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STUDY THE EFFECT OF LOCAL METAKAOLIN ON THE BEHAVIOR OF REINFORCED CONCRETE SLAB EXPERIMENTALLY AND NUMERICALLY

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ABSTRACT

This paper presentsan experimental and numerical investigation of the local metakaolin effect on the behavior of reinforced concrete slabs as a partial substitute for cement in concrete.This was achieved by activating Metakaolin at 700 degrees C.We utilized various contain percentages as (0 –5–10–15–20–25) %,of local metakaolin (MK) at the water-cement ratio of 0.55.We have replaced each amount of the cement with thesame amount of Metakaolin and produced 6 cubes (15cm*15cm*15cm) from each one.These cubes are then utilized for mechanical testing. The samples were subjected to compressive strength, indirect tensile strength, and water sorptivity testing. The mechanical test revealed that the strength of concrete grew from 5% to 15% replacement ,peaked at15%,then subsequently fell below this amount.When the additive Metakaolin (MK) is used in the optimal amount, the test results show that it tends to increase the strength of the concrete mix when compared to standard concrete.the optimum result of the reinforced concrete slab had been applied using the finite element approach as we use these results experimentally (Ansys).

KEYWORDS: Metakaolin, Strength, Ansys, Mechanical tests, Pozzolanic materials, Cementing materials, concrete slab.

دراسة تأثير الميتاكاولين المحلي على سلوك البلاطات الخرسانية المعززة تجريبياً وعدديا

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الملخص العربي :

يقدم هذا البحث دراسة تجريبية وعددية لتأثير الميتاكولين المحلي على سلوك البلاطات الخرسانية المسلحة كبديل جزئي للأسمنت في الخرسانة. لقد حصلنا على هذا عن طريق تحفيز مادة الميتاكاولين عند درجة حرارة 700 درجة مئوية. لقد استخدمنا نسب خلط مختلفة مثل (0 - 5 - 10 –15 - 20 –25)٪ ، من الميتاكولين المحلي (MK) بنسبة خلط ماء 0.55. لقد استبدلنا كل كمية من الأسمنت بنفس كمية الميتاكاولين وأنتجنا 6 مكعبات (15 سم * 15 سم * 15 سم) من كل واحدة. ثم يتم استخدام هذه المكعبات للاختبار الميكانيكي. تم خضوع العينات تحت مقاومة الانضغاط وقوة الشد الغير مباشرة واختبار نفاذية المياه . أظهر الاختبار الميكانيكي أن قوة الخرسانة زادت من 5٪ إلى 15٪ من الاستبدال ، وبلغت ذروتها عند 15٪ ، ثم انخفضت بعد ذلك إلى أقل من هذه الكمية. عند استخدام المادة المضافة الميتاكاولين (MK) بالكمية المثلى ، تظهر نتائج الاختبار أنها تميل إلى زيادة قوة خليط الخرسانة مقارنةً بالخرسانة القياسية. كما نقوم بتطبيق النتيجة المثلى للبلاطة الخرسانية المسلحة باستخدام نهج العناصر المحدودة حيث نستخدم هذه النتائج بشكل تجريبي (Ansys) .

الكلمات المفتاحية: ميتاكاولين ، قوة، اختبارات ميكانيكية ، مواد بوزولانية ، مواد اضافيه لتحسين الخواص، بلاطة خرسانيه .

1- INTRODUCTION: -

Numerous research projects are being conducted worldwide for cement substitute materials as a result of the ongoing rise in cement prices and the impact of air pollution that occurs during cement production. It has been researched use fly ash, corn cob ash, great nut shell ash, rice husk ash, and corn cob ash as additional materials to replace some of the cement used in construction. Recently, the utilization of various pozzolanic materials such as clay, kaolin, and industrial waste has come to light (like slag, silica fume, etc.).

According to these studies, using Metakaolin in place of some of the cement increases the compressive strength of concrete. Some researchers performed studies on the effect of the combination of Silica Fume and Metakaolin showed that compressive strength and workability are improved. In comparison to the reference mixture, other investigations on porosity, water permeability, and chloride penetrability were assessed [2]. They discovered that the addition of Metakaolin increased the concrete's durability but had no effect on its water permeability [4]. Another study looked at the usage of Metakaolin 25% as a cement replacement in six different types of concrete, ranging from quick release to self-compacting to high-performance. They found that the permeability and penetration of chloride are reduced and strength is increased in concrete so this improves the performance of concrete using Metakaolin replacement by weight of the cement. It will be at a level of 20% [1,3,5,6,7, 8].

Many researchers have been studying the structural behavior in reinforced concrete as a partial substitute for cement in concrete with different percentages, some researchers indicate the percentages from (5% to 35%) and others from (0% to 15%).[9]

There are researches show that the optimum behavior of Metakaolin percentage was 20% and another was 15%, then decreases below these percentages. Some studies that made a mixture of Metakaolin and another addition, such as, Limestone and Fly Ash.[12] They also made these studies of Metakaolin partial replacement with cement in different percentages. Some researchers give better mechanical properties at 7 and 28 days such as compressive strength and flexural strength while other researchers give better results at 7,28,90,180 such as water penetration, sorptivity, salt bonding, and electrical resistivity. All of the research confirmed that the use of Metakaolin gives high resistance and durability [10,11,13,14].

The impact of Metakaolin and Fly Ash on the strength and durability of concrete was studied. Several techniques, including concrete resistivity, oxygen permeability, and water absorption, were used to assess the durability. It was found that utilizing 15% Fly Ash and 15% Metakaolin replacement is beneficial, but that employing 30% Fly Ash replacement leads to a substantially early drop in compressive strength when compared to a reference mix of 100% Portland cement [15].

Using finite element analysis, reinforced concrete beam flexural behavior has been studied. The validity of the Ansys analysis was found to be satisfactory when compared to the theoretical conclusions of the elastic analysis. The tiny disparity in findings could be due to a modeling error, such as failing to remove the amount of the mild-steel reinforcement from the concrete volume [16].

At high temperatures, the performance of Fly Ash (FA) and Metakaolin (MK) mortar was evaluated. The partial substitution of cement with (MK) from 5% to 20%, (FA) from 20% to 60%, and temperatures ranging from 270°C to 800°C was studied. Scanning Electron Microscope (SEM) images were used for qualitative examination of the microstructure of heated and unheated mortar, while Image Pro-plus software was used for quantitative analysis of (SEM) photos. Compressive strength is reduced but charge passing increased for all blends as temperature increased from 270C to 800 0C, with considerable strength and durability loss occurring beyond 4000°C, which was regarded as threshold point for degradation [17].

As a partial replacement for cement in concrete with a range of percentages from 5% to 35% is applied, the structural behavior of the concrete structure infused with metakaolin has been examined .Concrete made with Metakaolin outperformed the control sample at all replacement percentages, according to the mechanical test, which showed that concrete strength increased from 5% to 20%, peaked at 20%, then decreased below this value. The chemical analysis results showed that Metakaolin is a class "N" pozzolan, which explains why it outperformed the control sample [18].

