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THE EFFECT OF WASTE BRICK POWDER AS CEMENT WEIGHT REPLACEMENT ON PROPERTIES OF SUSTAINABLE CONCRETE

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Abstract: Construction and Demolition (C&D) waste constitutes a major portion of total solid waste production in the world. The main purpose of this research is to study the effect of addition of waste Yellow Clay brick powder (YCBP) on the behavior of concrete (C25) at both conditions; fresh and hardened on the mechanical properties of concrete through by using of different partial replacement of powdered brick with cement until 50 percent by weight (0% , 5% , 10% , 15% , 20% , 25% and 50%) and addition 10% of micro SF by weight replacement of cement to produce concrete and to reduce the impact on environment by consuming the material generally considered as waste product. The yellow clay brick was crushed and grinded manually and also sieve through 75µm sieve size in order to be fineness as cement. Cubes of size 150mm, Cylinders of size 300mm x 150mm and prisms of size 100mm x 100mm x 500mm were casted and tested, different ratios of waste CBP have been used to study its effect on the workability (slump flow), compressive strength and splitting tensile strength for 7, 14 and 28 days; and the modulus of rupture for 28 days. The results compared with the reference specimens and study the relationship between the mechanical properties of concrete. The addition was the use of waste as an alternative to cement and up to 10% with a slight decrease in the properties of concrete compared with ordinary concrete

Keywords: *Brick Dust, Waste clay bricks, Replacement, Construction and Demolition, Workability, Mechanical Strength.*

تأثير مسحوق مخلفات الطابوق كأحلال من وزن السمنت على خواص الخرسانة المستدامة

الخلاصة: تشكل مخلفات البناء والهدم جزءا كبيرا من إجمالي إنتاج النفايات الصلبة في العالم. الهدف الرئيسي من هذا البحث هو دراسة تأثير إضافة مخلفات طابوق البناء الاصفر الطيني كمسحوق (YCBP) على سلوك الخرسانة ذات الصنف (C25) في مرحلة الخرسانة اللينة و في مرحلة الخرسانة المتصلبة وتأثيرها على الخواص الميكانيكية للخرسانة من خلال أستخدام مسحوق مخلفات الطابوق بنسب أستبدال مختلفة من وزن الأسمنت في الخلطة الخرسانية (0%, 5%, 10%, 15%, 20%, 25% الى 50%) مع أضافة 10% من غبار مايكرو السليكا فيوم لإنتاج خرسانة مستدامة وتقليل التأثير على البيئة من خلال استهلاك المواد التي تعتبر عموما مخلفات البناء. تم تكسير و سحق مخلفات طابوق البناء ومن ثم طحنها وأستخدام المسحوق العابر من الغربال 75µm من أجل أن تكون نعومة المسحوق كنعومة الاسمنت. مكعبات خرسانية ذات مقياس 150 ملم، اسطوانات خرسانية بمقاس 300 ملم × 150 ملم ومناشير بمقاس 100 ملم × 100 ملم × 500 ملم تم صبها واختبارها بأستخدام نسب مختلفة من مخلفات الطابوق الطيني (CBP) لدراسة تأثيرها على قابلية التشغيل، مقاومة الانضغاط مقاومة الشد بعمر 7، 14 و 28 يوما؛ ومعامل الكسر بعمر 28 يوما. النتائج مقارنة مع العينات المرجعية ودراسة العلاقة بين الخواص الميكانيكية للخرسانة. تكمن أهمية البحث في أستخدام الفضلات الناتجة من الطابوق في أنتاج خرسانة عادية مما يساهم في تأمين البيئة من هذه المخلفات بالاضافة الى تقليص كميات السمنت المستخدمة في صناعة الخرسانة مما يقلل أيضا من أنبعاثات غاز CO_2

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الناتج من تصنيع السمنت . أما الاضافة التي أسهم فيها هي أستخدام الفضلات كبديل عن السمنت وبنسبة تصل الى 10% مع حدوث أنخفاض بسيط في خواص الخرسانة مقارنة مع الخرسانة العادية .

1. Introduction

Reduction of Portland cement without reducing performance of concrete is very important for huge projects that need a lot of cement. Today, pozzolana and cementitious materials plays an important role in concrete.

