Study the Effect of Partial of Replacement of Industry Cement Waste with Sand on Mechanical and a Partial Property of Concrete and Mortar

Khuld Ahmed Jasim Al Baity

Babylon Laboratory, National Center of construction Laboratories

KholdAlbaity@gmail.com

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Abstract

The technical and economic problems that arise from transportation industry cement waste outside the cement plant ,as well as the sever pollution of the surrounding environment by this waste ,make the subject matter worth studies .This study was thus conducted to examine the feasibility of using industry cement waste in concrete and mortar mixes as partial replacement for sand. The percentage of industry cement waste replacement used from 5% and 30% in mortar and concrete respectively .The presence of industry cement waste as sand partial replacement increases the compressive strength of relatively lean mixes, especially at early age ,while adversely effects the strength of rich mixes .The inclusion of 25% of industry cement waste by weight of sand in lean mixes, improvement in compressive strength by about 30% and 20% in concrete and mortar for 7 days respectively. The effect of replacing industry cement waste (ICW) as a sand partial on the compressive strength of concrete and mortar mixes of resistance Portland cement higher than ordinary Portland cement where discussed by several authors. Other concrete properties including modulus of rupture and density show trend similar to that observed in compressive strength.

Keyword: - (ICW), Industry Cement Waste, Concrete, Mortar.

1- Introduction

In recent years, considerable researches have been focused on solving environmental problems by the reduction of industrial wastes. Studies have been carried out to investigate the possibilities of using industrial wastes such as fly ash, blast furnace slag, silica fume, cement kiln dust and other wastes

The use of waste and by product materials in the construction industry may help to conserve recourses of the natural raw materials that are used in the industry, and at the same time, can help to preserve the environment by reducing the disposal of same waste materials.

These wastes have been mainly used for same time as filler in roads and embankments, but the energy saving aspect of the utilization of industrial wastes as a concrete ingredient of special significance. Therefore, many wastes and by – products were found to have potential use in concrete industry.

2- Literature Review

The use of ICW in the manufacture of concrete was studied in some earlier experimental works as partial replacement of fine aggregate:

[18] Have investigated the properties of concrete and mortar when ICW was used as a partial and full replacement for fine aggregate.

In this investigation. different mix proportion were used for the concrete and mortar, with percentages of replacement of 0, 25,50,75 and 100 by weight of fine aggregate, the water – cement ratio for each mix proportion was kept constant.

The results showed that the workability of the mixes decreased with increasing ICW Content, especially at high levels of replacement. On the other hand, the 28 days compressive strength decreased with the increase in percentage addition of ICW. The total replacement of fine aggregate by ICW significantly reduced the compressive strength of both concrete and mortar at all mix proportion. However, the reduction magnitude in the compressive strength at the total replacement was about 53 and 69 percent in cement mortar and concrete respectively.

It was reported that ICW up to 25 percent do not significantly affect the workability and compressive strength and therefore up to this level, the fine aggregate could be replaced by ICW in cement mortar and concrete.

[3] Reported it can be seen that the sulphur trioxide and alkali contents of ICW are greater than those of cement. Sulphur trioxide is originated from the clay of raw material and fuel used in cement burning while the source of alkalis in ICW is both the raw materials and fuel.

[4] , [5] and [15] reported by some previous studies the properties of ICW vary from cement plane to another depending on great part on the cement making process and quality of the raw material . The chemical analysis of ICW is shown in Table (1) for the purpose of comparison, typical composition of resistance Portland cement other waste materials having cementious properties such as fly ash and blast furnace slag are included in this table [1].

[2] Reported the geological and physical properties of ICW are shown in Tables (2) and (3) respectively.

Industry Cement Waste

Industry cement waste (ICW) is affine powdery waste generated during the manufacture of Portland cement. As the raw materials for making cement are heated and tumbled in kiln, dust particles are created and carried with hot exit gases.

To control the dust from escaping into the environment, most of cement plant equipment are working to collect large volumes of dust from the exit gases before they are discharged to the atmosphere [6]. This dust is collected by using mechanical collectors or electrostatic precipitators.