At various levels, the durability of self-compacting concrete containing metakaolin (the cement that metakaolin replaces) has been assessed. In comparison to a reference mixture, porosity, water permeability, and chloride penetrability were assessed. The addition of Metakaolin increased the concrete's durability but didn’t affection its water permeability [19].

The most current subject of study in concrete elements is the usage of Nano-concrete (NC). As a result, this study was carried out to investigate the flexural behavior of nano-concrete beams. The impact of employing glass fiber reinforcement bars (GFRP) on concrete strain, crack patterns, number of cracks, and mode of failure was investigated. The results showed improved concordance between experimental and analytical data [20].

Several attempts have been made to improve the mechanical qualities of heavy weight concrete for radiation shielding, good workability, high durability, moderate compressive and tensile strengths, strong crack resistance, low permeability, and low shrinkage. Six mixes were constructed in this investigation employing magnetite coarse and fine aggregate with a replacement of cement. The testing results showed that the magnetite aggregate mix with 3% polyethylene improved mechanical properties over similar concrete mixes; nevertheless, the compressive strength of magnetite with 15% rice was lower [21].

Geopolymer concrete (GC) is a large type that is made by using metakaolin ground granulated blast furnace slag (GGBS), silica fumes, fly ash, and other cementitious materials as binding elements. Under axial compression loading, nine geopolymer ferrocement columns with diameters of 150 mm 150 mm 1600 mm and varied volume-fraction and layers, as well as a number of metallic and nonmetallic meshes, were tested until failure. The performance of the geopolymer columns was investigated in terms of mid-span deflection, ultimate failure load, and first crack load with different phases of loading, the cracking patterns, energy absorption and ductility index [22].

2-EXPERIEMNTAL PROGRAM FOR METAKOLIN PERCENTAGES:

DETAILS MODELS:

In this research, different percentages of Metakaolin were used as a partial replacement of cement by weight with (0, 5, 10, 15, 20, and 25%). In addition to that, two cement content were used which are 250 and 350 kg/m^3. Fresh concrete mixes properties were determined

by slump test while hardened concrete mixes were determined by compressive strength, indirect tensile strength, and water sorptivity tests.

- The experimental program was divided into five groups: **-**

1. In the 1st group, two concrete mixes, different in cement content, with 0% Metakaolin were cast. These 12 cubes (150*150*150 mm^3) were prepared to perform a compressive strength test after 7 and 28 days as per ASTM C 39. While the standardized slump test described in ASTM C-143 is used to determine the workability of concrete mixtures in their fresh condition measurements, then the control mix was chosen according to its workability and strength.

2. In the 2nd group, five concrete mixes, different in cement content, with (5,10,15,20,25) % Metakaolin were cast. There were 60 cubes (150*150*150 mm^3) prepared to perform a compressive strength test after 7 and 28 days as per ASTM C 39. While the standardized slump test described in ASTM C-143 is used to determine the workability of

concrete mixtures in their fresh state, then the control mix was chosen according to its workability and strength.

3. In the 3rd group, six concrete mixes, different in cement content, with (0,5,10,15,20 and 25)% Metakaolin were cast. There were 36 cubes (100*100*100 mm^3) prepared to perform an indirect tensile strength test after 28 days.

4. In the 4th group, six concrete mixes, different in cement content, with (0, 5, 10, 15, 20, and 25) % Metakaolin were cast. These 12 cubes (70*70*30 mm^3) were prepared to perform asorptivity test after 28 days.

5. Finally in the 5th group, two concrete mixes, different in cement content, with (0 and 15) % Metakaolin were cast. There were four slabs with dimensions (1000*1000*100 mm) were prepared and tested after 28 days.

2.1 Materials: -

2.1.1 Cement:

The cement used in this investigation is of type I, which has chemical and mechanical properties as listed in Table 1.

Table1: Ordinary Portland cement properties

Element	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	L.O.I
Cement	20.13	5.32	3.61	61.63	2.39	2.87	0.37	0.13	1.96

Property	Result
Compressive strength (3-days)	156.6 kg/cm^2
Compressive strength (7-days)	195.7 kg/cm^2

2.1.2 Metakaolin:

Industrial Metakaolin was used as incorporating material. The Chemical composition &physical properties of Metakaolin are reported in Table 2.

Table 2: Metakaolin chemical composition & physical properties

Chemical composition		Physical properties	
SiO_2	50%	Brightness(RY) (DIN 6174)	82 % min
Al_2O_3	31.2%	Whiteness (DIN 6174)	83.5 % min
Fe_2O3	0.90%	Color	gray
TiO_2	0.03%	Yellowness index	5.6 max
CaO	0.15%	Hardness (Mohs)	2-2.5 Mohs
MgO	0.60%	Density	2.55 g/100g
K_2O	0.10%	Ph (iso787/9)	8.9 max
Na_2O	0.30%	Oil absorption (iso 787/5)	40+ 1 g/100g
L.O.I	23.89%	Specific gravity g/cm	2.60
		Surface area m^2 /g	8

2.1.3 Fine aggregate:

As fine aggregate, natural clean sand that was readily available, had a fineness modulus of 2.25, a specific gravity of 2.58 g/cm3, and a particle size less than 0.5 mm.

2.1.4 Coarse aggregate:

Clean Crushed dolomite with a specific gravity of 2.96g/cm3 and a maximum particle size of 12 mm was used as coarse aggregate. Utilize a sieve while analyzing coarse aggregates.

2.1.5 Water:

The mixture was prepared using potable water. The water supply network system provided this water. The water utilized did not include any organic materials or suspended particulates that would have affected how fresh and hardened concrete behaved.

2.1.6 Super plasticizer:

- In this experimental program ARACO SP 122, a superplasticizer for highly effective water, reducing agent, and production of high-quality concrete were used.
- The Experimental dosage is 2.5% by weight of cement.
- The properties of superplasticizer are shown in Table 3.3

Table3: Properties of superplasticizer

Density	1.2±0.005 KG\ L (ASTM C494)
Color	Black Liquid
Recommended Dosage	0.5-2.7 % by weight of cement

2.2 Equipment:

2.2.1The standard sieves:

The sieves used for particle size distribution were carried out using sieves of mesh opening. The Sieves used for fine aggregate were as follows (9.5, 4.75, 2.36, 1.18, 0.60, 0.30, 0.15, 0.075 mm) while Sieves used for coarse aggregate were as follows (37.5, 20, 14, 10, 5, 2.36 mm).

2.2.2 Mixer:

To create concrete, cement, water, and material like sand or gravel were blended uniformly in a concrete mixer. A rotating drum is typically used in a concrete mixer to mix the ingredients. Portable concrete mixers are frequently utilized for smaller volume projects so that the concrete can be prepared on the job site, allowing the workers plenty of time to use it before it hardens. Concrete can be mixed by hand as an alternative to machinery.

2.3 Testing Methods:

2.3.1 Slump cone:

A cone has a height of 30 cm, a bottom diameter of 20 cm, and a top diameter of 10 cm. The tamping rod is of steel 16 mm in diameter and 60 cm long and rounded at one end.