Wastes of industries and constructions which have pozzolanic or cementitious property, not only can reduce environmental pollution and energy consumption of construction industry, but also make it cheap.

According to some authors the best way for the construction industry to become a more sustainable one is by using wastes from other industries as building materials[1-3]. Around 850kg of CO_2 are emitted per ton of clinker produced [4].

Therefore, the replacement concrete by brick wastes represents a tremendous saving of energy and has important environmental benefits. Besides, it will also have a major effect on decreasing concrete costs, since the cost of cement represents more than 30 percent of the concrete cost.

The waste materials of clay bricks are usually come in different ways. Some are created in factories during and after the production process as a result of human mistakes, inappropriate materials, or a mistake in production process, some others are formed in transportation and distribution stage and finally a large part of waste materials are formed as a result of destroying buildings. The amount of waste materials may account to millions of tons annually.

Many researches were conducted to use waste clay brick materials in concrete industry, Swaroop. et.al.[5]; investigated the effectiveness on durability characteristics of concrete developed by using brick powder (BP) and quarry dust (QD) , In the backdrop of such a bleak atmosphere, there is large demand for alternative materials from waste. Secondary cementing materials like Brick Powder can be used to partially replace cement because of pozzolanic nature.

Materials like quarry dust best suites to sand due to its physical and chemical properties, fineness etc.

Also these materials are known to increase durability, resistance to sulphate attack and Alkali-Silica reaction(ASR). In their work, used different mixes of concrete considered are :

1. Conventional aggregate concrete (CCA)
2. Concrete made by replacing 10% cement BP…... (CBP10)
3. Concrete made by replacing 10% with BP and 10% QD…... (CB10Q10)
4. Concrete made by replacing 10% with BP and 15% QD…..(CB10Q15)
5. Concrete made by replacing 10% with BP and 20% QD…..(CB10Q20)
6. Concrete made by replacing 15% cement with BP..…(CBP15)
7. Concrete made by replacing 15% with BP and 10% QD…..(CB15Q10)
8. Concrete made by replacing 15% with BP and 20% QD…..(CB15Q20)

9. Concrete made by replacing 15% with BP and 30% QD…..(CB15Q30)

Their result showed that the brick powder (BP) and quarry dust (QD) For all types of mixes considered always an increase in strength is seen for both 7, 28 & 120 days curing.

Usha Rani, et al[6]; aimed to investigate the suitability of using crushed brick in concrete. Crushed brick originated from demolished masonry was crushed in the laboratory and added partial sand replacement. Three replacement levels, 15%,20% and 25%, were compared with the control.

The tests on concrete showed that the mechanical properties (compressive, flexural and splitting tensile strengths) of concrete containing crushed brick were well comparable to those of the concrete without ground brick.

The main focus of the research is to present additional information in the field of recycling clay masonry rubbles in order to explore the possible uses of these recyclable materials in structural applications.

Naceria, et al.[7]; showed that the quantity of pozzalanic admixture (waste brick) of cement manufactured is the principal parameter who influences on the variation of the physic-chemical properties of the cement tested.

This paper presents a preliminary study on the assessment of the pozzolanic activity of waste bricks powder as well as its potential use in concrete as a partial replacement of cement.

A series of tests were conducted to study the pozzolanic activity and the compressive strength tests were to monitor the strength development of the concrete at different ages containing from 5 to 50 percent bricks powder as cement replacement.

The other objective is to reduce the cost of construction but also helps to reduce the impact on environment by consuming the material generally considered as waste product.

2. Experimental Program

2.1. Materials Used

2.1.1. *Cement*

Ordinary Portland cement (OPC) type (I) manufactured at northern cement factory Bazian, Al-Sulaimaniya / Iraq with the trademark of (Al-mass) has been used in this investigation.

Tables (1) and (2) show the chemical composition and main compounds, and physical properties of the cement used throughout this work respectively.

The test results show that the used cement conforms to the requirements of the Iraqi Standard Specification (I.O.S No.5/1984-Type I)[8].

