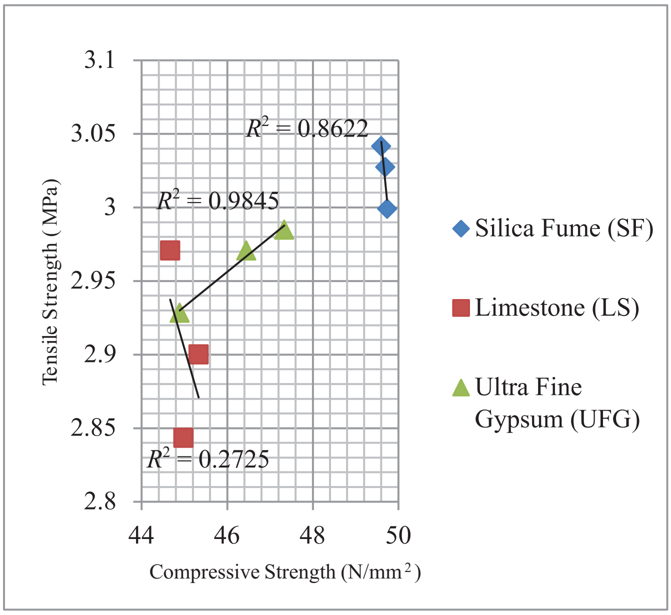

Fig. 12. Mineral admixture correlation between compressive and tensile strength.

6. *Correlation between Compressive and Flexural Strength*

The relationship between the concrete compressive and flexural strength is presented in Fig. 13. No correlation is noticeable between the two concrete properties as the R^2 values were 0.3, 0.9 and 0.002 for SF, LS and UFG, respectively. However a linear relationship between the two concrete properties – compressive and flexural strength – for all concrete mixes can be observed. This can be seen clearly when mixing concrete with all mineral admixtures, as the dispersion of the points seem to be in a straight line. Thus, using the R^2 there seems to be no correlation; however, using the graph, there seems to be a linear relationship between the two concrete properties.

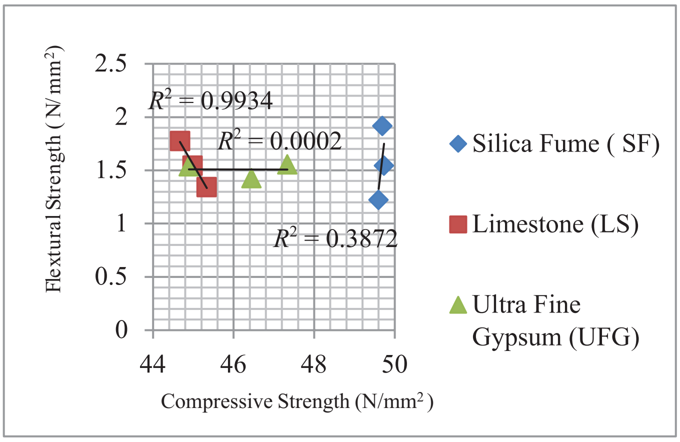

Fig. 13. Mineral admixture correlation between compressive and flexural strengths.

7. *Correlation between Tensile and Flexural Strengths*

In Fig. 14, the relationship between the tensile and flexural strengths for all mineral admixtures included in the database and the corresponding best fit linear line are shown. As in the case of the correlation between the tensile and flexural strength using SF and UFG, it is noticed that there is a positive relationship between the two variables, as their corresponding R^2 values are 0.08 and 0.019; however, the distribution of the data points is relatively high. There seems to be no consistency in terms of increasing and decreasing values between the two parameters by using all admixtures in general, which indicates that there is no correlation between the flexural and tensile strengths of concrete when mixed with different mineral admixtures.

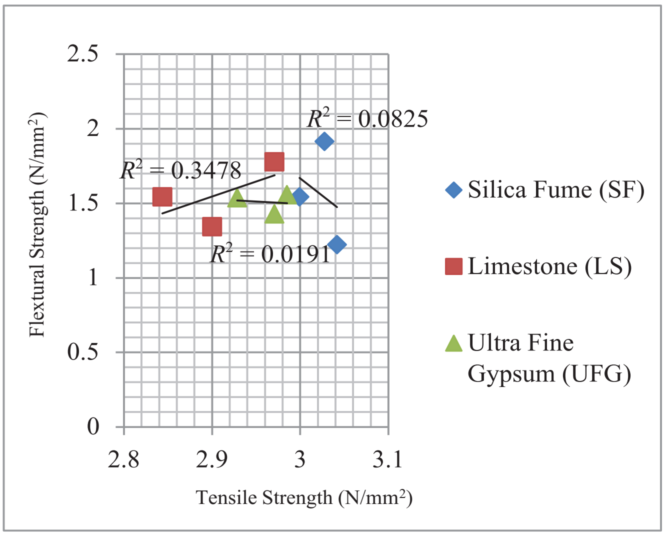

Fig. 14. Mineral admixture correlation between tensile and flexural strengths.