2.3.2 Standardcube test concrete:

Cubes having a dimension of (15 cm*15 cm*15cm) were used for the compressive strength test.

2.3.3 Oven:

The oven was used for drying the sample at a temperature of 70°Cfor 4 days and then left to cool for 24 hours to prepare the samples for the sorptivity test.

2.3.4 Curing tank:

The samples were demolded and cured in water for test day at a temperature of 20°C.

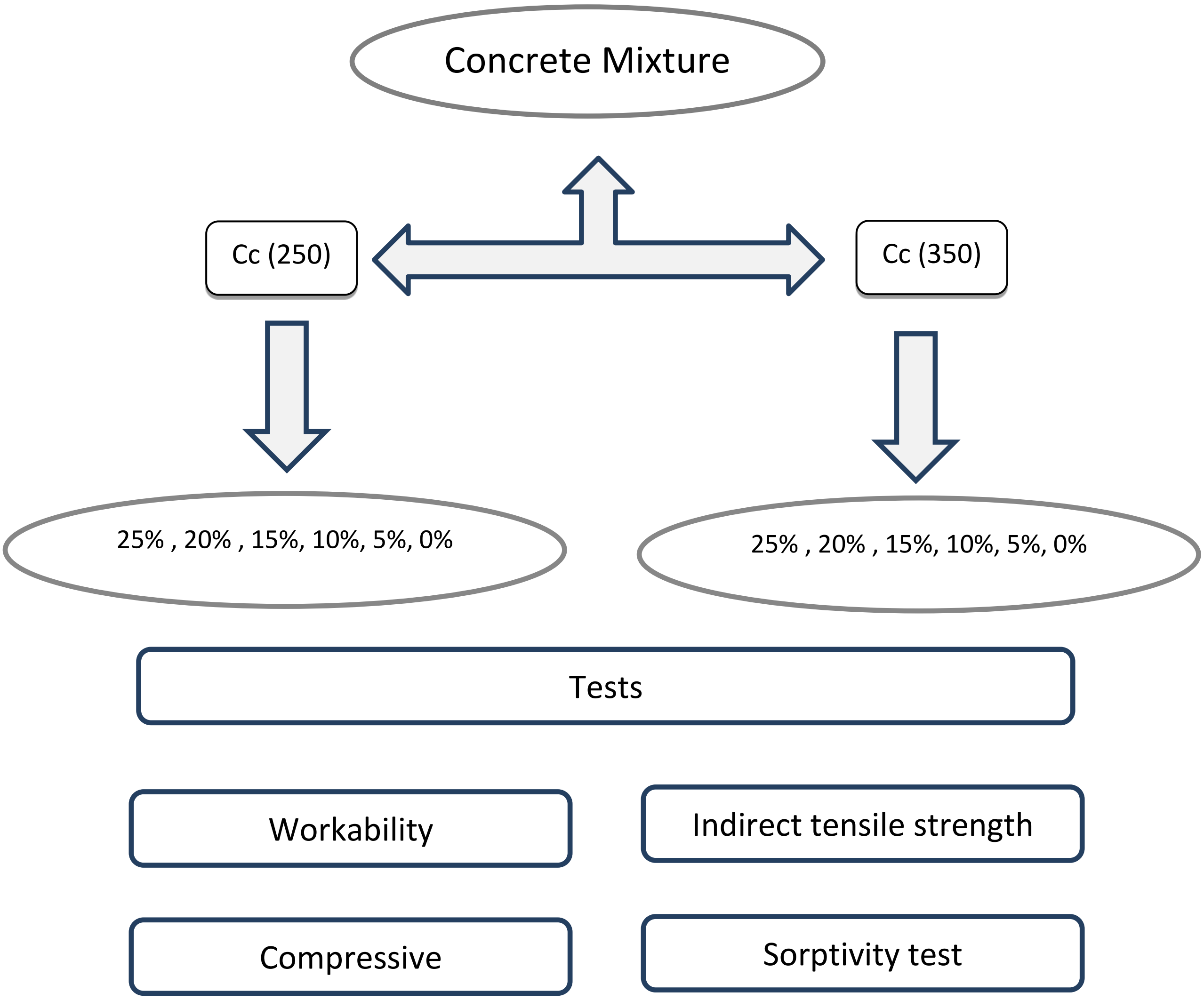
2.3.5 Universal testing machine:

A universal testing machine of 500 KN capacity in tension & 2000 KN capacity in compression was used for the mechanical characterization of investigated samples.

2.3.6 Strain rate calculation:

It is a tool that is used for measuring the strain on concrete.

2.4 Experimental Procedure:



2.5- Effect of Metakaolin Ratio on the Behavior of Reinforced Concrete Slabs Experimentally and Numerically Program: -

- Model Dim

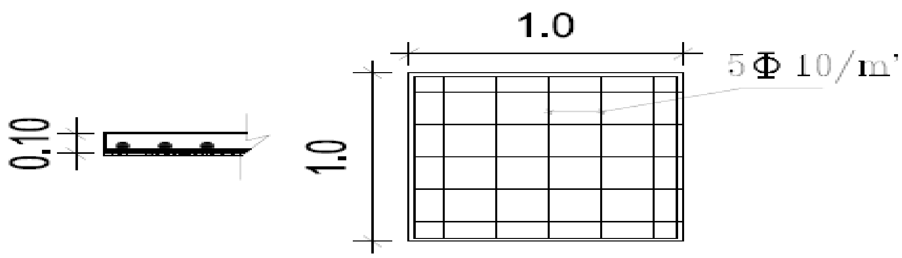


Figure 1: Model with Dimension

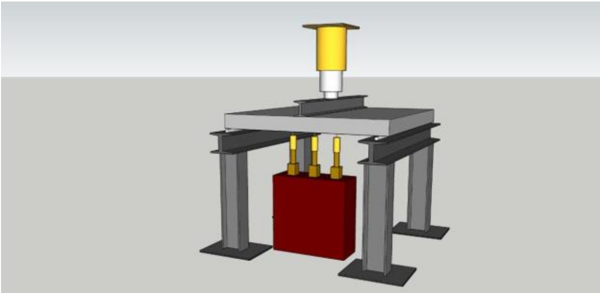


Figure 2: Model in 3D Figure 3: Preparing Model for Test

- After reaching the optimum percentage of Metakaolin replacement by weight with cement.

Prepare two slabs from two cement content, one slab with control mix zero Metakaolin and the other with 15% Metakaolin replacement by cement weight and test the models in the lab, then make the same for the four models and simulate on finite element Ansys 17.0 after comparing with the results experimentally and by finite element.

3- RESULTS &DISCUSSIONS:

3.1- Workability Test:-

Table 4 illustrates the workability of concrete with partial cement replacement by Metakaolin in percentages ranging from 5% to 25% in 5% increments. Workability diminishes as Metakaolin content in concrete increases.