The percentage of ICW wasted in cement manufacturing process is (15-20) percent of the out of the kiln, since the chemical components of ICW are nearly the same as the cement raw materials, some of ICW can be recycled into the kiln [16], however, large quantities of ICW are disposed.

There is a great deal of variation between different sources of ICW. The major variables affecting ICW quality are the composition and proportion of the feed materials, type of the kiln, fuel, processing efficiency and the type of the dust collection system [2].

[8] Neville, silt and f ne dust should not be present in excessive quantities because owing to their fineness and therefore large surface area, silt and fine dust increase the amount of water necessary to wet all the particles in the mix.

[17] Has reported that increasing the dust content from 10 to 25 present resulted in only small decrease in the compressive strength of the concrete.

[16] They noticed that up to a level of 15 percent the compressive and flexural strengths increases with the increasing the percentages of the fine materials.

[19] It was reported that ICW could be used in constructions industries by up to 20 % as sand replacement without detrimental effect on the performance of concrete and mortar.

3-Experimental work

The experimental tests of current research are conducted to support and verify the statically approach followed in this study.

3.1 Industry Cement Waste and Cement Test

ICW and cement used in this study was supplied by Karbala Cement factory .The physical and chemical analyses are shown in Table (4). Karbala Cement factory manufactured resistance Portland cement which conforming The Iraqi specification (IQS: 1984) are shown in Table (5).

3.2 Concrete Mixes.

Two control mixes of 1:2:4 and 1:1.5:3 (cement: sand: gravel), ICW was used as sand replacement; the workability of concrete mixes used in this study was measured by slump test and as shown in Table (12).w/c ratio were adjusted to have workable mixes with constant slump when compared with control mix. The properties of sand and gravels shows in Tables (10) and (11).

3.3 Mortar Mixes

Two types of control mixes were also made which have cement: sand ratio of 1:2 and 1:3. ICW was used as sand replacement, the w/c ratio were adjusted to maintain a constant flow when compared with control mix.

3.4 Compressive Strength Test Result of Concrete

The compressive strength data obtained at age of 7,28 and 90 days are shown in Table(6) and plotted in Figs (1), (2), (3) and (4) using (150,150,150)mm cube.

3.5 Modulus of Rupture Test Results of Concrete

The modulus of rupture test results of all mixes at the age of 28 and 90 days are presented in Table (7) and plotted in Figs (5) and (6). Using (100,100,400) prisms.

3.6 Density Results

The concrete density for 28 days are presented in Table (8) and plotted in fig (7).

3.7 Mortar Compressive Strength Test Results

The compressive strength test result are shown in Table (9) and plotted in Figs (8), (9), (10) and (11) Using (70.7x70.7) mm cube.

4- Discussion

The results indicate that when is used the water demand to produce the same workability for 1:1.5:3 and 1:2:4 mix is a function of the percentage of ICW used and increases with the increase in ICW content. It can be noticed that up to 25% and 15% ICW for 1:2:4 and 1:1.5:3 mixes respectively ,the water demand is slightly higher than that of the control mix, such demand increases rapidly when more than these percentage of ICW is used.

This increase could be due to the increase in the proportion of the fine particles in the modified mixes [4]. However, excessive quantities of fine dust causes an increase in the surface area of particles which will result in an increase in the amount of water required to wet the particles [8].

Figs(1), and (2) shows an improvement in the compressive as the ICW percentage is increased ,especially at the early age 7 days, beyond 25% ICW replacement by sand, the strength at all ages started to decrease .However, the best strength has been achieved at 1:2:4 mix which has 25% of ICW. The increase in compressive strength is 30 and 12 percent for 7 and 28 days respectively .The increase in compressive strength is probably due the filler effect of fine materials in ICW. However, the addition of fine materials as an admixture by replacing equal quantities of fine aggregate ,increases the compressive strength of concrete , especially at the early ages [9] and [10]

For1:1.5:3 mix shows that up 15%of ICW replacement the compressive strength is generally enhancement decrease comparable than that the control mix, beyond 25%of ICW the strength at all ages started to decrease rapidly .It can be stated that, at a larger content of ICW, the loss in compressive is due to presence of the fine materials of ICW which causes a consequent increase in the water demand rapidly to maintain same workability. However, fine dust should not be presented in excessive quantities because owing to their fineness, large surface area for fine dust increases the amount of water necessary to wet all the particles in the mix and then a reduction in strength will result [9].