Table (1) Chemical Composition and main compounds of Al-mass ordinary Portland cement used throughout this work *

Oxide Composition	***% by weight***	***Limits of Iraqi specification No.5:1984[8]***
Silica Dioxide (SiO_2)	21.61	-
Lime (CaO)	64.23	-
Magnesia Oxide (MgO)	2.28	<5.0
Iron Oxide (Fe_2O_3)	3.30	-
Alumina Trioxide (Al_2O_3)	4.97	-
Sulphate (SO_3)	2.65	<2.8
Loss on ignition (L.O.I)	1.90	<4.0
Insoluble residue (I.R)	0.85	<1.5
Lime saturation factor (L.S.F)	0.909	0.66 – 1.02
Main Compounds (Bogue′s equation) %by weight of cement		
Tricalcium Silicate (C_3S)	51.510	-
Dicalcium Silicate (C_2S)	23.182	-
Tricalcium Aluminate (C_3A)	7.593	-
Tetracalcium Alumino-Ferrite (C_4AF)	10.032	-

* The chemical composition tests was made by National Center for Construction Laboratories (NCCL) / Central Baghdad Laboratory

Table (2) Physical Properties of Al-mass Ordinary Portland Cement used throughout this work *

Physical Properties	***Test result***	***Limits of Iraqi specification No.5:1984[8]***
Fineness (m^2/kg) by Blaine method	335	≥ 230
Setting time (Vicat′s method)		
Initial setting (min)	150	≥ 45 min
Final setting (hrs.)	4:40	≤ 10 hrs
Compressive strength for cement mortar cube (70.7)mm at, MN/m^2		
3 days	30.0	> 15
7 days	39.5	> 23
Soundness using Auto clave%	0.03	< 0.8

* The chemical composition tests was made by National Center for Construction Laboratories (NCCL) / Central Baghdad Laboratory

2.1.2. *Clay brick powder*

The waste clay bricks (WCBs) used in the investigation were taken from the building. The WCBs were converted into the same size of aggregates, then, the products were placed inside the impact crusher, after that, ground and softening the products to different average particle size were converted into fine powder.

After grinding, which has been sieved and grains passing through 75micron was the primary material used, Fig.(1 & 2). The waste clay bricks types used derived from a variety of sources in Iraq, and are referred to as Yellow Clay Brick (YCB).

The chemical compositions of Yellow clay brick powder (YCBP) was analyzed and results obtained are reported in Table 3.

Plate 1. Step's of crushing and grounding the WCBs

Plate 2. Step's of sieving and grains passing through 75µm

Table (3): The chemical composition of CBP* (wt.%)

Composition	*YCBP*
SiO_2	*40.60 %*
Al_2O_3	*12.00 %*
Fe_2O_3	*4.93 %*
CaO	*28.10 %*
Na_2O	*1.30 %*
K_2O	*0.87 %*
MgO	*5.16 %*
TiO_2	*0.56 %*
P_2O_5	*0.17 %*
SO_3	*5.31 %*
L.O.I	*1.21 %*

* The chemical composition tests were made by the Central Laboratories Department for Iraq Geological Survey

2.1.3. *Micro silica fume*

Silica fume (SF) has been used as an artificial pozzolanic admixture that is effective in improving the mechanical properties significantly. The American Concrete Institute ACI234R-96[9] defines silica fume as "very fine non-crystalline silica produced in electric arc furnaces for silicon or alloys containing silicon". Silica fume or microsilica (very fine amorphous silica particles < 1µm) used throughout this research is commercially known as partial replacement of cement weight. Tables (4&5) illustrate the composition and properties of microsilica fume according to manufacturer editions and was chemical composition test carried out by the Central Laboratories Department for Iraq Geological Survey. The results show that silica fume used satisfies the requirements of ASTM C1240[10].

Table (4) Physical properties and requirements of silica fume *

Physical properties	*Results*	*Limit of Specification Requirement (ASTM C1240)[10]*
Colour	Grey to medium grey	
Specific surface area (m^2/kg)	22000	≥ 15000
Strength active Index with Portland cement at 7 days, min. percent of control	122	≥ 105
Percent retained on 45µm (No.325), max,%	8	≤ 10

*from manufacturer label

Table (5) chemical properties of silica fume *

Oxides composition	Abbreviation	Oxide Content (%)	Limit of Specification Requirement (ASTM C1240)[10]
Silica	SiO_2	93.03	85.0 (min)
Alumina	Al_2O_3	< 0.04	-
Iron oxide	Fe_2O_3	0.05	-
Lime	CaO	1.38	-
Sodium oxide	Na_2O	0.21	
Magnesia	MgO	0.35	-
Titanium dioxide	TiO_2	< 0.01	
Sulfate	SO_3	0.55	-
Phosphorus pentoxide	P_2O_5	0.19	
Potassium oxide	K_2O	1.09	-
Loss on ignition	L.O.I.	3.37	6.0(max)