Table 4: Results of workability of concrete mixture

MIX	Slump value (cm)	
	cc 250	cc 350
0%	17	19
5%	14	17
10%	12	16
15%	11	13
20%	9	13
25%	9	10

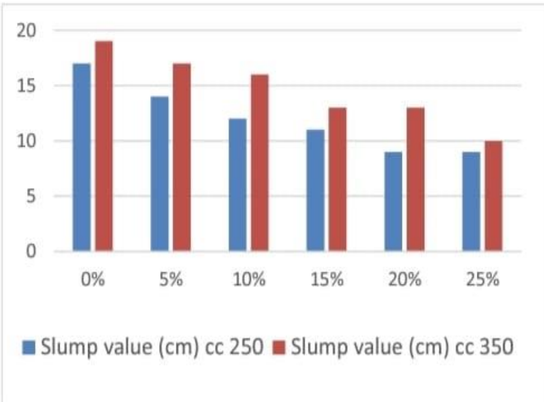


Figure 4: workability of concrete mix

- The experimental result shows that when Metakaolin in concrete increases workability decreases.

3.2 - Compressive Strength: -

Results of a test using (0 - 25%) Metakaolin on hardened concrete for 7 and 28 days are shown in Table 5.

The results demonstrate that as curing time increases, compressive strength increases.

The compressive strength of the specimens with various percentages of Metakaolin as a replacement for cement increased as compared to the control mix. At 7 and 28 days, the compressive strength test was conducted.

It was found that the use of a percentage of cement with Metakaolin leads to early resistance, and that the use of Metakaolin as an alternative to cement weight gives an increase in resistance at a rate of 25.2% to 36.7% in cement content 250 Kg/m3, and give an increase in resistant at rate 17. 2% to 25.3% in cement content 350 Kg/m3.

The results indicate that the maximum strength was achieved at 15% replacement for all test ages and decreased below this percentage.

Table 5: Results of compressive strength test

CC350		MIX	CC250	
7 days	28 days		7 days	28 days
27.7	39.5	0%	22.1	34.5
29.6	39.6	5%	28.3	39.3
32.6	43.6	10%	29.1	40.2
34.7	46.3	15%	30.2	43.2
25.1	39.1	20%	24	32.8
23.6	32.8	25%	19.1	25.9

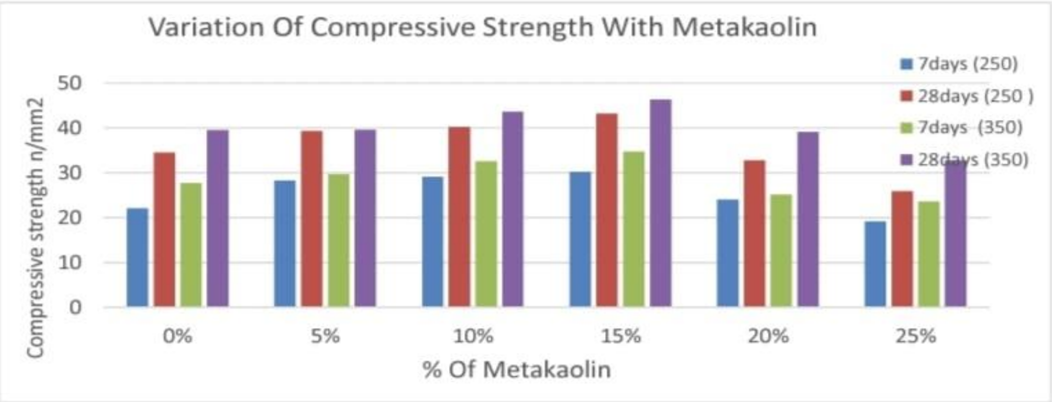


Figure 5: Compressive Strength

3.3 In Direct Tensile Strength:-

Table 6 gives the results of the tensile strength test conducted on hardened concrete with (0 – 25) % Metakaolin at the age of 28 days.

- Tensile strength measurements revealed that concrete using Metakaolin as a bonding agent is much stronger than concrete using only Portland cement.
- After 28 days and the addition of Metakaolin in place of cement, the maximum tensile strength of concrete was discovered to be 15

Table 6: Results of tensile strength

250		Mix	350	
Tensile Strength(N/mm^2)	Load(KN)		Load(KN)	Tensile Strength(N/mm^2)
2.52	40	**0%**	43.5	2.74
2.62	41.5	**5%**	46.5	2.93
2.71	43	**10%**	49.5	3.12
2.81	44.5	**15%**	51.5	3.25
2.45	39	**20%**	44	2.77
1.89	30	**25%**	39.5	2.39

3.4 SorptivityTest:-

Water sorptivity (capillary water absorption test) was determined for control mix and 15% Metakaolin replacement of cement at 28 days as shown in the figures for the two cement content.

For each mix, the volume of water penetrated per unit area in mm(i) was plotted versus the square root of the elapsed time in a minute (time 0.5)

Equation :S= i √tim

S= sorptivity in(mm/min$^{0.5}$) i= volume of water penetrated per unit area in(mm)

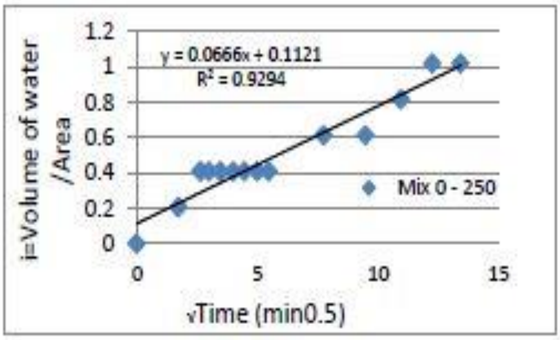


Figure 6 : Result of Sorptivity test for mix (0 – 250)

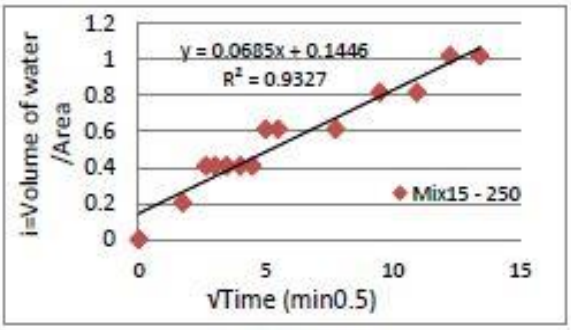


Figure 7 : Result of Sorptivity test for mix (15 – 250)

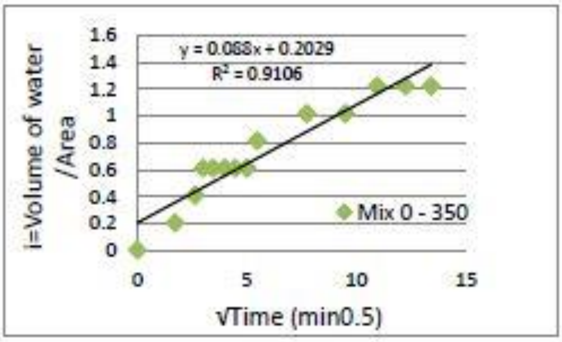


Figure 8: Result of Sorptivity test for mix (0 – 350)

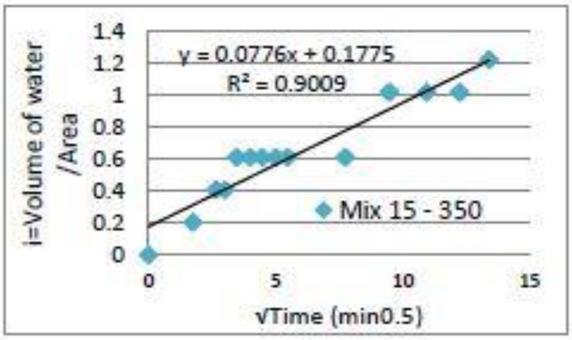


Figure 9: Result of Sorptivity test for mix (15 – 350)

4- Result (Ansys And Experimental):

Analysis of slab models :-

The result of Failure load of slab experimentally (lab) and theoretically (Ansys) Table 7.