Also, the presence of alkalies and sulphate in ICW may have role in the decrease of concrete strength [5].

It can be noticed the effect of replacing sand by ICW on the compressive strength is more pronounced in lean mix 1:2:4 than in rich mix 1:1.5:3 this variation in strength is due the presence of

ICW which may fill the pores of lean concrete mixes ,but for rich mixes , in which the cement paste as affine materials has filled most of the pores of concrete , ICW will not help in increasing the strength ,but above a certain limit ,will cause a reduction in strength. In addition, the fine materials can be beneficial for lean concrete probably because of its ability to modify the structure of the cement paste, but it has a little effect in concrete, which are relatively rich in cement [9] and [11].

For1:2:4 mix shows that most of the compressive strength did not show significant strength development rate as that at 7 days.

The contribution to the strength increase in 7 days may be due to the presence of alkalis in ICW, which increases the rate of cement hydration at early ages [12].Also when the fine materials are used in the mix, the gain of concrete strength especially at early age can be attributed to the accelerated hydration of cement paste and to the filler effect of these materials [13] and [14].

Table (7) shows the effect of ICW on the modulus of rupture is found to be similar to that of compressive strength. The 28 days concrete density are presented in Table (8), it can be observed that in rich mix 1:1.5:3 the reduction in the density is lower than relatively lean mix 1:2:4, from 5% to 25% of ICW is used, the result show that the density of mixes decreases with the increase in the percentage of ICW. The reason of this decrease is that ICW has relatively lower specific gravity .Therefore, replacement of ICW especially on the basis of weight , will decrease the density of the mixes when compared with control mix.

Table (9) shows that the presence of ICW in the mortar has shown an increase in compressive strength for 1:3 mixes up 25% of ICW. The compressive strength development with time up to 90 days. In addition , the strength of specimens having up to 25% of ICW is higher than that of control mix at all ages, the best strength has been achieved at 7 days is 20%while less enhancement in strength is observed at 28 and 90 days. for 1:2 mix up 15% of ICW the compressive strength results is slightly increase than that of the control mix with time at ages 28 and 90 days. While the results of 7 days strength have shown slightly reducing the strength.

5- Conclusions

[1] The water demand to produce the same workability increases with the increases of replacement. The water demand is slightly higher than that of the control mix. The compressive strength of concrete increases of lean mixes in the mix of 1:2:4 at 25% of ICW by 30 and 12 percent at the age of 7 and 28 days respectively, while reduce in rich mix in the 1:1.5:3 at 15% of ICW by 3.9 and 5.4 at the age of 7 and 28 days respectively.

[2] The compressive strength of mortar has shown increases in the mix of 1:3 at 25% of ICW by 19.9 and 12.2 percent at the age of 7 and 28 days respectively while reduce in mix of 1:2 at 15% of ICW by 5.4 percent and 4 at the age of 7 days respectively.

[3] The effect of replacing on the compressive strength of concrete and mortar mixes is significant affected on the mix proportions and appears more clearly at the age of 7 and 28 days respectively.

[4] The replacement increases the tensile strength of lean concrete at the age of 7 and 28 days.

[5] The density of concrete specimens are generally found to decreases with increase in the percentage of ICW.

[6] The compressive strength results of concrete shown increases with the increase in ICW content of resistance Portland cement than ordinary Portland cement due to decreases So3, MgO , L.O.I, IR , Cl, K2O, Ma2O and increasing in fineness. This positive effect was noticed at age of 7 days.

[7] The presence of same cementitious compounds in ICW which causes the increases in the amount of hydration products, the accumulation in these products with tie closes the available pore space which leads to decreases the total porosity; finally increase the compressive strength with age [5]

[8] Compound of ICW that are not cementitous will react with cement hydration products to form cementitious compounds [16]

CONFLICT OF INTERESTS.