8. Correlation between Compressive Strength and Modulus of Elasticity

On the other hand, as it can be seen in Fig. 15, a very strong correlation was found between the compressive strength and modulus of elasticity values for all mixes. Using the graph, there seems to be a very strong correlation between the two parameters for all concrete mixes, as a long linear line is drawn along all points for all mixes. In addition, the mathematical model confirms this as values of R^2 seem conclusive ranging closely from 0.6 to 0.9. Evaluating the distribution of the data and using the mathematical regression equation, it can be seen that values of R^2 distribution are close to 0.9 which indicates that the predicted test data are accurate, and a strong relationship is established between the compressive strength and modulus of elasticity.

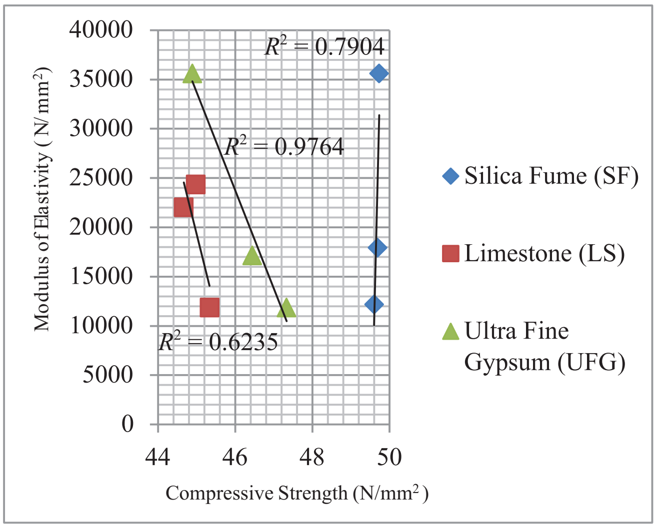

Fig. 15. Mineral admixture correlation between compressive strength and modulus of elasticity.

9. Evaluation of Mineral Admixture Effect on the Mechanical Properties of Concrete

Table IV evaluates the overall performance of the mineral admixtures on the mechanical properties of concrete.

TABLE IV

Properties of Mineral Admixtures

	Type of Mineral Admixture		
	Silica Fume (SF)	**Limestone (LS)**	**Ultra-Fine Gypsum (UFG)**
	Fresh Concrete		
Slump	↓	↓	↓
Unit Weight	↔	↔	↔
Air Entrainment	↓	↓	↓
	Hardened Concrete		
Compressive Strength	↑	↘	↘
Tensile Strength	↑	↑	↑
Flexural Strength	↑	↑	↑
Modulus of Elasticity	↑	↔	↑

↔ Unchanged ↑ Increased ↘ Slight Decrease ↓ Decrease

IV. CONCLUSION

This paper compares the performance of the mechanical properties of concrete continuing different mineral admixtures, identifying the correlation between them, also evaluating the use of a new mineral admixture (UFG) in concrete. Additionally, a mix of soft and coarse fine aggregate was used to ensure that the concrete was well graded and compacted. This comprehensive investigation of concrete strength has outlined the capability of mineral admixtures to enhance the mechanical properties of the fresh and hardened concrete, and also shown the ultimate benefits that mineral admixtures have on changing concrete microstructure, hence increasing concrete strength. In general, mineral admixtures, due to their variable sources and procedures, vary significantly in chemical composition as well as their interactions with cement, therefore producing different values. The results have shown that all mineral admixtures have reduced the properties of fresh concrete that has been studied in this research, except for the unit weight which remained constant. This may be attributed to the small particles of minerals used which reduced the air content in the concrete and also absorbed water more rapidly. thereby decreasing concrete slump and workability. The paper has also confirmed the ability of these minerals to enhance the flexural and tensile strengths of concrete, as well as the modulus of elasticity. This is due to the ability of these minerals to speed up the hydration process of concrete as they chemically react with the cement. In contrast, the compressive strength value seems to have reduced slightly, except for SF. Using SF seems to have improved the mechanical properties of concrete the most, followed by UFG and LS respectively. For the fresh properties of concrete, there seems to be a reasonable correlation between the air entrancement and unit weight, and between workability and unit weight for all mineral admixtures. For the hardened properties of concrete, a reasonable correlation between compressive strength and tensile strength was noticed, as well as between compressive strength and the modulus of elasticity for all mineral admixtures.

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