The result of Crack loads is shown in Table 8.

Table 7: Compare between failure load of the slab experimentally (lab) and theoretically (Ansys)

MIX OF CONCRETE	Experimental Failure load (TON)	Theoretical failure load (TON)	Ratio between experimental &theoretical failure load (%)
s1 (0 % - 350)	8.2	9	91.1
s2 (15 % - 350)	9.1	10.05	90.5
s3 (0 % -250)	7.7	8.4	91.6
s4 (15 % -250)	8	9.315	85.9

Table8: Crack load of slab experimentally (lab) and theoretically (Ansys)

Mix	Crack load Experimentally (Ton)	Crack load from Ansys (Ton)
s1 (0 % - 350)	5.7	4.7
s2 (15 % - 350)	6.4	5.5
s3 (0 % -250)	4.6	3.9
s3 (15 % -250)	5.9	4.7

When compared to the control mix, the experimental results reveal that models that use 15% Metakaolin as a cement substitute have higher tensile strengths. It takes 28 days to get the test's results.

It was found that the use of a percentage of cement with Metakaolin leads to an increase in the value of the crack load, and also the use of Metakaolin as an alternative to cement weight gives an increase in failure load.

Table8: Failure load and crack load (lab) and theoretically (Ansys)

Mix	EXPERIMENTAL		ANSYS	
	Failure load (ton)	crack load(ton)	Failure load (ton)	crack load (ton)
s1 (0%-350)	8.2	5.7	9	4.7
s2 (15%-350)	9.1	6.4	10.05	5.5
s3(0%-250)	7.7	4.6	8.4	3.9
s4(15%-350)	8	5.9	9.135	4.7

Shape for crack:

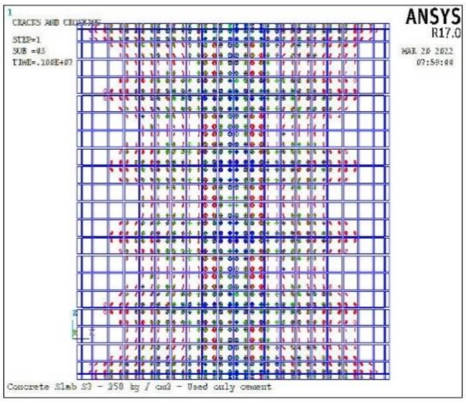


Figure 10 : crack (0-250) by Ansys

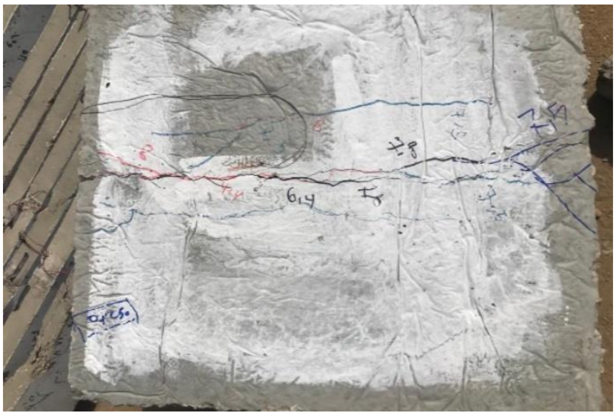


Figure 11 : crack (0-250) by Experimental

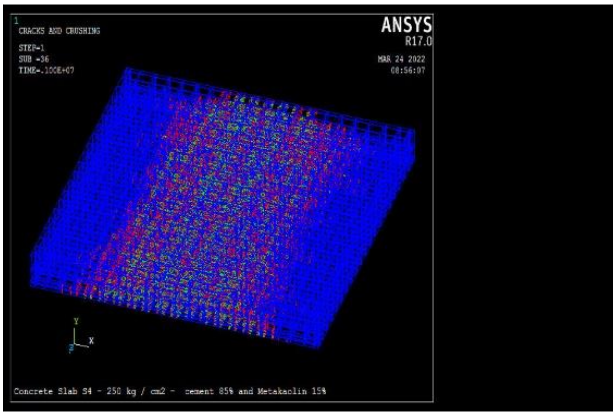


Figure 12: crack (15-250) by Ansys

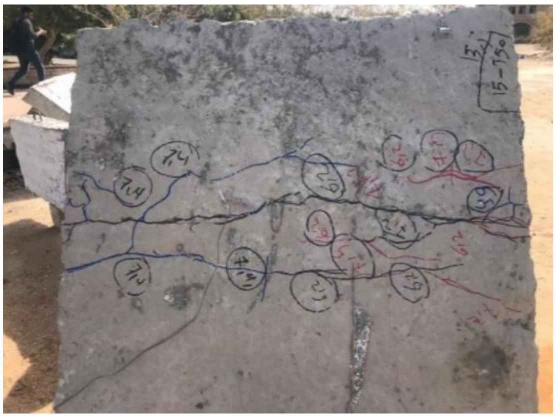


Figure 13 : crack (15-250) by Experimental

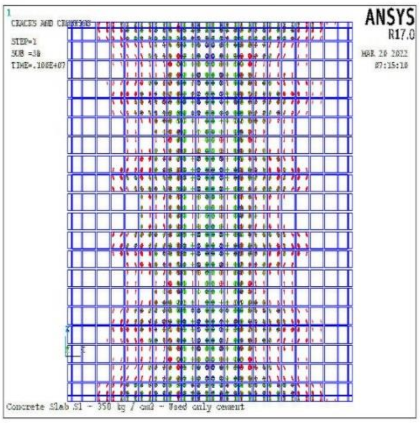


Figure 14 : crack (0-350) by Ansys

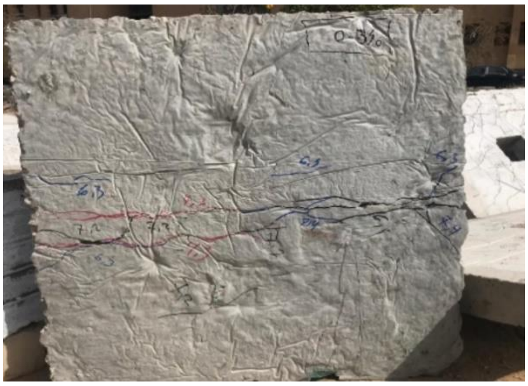


Figure 15 : crack (0-350) by Experimental

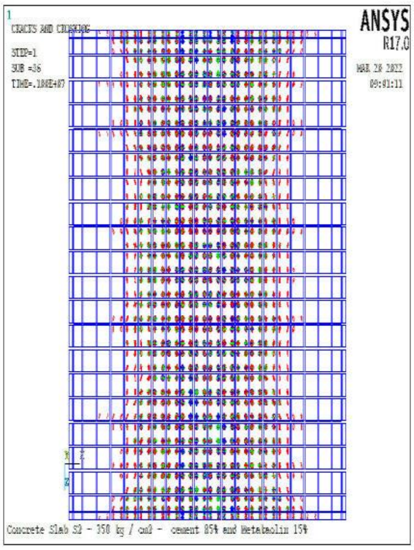


Figure 16 : crack (0-350) by Ansys

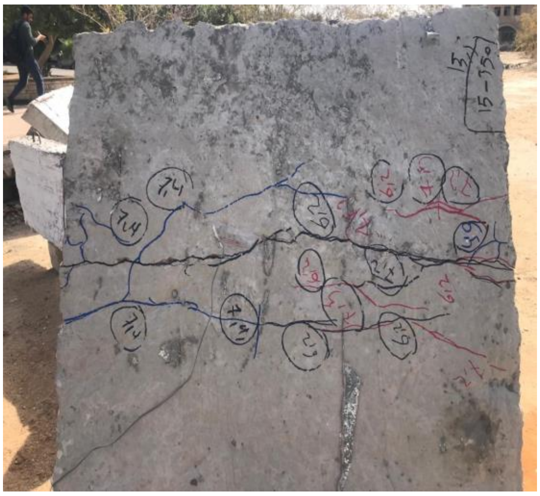


Figure 17 : crack (0-350) by Experimental

Value of strain on concrete:

Strain Concrete values were calculated from the top and bottom of the concrete slab These figures show the strain values on the concrete slabs at the tested values from (0-250),(15-250), (0-350) and (15-350).

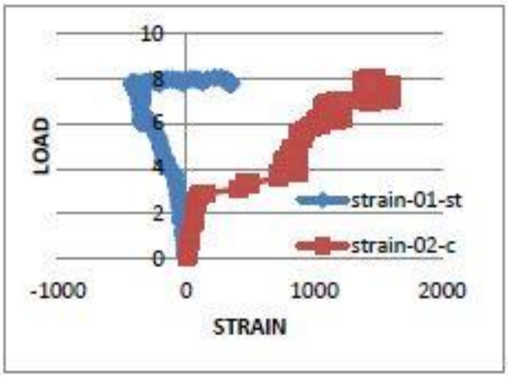


Figure 18 : strain (0-250) by Experimental

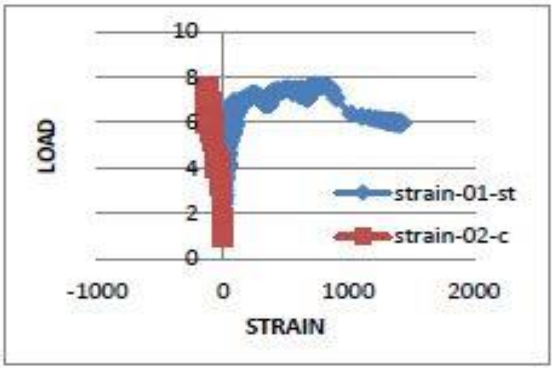


Figure 19 : strain (15 -250) by Experimental

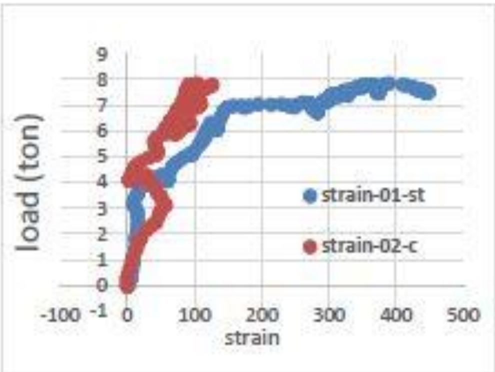


Figure 20 : strain (0-350) by Experimental

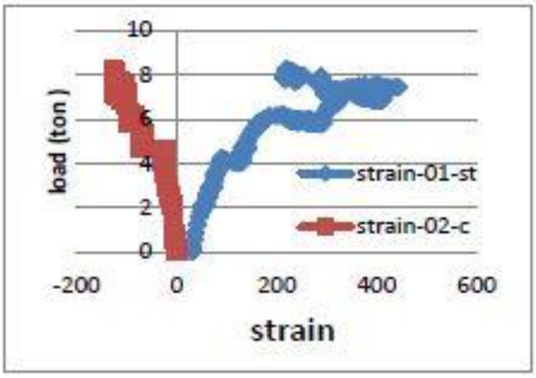


Figure 21 : strain (15 -350) by Experimental

4.1 Deflection analysis:-

- By using the data which is obtained from the finite element analysis (Ansys 17.0) for the slabs, it was concluded that increasing in values of load increases the value of deflection as shown in figures **(**9 to 12).

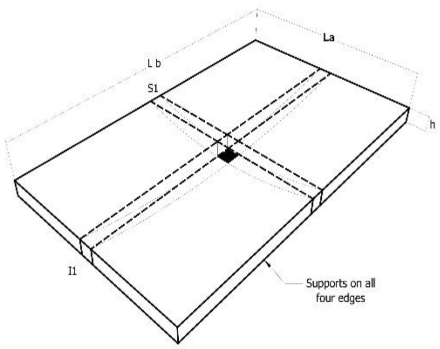
- And note that when the cement content increases, the value of the deflection decreases as shown in Table9.

- Also note that in the case of adding Metakaolin as a replacement material with cement it shows that its value of deflection decreases as shown in table 9.

Deflection of slabs:-

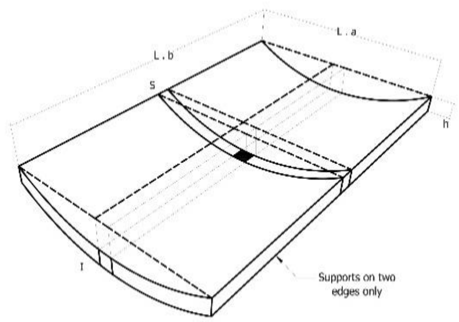
The exerted weight is only transferred in one direction using one-way slabs. Only the two opposite sides, as seen in Figure (1-a), may be supported. which essentially has a one-way structural action. The loads are carried perpendicular to the wall or supporting beams.