- There are no conflicts of interest.

5 -References

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Table (1) composition of ICW and other cementitious materials

Waste cement industry				Cementitious materials		
Oxide%	Ravindra.	Shoaibe	Al-zubaidy	Cement	slag	Fly ash
SIO2	12.2	12	14.1	20.98	30-39	34-63
AL2O3	5.8	1.1	4.7	3.76	7-26	13-36
Fe2O3	2.3	2.5	2.0	5.24	11-45	1-25
CaO	42.7	49.8	40.2	4.64	30-48	0.2-40
MgO	1.3	1.9	2.8	2.19	1-21	0-1.5
Na2O	0.8	3.9	1.7	-	0.2-1.2	0-1.6
K2O	4.3	2.6	3.2	-	0.2-1.5	0.1-2
SO3	6.5	6.3	5.8	1.88	-	0.05-5
CI	-	6.8	1.8	-	-	-
L.O.I.	22.1	17.9	24.3	0.77	-	0.8-15

Table (2) Geological Properties of ICW

Property	
Colour	Light brown
Surface Texture	Smooth
Surface Shape	Semi-Spherical Particles
Clear from organic material and other deterious substance	Particles

Table (3) the Physical Properties of ICW

Value	property
75%	Passing 30 um
300 um	Maximum Particle Size
4550-9000(cm2/gm)	Specific Surface
2.6-2.8	Specific gravity

Table (4) physical and chemical analysis of ICW and cement used throughout this work.

Chemical analysis	ICW	Cement
Sio2	19.96	20.92
Fe2o3	3.53	3.76
Al2o3	2.38	5.24
Cao	43.88	64.64
Mgo	2.87	2.19
So3	4.27	1.88
Na2o	1.95	
K2O	2.3	
Cl	0.81	
L.O.I	3.16	1.77
I.R	6.28	1.33
Free Lime	0.81	0.36
Physical analysis	ICW	cement
Specific gravity	2.70	3.15
Specific surface(g/cm2)	5052	3710
Initial setting time (m/s)		3:55
Final setting time (m/s)		4:10
Compressive strength(n/mm2)3,7 days		23,30

Table (5): physical and chemical requirement for resistance Portland cement according to the Iraqi standard (IQS: NO.5:1984), Iraqi reference (IRQ: NO 198: 1990)

<table>
<tr><td>Physical properties</td><td>Requirement</td><td>Chemical properties</td><td>Requirement</td></tr>
<tr><td>Fineness (Blaine)m2/kg</td><td>250</td><td>Lime saturation factor (LSF)</td><td>1.02-0.66</td></tr>
<tr><td>Setting Time (vicat)
a-Initial (not less than (min)
b-Final (not more than (hours)
soundness (auto clave)not more than%</td><td>45

0.8</td><td>Magnesium oxide(Mgo)%
So3%(not more than)when C3A<5%
C3A>5%</td><td>5(Max)
2.5
2.5</td></tr>
<tr><td rowspan="2">Compressive Strength (not less than)in Mpa
At the age of 3days
At the age of 7 days</td><td rowspan="2">15
23</td><td>Loss in ignition%(not more than)</td><td>4</td></tr>
<tr><td>Insoluble Residure %(not more)</td><td>1.5</td></tr>
</table>

Table (6) Compressive Strength Test Results of Concrete

Mixes	No of trials	Ratio	Compressive Strength (Mpa)		
			7 days	28 days	90 days
1:2:4	1	0	18.83	27.81	34.94
	2	5%	20.31	28.75	35.55
	3	10%	21.72	29.65	36.72
	4	15%	22.85	30.01	37.23
	5	20%	23.67	31.17	38.64
	6	25%	24.51	31.21	39.81
	7	30%	23.71	29.36	33.21
1:1.5:3	1	0%	24.41	33.95	39.84
	2	5%	24.17	33.64	40.13
	3	10%	23.69	33.19	39.63
	4	15%	23.45	32.11	39.43
	5	20%	23.15	31.97	39.0
	6	25%	23.02	30.9	38.61
	7	30%	22.63	29.5	36