* The chemical composition tests was made by and Central Laboratories Department for Iraq Geological Survey for Iraq Geological Survey

2.1.4. *Fine aggregate*

From Al-Ukhaider region, Karbalaa-Iraq, natural sand is used in this study which has fineness modulus of (3.18) and specific gravity (2.63). The grading of the fine aggregate was checked according to Iraqi Standard Specification (No.45: 1984)[11]. Table (6) shows the sieve analysis of fine aggregate. Table (7) shows the physical properties of the fine aggregate that are performed by National Center for Construction Laboratories (NCCL) / Central Baghdad Laboratory

Table (6) Sieve analysis of fine aggregate (Zone 2)

Sieve size mm	*% passing by weight*	*Limits of Iraqi standard specification No. 45:1984[11] (Zone 2)*
10	100	*100*
4.75	92	*90-100*
2.36	75	*75-100*
1.18	56	*55-90*
0.6	38	*35-59*
0.3	16	*8-30*
0.15	5	*0-10*
Pan	0	-

Table (7) Physical properties of fine aggregate

Physical properties	*Test result*	*Limit of Iraqi specification No.45:1984*[11]
Specific gravity	2.63	-
Sulphate content as SO_3	0.194%	0.5% (max)
Fineness modulus	3.18	
Fine materials passing from sieve (75µm)	2.2%	5% (max)
Dry rodded density kg/m^3	1715	-
Absorption	2%	
Moisture content	1.4	

2.1.5. *Coarse aggregate*

Natural crushed coarse aggregate of maximum size 10 mm was used in this research. It was brought from AL–Badrah region. The gradation, specific gravity, density and sulphate content were tested. The properties of natural coarse aggregate used are show in Tables (8,9). The results demonstrate that the grading and sulphate content of the coarse aggregate conform to the requirements of Iraqi Standard No. 45/1984[11].

Table (8) Sieve analysis of natural coarse aggregate*

Sieve size mm	*% passing by weight*	*Limits of Iraqi standard specification No. 45:1984[11]*
20	100	*100*
14	99	*90-100*
10	86	*50-85*
5	4.1	*0-10*
2.36	-	-

* The Sieve analysis tests was made by Construction Material Laboratory / Faculty of Engineering for Iraq Geological Survey

Table (9) Physical properties of natural coarse aggregate*

Physical properties	*Test result*	*Limit of Iraqi specification No.45:1984*[11]
Specific gravity	2.65	-
Sulphate content as SO_3	0.034%	$\leq$ 0.1%
Fine materials passing from sieve (75µm)	0.4	-
Compacted bulk density kg/m^3	1575	-
Absorption	0.7%	-

* The Physical properties tests was made by National Center for Construction Laboratories (NCCL) for Iraq Geological Survey

2.1.6. *Water*

The water used in the mix preparation and curing the specimens of concrete for 7,14 and 28 days was potable water from the water-supply network system (tap water).

2.2. *Concrete Mix Design*

A reference mix was made with ordinary Portland cement (a concrete without waste brick powder material), and proportioned according to the ACI 211.1-91[12] . The specified minimum compressive strength at 28 days for this mix was 25 MPa. Many trial mixes were adopted to check the required properties and accurate amount of W/B ratio. In order to achieve the scope of this study, six types of sustainable concrete mixes were used in the present research as listed in Table (10). The variables used in these mixes were type of pozzolana material. At the beginning of the mixture design, binder content 400 kg/m^3, fine aggregate content was 600 kg/m^3, coarse aggregate content was 1200 kg/m^3 and water content was 200 l/m^3. The proportion of these components by weight is (1:1.5:3) and w/c ratio is (0.5) were chosen as constant. Concrete mixes were made with waste bricks powder replacing 5, 10, 15, 20, 25 and 50 percent with addition 10% micro SF by weight of the cement as pozzolana and with the same amount of aggregates and water as in the reference.