However, rectangular slabs frequently have such dimensions (for instance, rather deep, stiff monolithic concrete beams), which cause two-way action as depicted in figure (1-b). As the curves in both directions produce biaxial bending moments, they can occur anywhere. It is useful to conceive of these slabs as being made up of two sets of parallel strips, one in each direction, that cross each other. Therefore, one pair carries a portion of the load while the other is responsible for the remainder. [23,24,25]



(a)

Fig 1.1. (a) load transfer in one-way slab (Nilson)



(b)

Fig 1.1. (b) load transfer in two-way slab (Nilson)

A rectangular plate with spans la and lb is depicted in Fig. 1.1(b) as two center strips. Each strip behaves roughly like a single beam that is uniformly loaded by its proportion of w; w_a; and w_b for uniformly distributed loads of w per square foot of the slab. Their midspan

deflection must be the same because they are both a part of the same slab. center deflection of the short and long strips being equal

$$5w_a\, l_a^4 /384EI = 5w_b\, l_b^4 /384EI \rightarrow w_a / w_b = (l_b/la)^4 \qquad \ldots\ldots\ldots\ldots\ldots\ldots (1.1)$$

The load is therefore distributed more heavily in the shorter route. Inversely proportional to the fourth power of the ratio of the span is the ratio of the two halves of the load. For instance, wa/wb = 16 if lb/la = 2.

Because the maximum midspan deflection is (wl4 /192EI) for hinged-fixed ends and (wl4 / 384EI) for fixed-fixed ends, this proportion also depends on the support conditions in each direction. Thus, if lb/la = 2, the span la is simply supported, and around 14% of the weight is carried by the hinged-fixed span lb and 24% by the fixed-fixed span lb, respectively. In contrast, if the square slab is supported by lb, however, the slab is simply supported.

$$l_b /l_a = 1;\ \text{therefore Eq.(1.1)} \rightarrow w_a = w_b = w/2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots (1.2)$$

Therefore, if just bending exists, each slab's maximum bending moment would be

$$M_{max} = (w/2)\, l^2 /8 = 0.0625\, wl^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots (1.3)$$

Table 9: Max Load – Max Deflection

Model	Max Load (ton)	Max Deflection (mm)
Mix (0-250)	8.4	34
Mix (0-350)	9	29.5
Mix (15-250)	9.3	25
Mix (15-350)	10.05	18

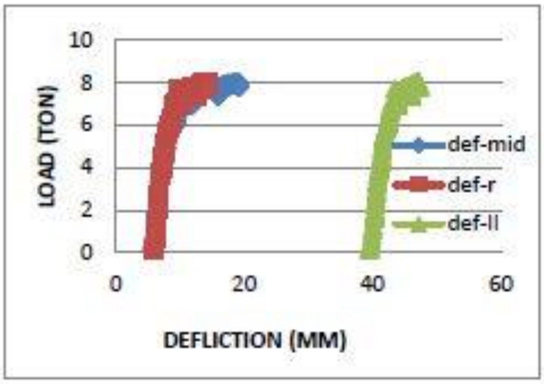


Figure 22: Deflection from Experimental

(Mix 0-250)

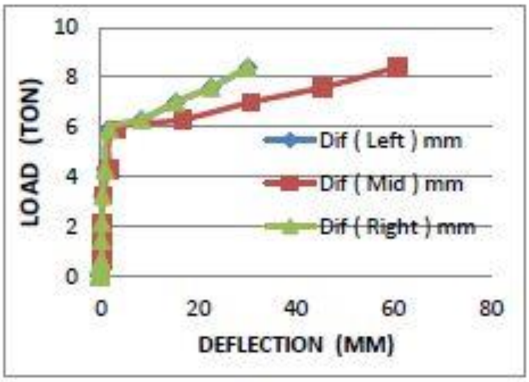


Figure 23 : Deflection from Ansys

(Mix 0-250)

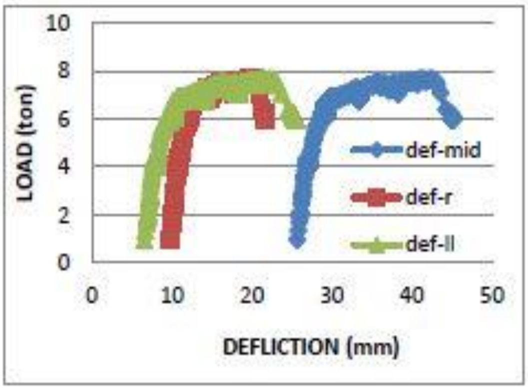


Figure 24: Deflection from Experimental

(Mix 15 -250)

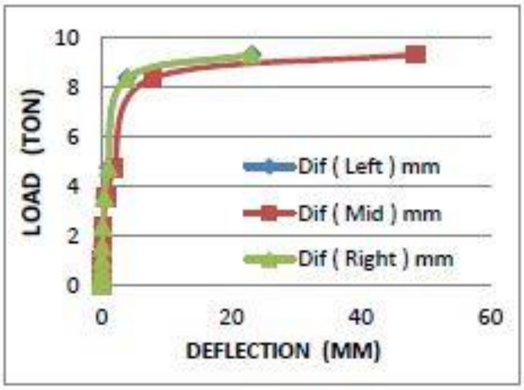


Figure 25: Deflection from Ansys

(Mix 15-250)

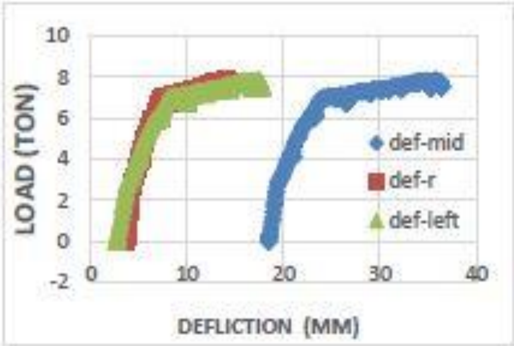


Figure 26 : Deflection from Experimental

(Mix 0-350)

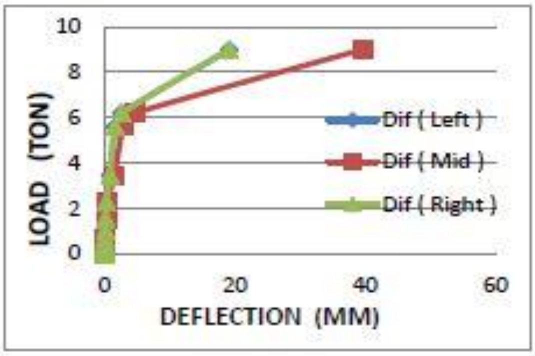


Figure 27: Deflection from Ansys

(Mix 0 - 350)

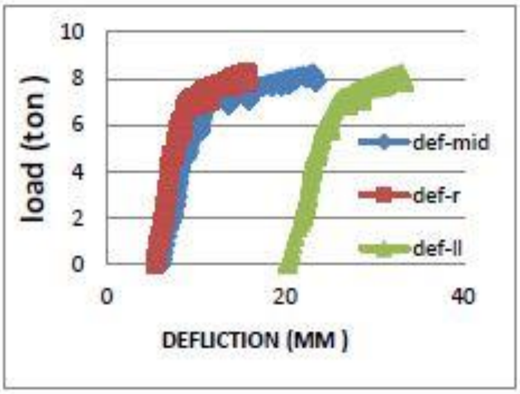


Figure 28: Deflection from Experimental

(Mix 15 -350)