Table (7) Modulus of Rupture Test Results of Concrete

Mixes	No of trials	Ratios	Modulus of rupture Mpa	
			28 days	90 days
1:2:4	1	0%	3.39	4.3
	2	5%	3.47	4.45
	3	10%	3.61	4.51
	4	15%	3.82	4.56
	5	20%	3.81	4.65
	6	25%	3.9	4.71
	7	30%	3.4	4.21
1:1.5:3	1	0%	4.12	4.75
	2	5%	3.9	4.63
	3	10%	3.8	4.51
	4	15%	3.72	4.46
	5	20%	3.6	4.3
	6	25%	3.51	4.22
	7	30%	3.2	4.01

Table (8) the Concrete Density Results

Mixes	No of trials	Ratios	Density for 28 days
1:2:4	1	0%	2385
	2	5%	2388
	3	10%	2395
	4	15%	2390
	5	20%	2383
	6	25%	2373
	7	30%	2365
1:1.5:3	1	0%	2405
	2	5%	2395
	3	10%	2383
	4	15%	2380
	5	20%	2378
	6	25%	2373
	7	30%	2370

Table (9) compressive strength test result of mortar

Mixes	No. of trial	Ratios	Compressive strength (MPa)		
			7days	28days	90days
1:3	1	0%	28.78	34.98	40.92
	2	5%	29.69	38.44	44.64
	3	10%	31.57	39.21	45.5
	4	15%	32.32	40.11	46.82
	5	20%	33.62	40.77	47.91
	6	25%	34.51	39.25	45.92
	7	30%	31.85	35.65	39.03
1:2	1	0%	32.67	39.25	44.4
	2	5%	31.85	39.93	45.81
	3	10%	31.11	40.51	46.01
	4	15%	30.88	40.85	46.33
	5	20%	30.65	39.65	43.75
	6	25%	30.05	38.24	41.45
	7	30%	29.22	36.71	39.21

Table (10) Properties of the sand.

Sieve Size (mm)	Percent Passing	IQS 45: 1984, limit, Zone 3
9.5	100	100
4.75	95	90-100
2.36	90	85-100
1.18	80	75-100
0.60	63	60-79
0.030	30	12-40
0.15	3	0-10
0.075	1.6	0
Properties	Test Result	IQS 45: Limits
Sulphate Content So3 (%)	0.27	≤ 0.5
Specific Gravity	2.64	

Table (11) Properties of the gravel.

Sieve Size (mm)	Percent Passing	IQS 45: 1984, limit, Zone 3
37.5	100	100
20	100	95-100
9.5	45	30-60
4.75	6	0-10
0.075	0.8	3 حد اعلى
Properties	Test Result	IQS 45: Limits
Sulphate Content So3 (%)	0.03	≤ 0.1
Specific Gravity	2.6	

Table (12) Concrete Mixes Workability.

Mixes	No of trails	Ratio	W/C	Slump (cm)
1:2:4	1	0%	0.5	5.0
	2	5%	0.5	5.0
	3	10%	0.51	5.0
	4	15%	0.52	5.0
	5	20%	0.53	5.0
	6	25%	0.54	5.0
	7	30%	0.55	5.0
1:1.5:3	1	0%	0.5	5.0
	2	5%	0.5	5.0
	3	10%	0.51	5.0
	4	15%	0.52	5.0
	5	20%	0.53	5.0
	6	25%	0.54	5.0
	7	30%	0.55	5.0

Fig. (1) Influence of replacing by ICW on the compresive strength of concrete 1:2:4.