Table (10) Samples name and composition

Abbreviation	*Cementitious materials percent*			*Cementitious materials weight (kg/m^3)*		
	Cement	Pozzolana		Cement	Pozzolana	
		CBP	microSF		CBP	microSF
OPC-NC	100	0	0	400	0	0
YCBP5SF	85	5	10	340	20	40
YCBP10SF	80	10	10	320	40	40
YCBP15SF	75	15	10	300	60	40
YCBP20SF	70	20	10	280	80	40
YCBP25SF	65	25	10	260	100	40
YCBP50SF	40	50	10	160	200	40

The concrete mixtures were mixed in accordance with ASTM C192. And workability of the fresh concrete was measured with a standard slump cone, slump test fulfilled according to ASTM C143[13]. The interior of the drum was initially washed with water to prevent absorption.

The coarse and fine aggregate were mixed first, followed by addition of the cement and pozzolan (YCBP) with 10% microSF and water containing required amount. With each mix, control specimens are prepared to determine the mechanical properties of the hardened concrete at 7,14 and 28 days. Control specimens involve 9 cubes (150)mm for compressive strength measurement, 21 cylinders (150×300)mm for compressive strength measurement, splitting tensile strength, and 1 prism (100×100×500)mm for flexural strength (modulus of rupture).

3. Fresh and Hardened Properties Tests of SC-YCBPSF

The different tests were conducted in the laboratories as shown in below. It consists of mixing of concrete by partial replacing cement with proportions (by weight) of waste yellow clay brick powder (YCBP) added to concrete mixtures were as follows: 0% (for the control mix), 5%, 10%, 15%, 20%, 25% and 50% with addition 10% micro SF Concrete samples are tested, to evaluate the concrete fresh and harden properties like Workability, Compressive strength, Split tensile strength and Flexural strength requirements.

3.1. *Workability of Concrete (Slump Test)*

The workability of all concrete mixes was measured immediately after mixing in accordance with test method of ASTM C143/ C143M [13]

Table (12) Measured values of Concrete Workability

MIx	*% of YCBP replacement*	*Slump value (cm)*
NC-OPC	0	11.1
SC-YCBP5SF	5	6.9
SC-YCBP10SF	10	5.7
SC-YCBP15SF	15	4.7
SC-YCBP20SF	20	3.8
SC-YCBP25SF	25	3.1
SC-YCBP50SF	50	2.6

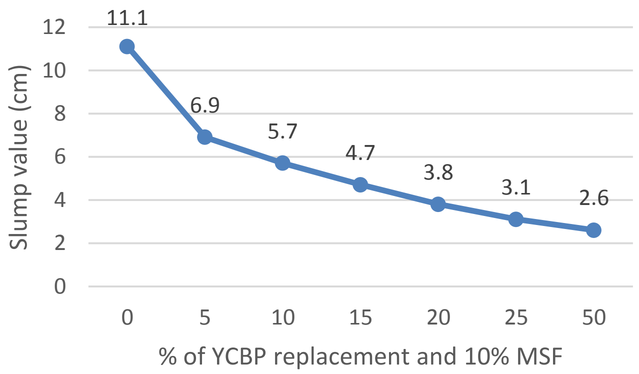

Figure (1) Effect of different YCBP percentage on the concrete workability after addition 10% micro SF

Figure (1) shows the relationship between the waste yellow clay brick powder and the slump test value of the sustainable concrete mix with added 10% MSF. According to the results obtained, when addition 10% of MSF from the cement weight in the sustainable concrete mix with YCBP replacement, the results show, from table (12), the workability of Green concrete at fresh state are more decrease about (37.83%, 48.64%, 57.65%, 65.76%, 72.07% and 76.57%) respectively when replacing (5%, 10%, 15%, 20%, 25% and 50%) of YCBP from the cement weight.

3.2. *Compressive Strength Test*

Standard cubes (150)mm are used according to (B.S 1881: part116[14]), are casting and testing to determine the compressive strength at 28 days. The machine used in the test is hydraulic compression machine of 2000 kN capacity. The average of three specimens at age of 28 days is used to determine the compressive strength for the NC as well as the partial and fully replacement mixes, as shown in figure (2).