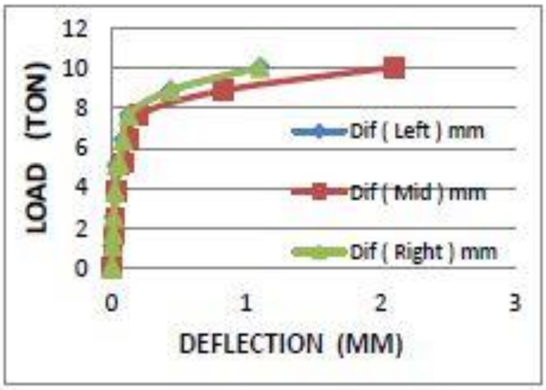


Figure 29 : Deflection from Ansys

(Mix 15 - 350)

By using the data obtained from the finite element analysis (Ansys 17.0) of the slabs and laboratory data, it was concluded that increasing the load values increases the deflection value. This is shown as Figures (22 and 23) ,(26 and 27) which are mixtures without addition.

4.2 Shape of Ansys Results: -

The Reinforced concrete slab was modeled by finite element method (ANSYS) V. 17.0 from ANSYS the different total deformation forms (0% - 250) and (15% -250) (fig 30, 31);

(0% - 350) and (15% - 350) (fig ,32,33)

And also, is the same strain and stress as we will see in (fig ,34,35,36,37,38,39,40,41)

respectively.

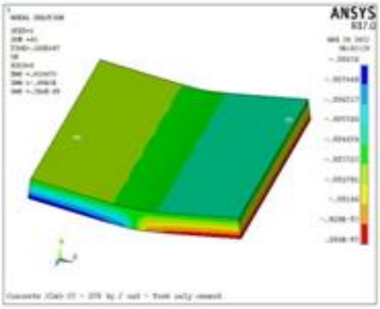


Figure 30: Displacement slab (0%-250)

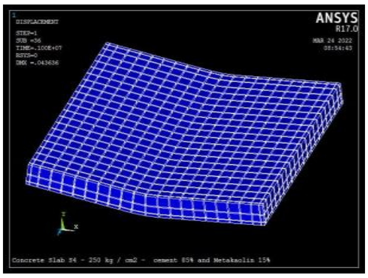


Figure 31: Displacement slab (15%-250)

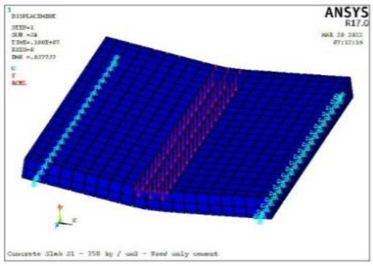


Figure 32: Displacement slab (0%-350)

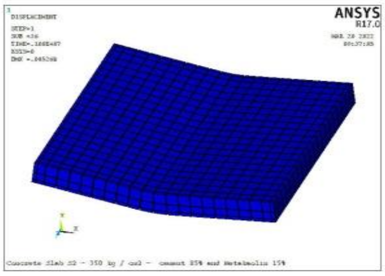


Figure 33: Displacement slab(15%-350)

Figure 34: Strain slab (0%-250)

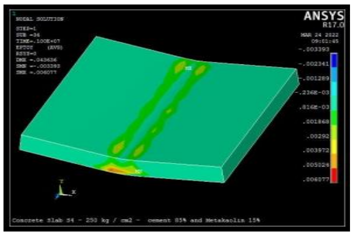


Figure 35: Strain slab (15%-250)

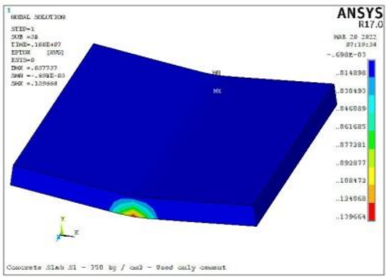


Figure36: Strain slab (0 %-350)

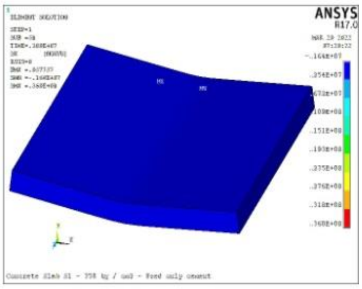


Figure 37: Strain slab (15%-350)

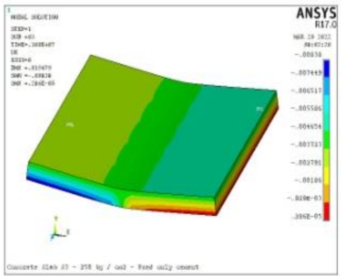


Figure 38: Stress Slab(0%-250)

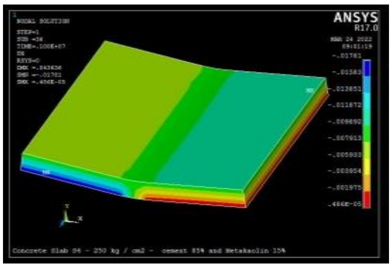


Figure39: Stress slab (15%-250)

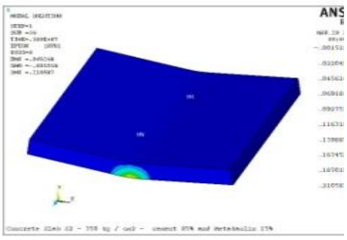


Figure 40: Stress slab (15%-250)

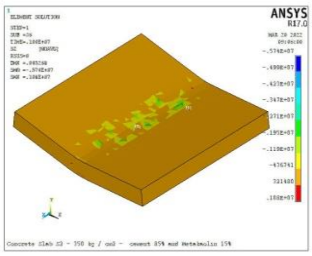


Figure 41: Stress slab (15 %-250)

5. Conclusions:

In the research, a reinforced concrete slab was analyzed using the finite element method.

The size of the load, the load-deflection, the stress, and the presence of cracks are the characteristics considered in this study. The following deductions can be made once the model has been assembled and examined:

1- The use of Metakaolin as a substitution of a percentage of the weight of the cement gives an increase in the resistance by a rate ranging from 17.22% to 25.2%.

2- The use of Metakaolin substitution in low resistors gives a better improvement rate than in high resistances

3- When compared to normal concrete, concrete that contains metakaolin significantly boosts compressive and flexural strength.

4- The workability of concrete decreases as the proportion of Metakaolin in concrete rises.

5- The strength of concrete rises with the addition of Metakaolin, up to 15% cement replacement.

6- The workability of concrete reduces as the percentage of Metakaolin powder in concrete increases.

7- The use of replacing a percentage of cement with Met kaolin results in early resistance.

CONFLICT OF INTEREST

The authors have no financial interest to declare in relation to the content of this article.

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