Table (13) Average compressive strength in ages 7,14 and 28 days

Mix	% of YCBP replacement	*Compressive strength (MPa)* 7 days	14 days	28 days
NC-OPC	0	20.5	24.26	30.11
SC-YCBP5SF10	5	22.22	25.30	31.40
SC-YCBP10SF10	10	20.69	23.26	27.35
SC-YCBP15SF10	15	19.25	21.92	24.90
SC-YCBP20SF10	20	17.39	19.88	21.86
SC-YCBP25SF10	25	15.06	18.57	18.45
SC-YCBP50SF10	50	11.55	15.68	14.71

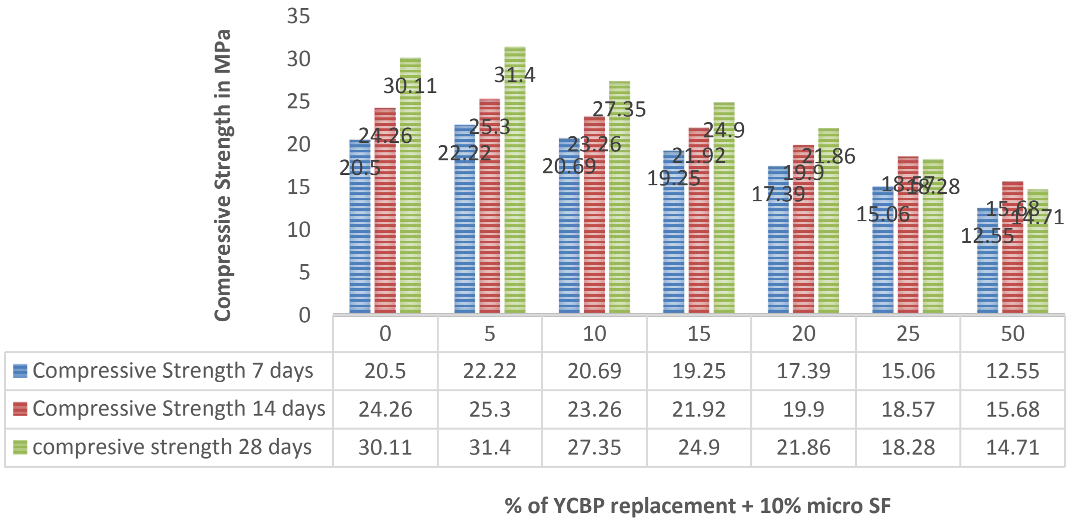

Fig.2 Average compressive strength with % of YCBP replacement

Figure (2) shows the relationship between compressive strength for OPC-NC (reference mix) and the weight replacement ratio of OPC by waste yellow clay brick powder.

According to the results obtained, the results show, When addition 10% of micro silica fume from the cement weight in the sustainable concrete mix with YCBP replacement, the compressive strength development of concrete increase in 7 days curing about (8.39%, 0.93%) respectively when replacing (5% and 10%) of YCBP and that strength decreasing about (6.09%, 15.17%, 26.53% and 43.65%) respectively when replacing (15%, 20%, 25% and 50%) of YCBP from the cement weight, but the compressive strength increase to (4.28%) when replacing 5% of YCBP and decrease about (9.16, 17.30, 27.39, 39.28 and 51.14) percent in 28 days curing respectively for replacing (10%, 15%, 20%, 25% and 50%) from the cement weight in the concrete mix by YCBP with MSF .

3.3. *Splitting Tensile Strength Test*

The splitting tensile strength test was carried out according to the ASTM C496/C496M[16]. Cylinders with the dimensions of d=150mm, h=300mm were prepared according to ASTM C192. This test is carried out by placing a cylinder specimen horizontally between the loading surfaces on a hydraulic compression testing machine of 2000 kN capacity and the load is applied until failure of cylinder along the vertical diameter as shown in figure (3). Three cylinders were tested for each batch at the age of 7, 14 and 28 days, and an average value of the splitting tensile strength was obtained, as shown in table (14), by using the following equation:

Table (14) Average splitting tensile strength in ages 7,14 and 28 days

		Splitting tensile strength (MPa)		
Mix	% of YCBP replacement	7 days	14 days	28 days
NC-OPC	0	2.197	2.82	3.28
SC-YCBP5SF10	5	2.36	2.927	3.38
SC-YCBP10SF10	10	2.166	2.645	3.225
SC-YCBP15SF10	15	1.924	2.292	2.94
SC-YCBP20SF10	20	1.605	2.06	2.73
SC-YCBP25SF10	25	1.414	1.697	2.433
SC-YCBP50SF10	50	0.93	1.08	1.39

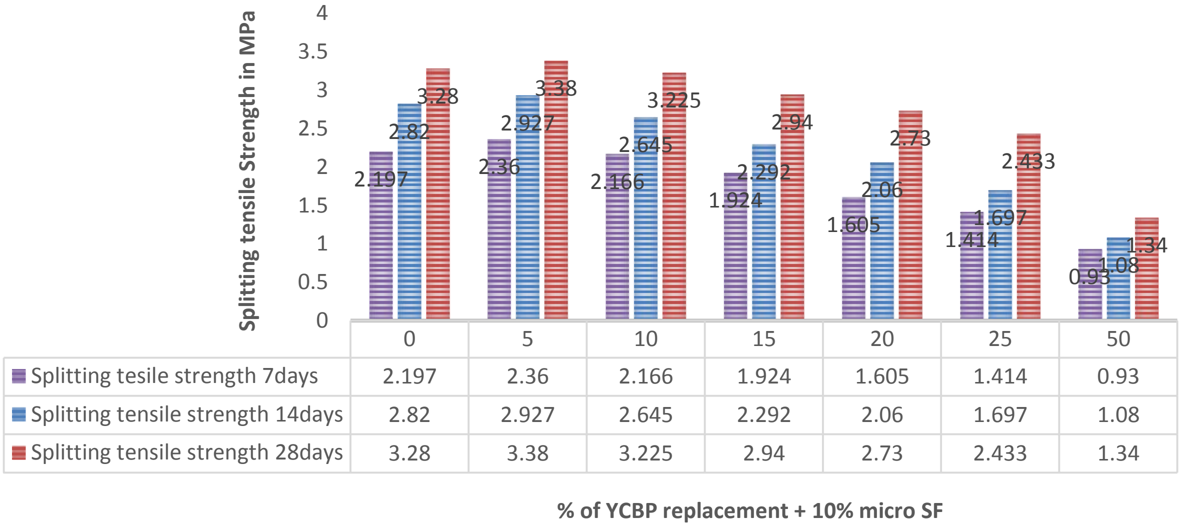

Fig. (3) Average splitting tensile strength with % of YCBP +10% SF replacement

$$f_{sp} = \frac{2P}{\pi d L} \quad \dots\dots\dots \quad (1)$$

where:
f_{sp}= Splitting tensile strength (MPa)
P = Maximum applied load (N)
d = Diameter of the cylinder (mm)
L = Length of the cylinder (mm).
From table (14) and Fig.(3), the reduction of splitting tensile strength with presence of YCBP due to the effect of bond strength between the cement and YCBP in the concrete mix and the weakness of yellow clay brick which entirely made up of concrete.

3.4. *Modulus of Rupture Test*

The flexural strength (modulus of rupture) test is performed according to ASTM C78-02[17] on prismatic specimens of (100×100×500)mm were cured in water and tested at 28 days, with four point loading using a hydraulic testing machine (ELE) of 50 kN capacity, the results as shown in table (15) and fig.(4)
The modulus of rupture is calculated, as follows:

$$f_r = \frac{PL}{bh^2} \quad \dots\dots\dots \quad (2)$$

where:
f_r= modulus of rupture (MPa)
P= maximum applied load (N)
L= distance between the support
(span length) (mm)
b= width of prism (mm)
h= depth of prism (mm)

Table (15): Modulus of Rupture value in MPa

% of YCBP replacement	*Modulus of Rupture MPa*
0	4.635
5	5.04
10	4.88
15	4.23
20	3.42
25	2.47
50	2.01

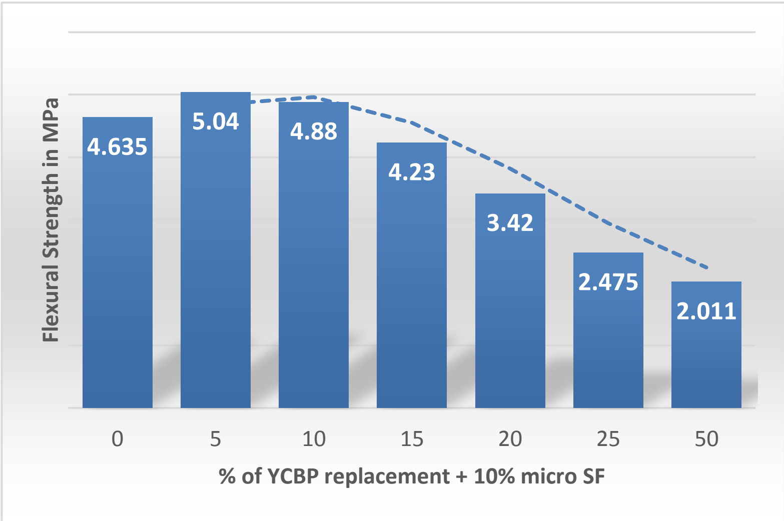

Fig. (4) : Modulus of rupture with % of YCBP replacement

Table (15) and figure (4) shows a comparison of the flexural tensile strength for normal concrete mix and the type of concrete included YCBP with 10% MSF mixes. The comparison between flexural strength values for sustainable concrete with YCBP with a combination of normal concrete, shows that the flexural strength of the YCBP concrete specimen is more decreased when replacement 50% YCBP from the cement weight. This is attributed to the lower tensile strength of YCBP and the weaker bond between YCBP and cement matrix.

4. Conclusions

Based on the results obtained from experimental work for normal and sustainable concrete with (YCBP) and 10% MSF, in this study that waste bricks can be used until 50 percent as a replacement of cement in concrete, besides to their corresponding cubes, cylinders and prisms specimens, the conclusions can be illustrated below:

1. When addition 10% of MSF from the cement weight in the sustainable concrete mix with YCBP replacement, the results show, the workability of concrete at fresh state are more decrease about (37.83%, 48.64%, 57.65%, 65.76%, 72.07% and 76.57%) respectively when replacing (5%, 10%, 15%, 20%, 25% and 50%) of YCBP from the cement weight as compared with reference mix.
2. When addition 10% of MSF from the cement weight in the sustainable concrete mix with YCBP replacement, the results show, the compressive strength development of concrete increase in 7 days curing about (8.39%, 0.93%) respectively when replacing (5% and 10%) of YCBP from the cement weight and that strength decreasing about (6.09%, 15.17%, 26.53% and 43.65%) respectively when replacing (15%, 20%, 25% and 50%) of YCBP from the cement weight, but the compressive strength increase to (4.28%) when replacing 5% of YCBP and decrease about (9.16, 17.30, 27.39, 39.28 and 51.14) percent in 28 days curing respectively for replacing (10%, 15%,

20%, 25% and 50%) from the cement weight in the concrete mix by YCBP with MSF. The results shows that there is slight decrease in compressive strength of the mixes (5% and 10%) as compared with reference mix.

3. The results show that the developing of splitting tensile strength with age for YCBP containing 10% MSF from cement weight compared with reference concrete. The percentage of increase in splitting tensile strength in 7 days curing is (7.41%) when replacing (5%) of YCBP and that strength decreasing about (1.41, 12.42, 26.94, 35.63 and 57.67) percent respectively when replacing (10%, 15%, 20%, 25% and 50%) of YCBP from the cement weight, but the splitting strength increase to (3.04%) when replacing (5%) of YCBP and that strength decreasing about (1.67, 10.36, 16.77, 25.82 and 59.14) percent in 28 days curing respectively for replacing (10%, 15%, 20%, 25% and 50%) in the concrete mix by YCBP with 10% MSF relative to the reference concrete specimen. The results also shows the same trend as mentioned above in point (2) especially in samples tested at 28days.
4. The results of sustainable concrete containing YCBP indicate that the inclusion of 10% MSF shows increase in flexural strength compared with reference concrete. The percentages of increase in flexural strength for concrete mix are (8.73% and 5.28%) when replacing (5% and 10%) of YCBP respectively relative to reference concrete NC. This is due the action of micro silica that arrested the cracks, and that strength decreasing about (8.74, 26.21, 46.60 and 56.62) percent in 28 days curing respectively for replacing (15%, 20%, 25% and 50%) from the cement weight in the concrete mix by YCBP with MSF relative to the reference concrete specimen.
5. The concrete can be produce by using the 10% replacement of cement, which is giving the same mechanical properties of reference concrete.

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