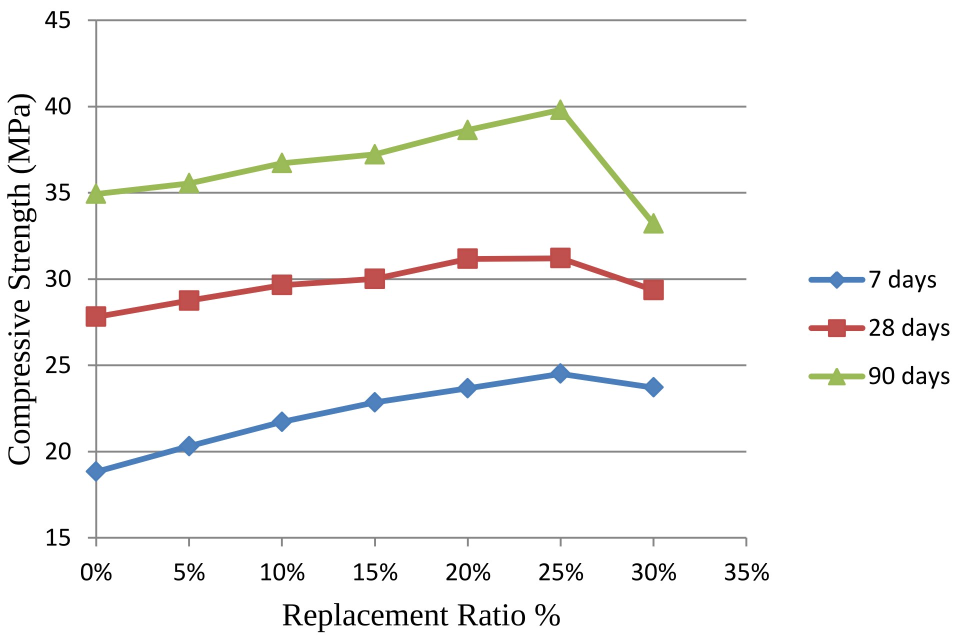


Fig. (2) Influence of replacing by ICW on the compressive strength of concrete 1:1.5:3.

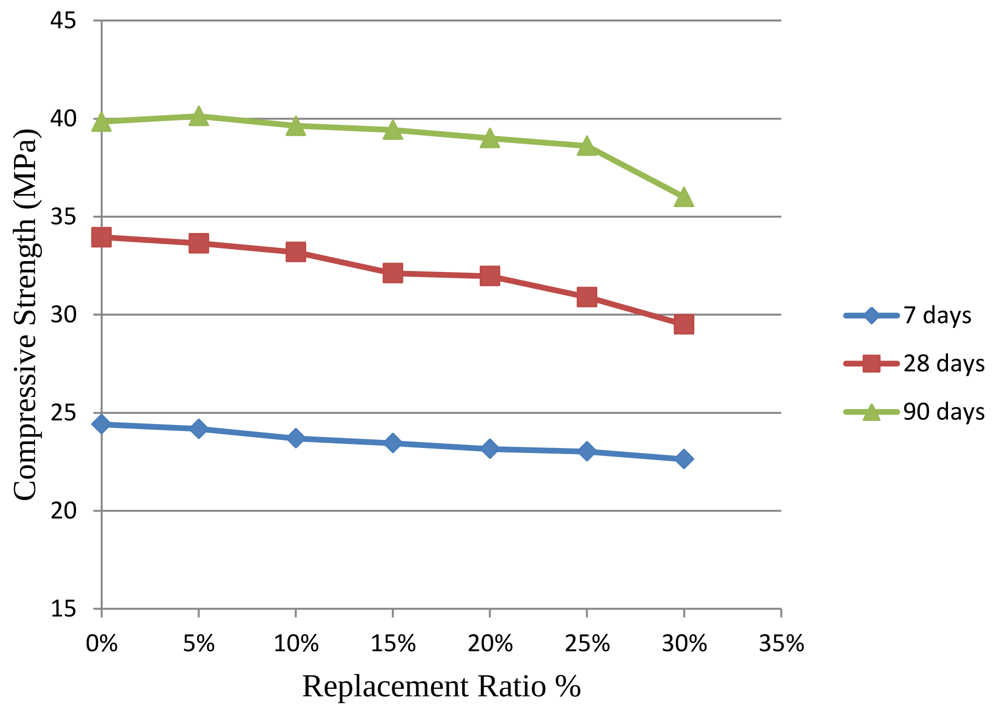


Fig. (3) Concrete compressive strength development mixes of replaced by ICW (1:2:4)

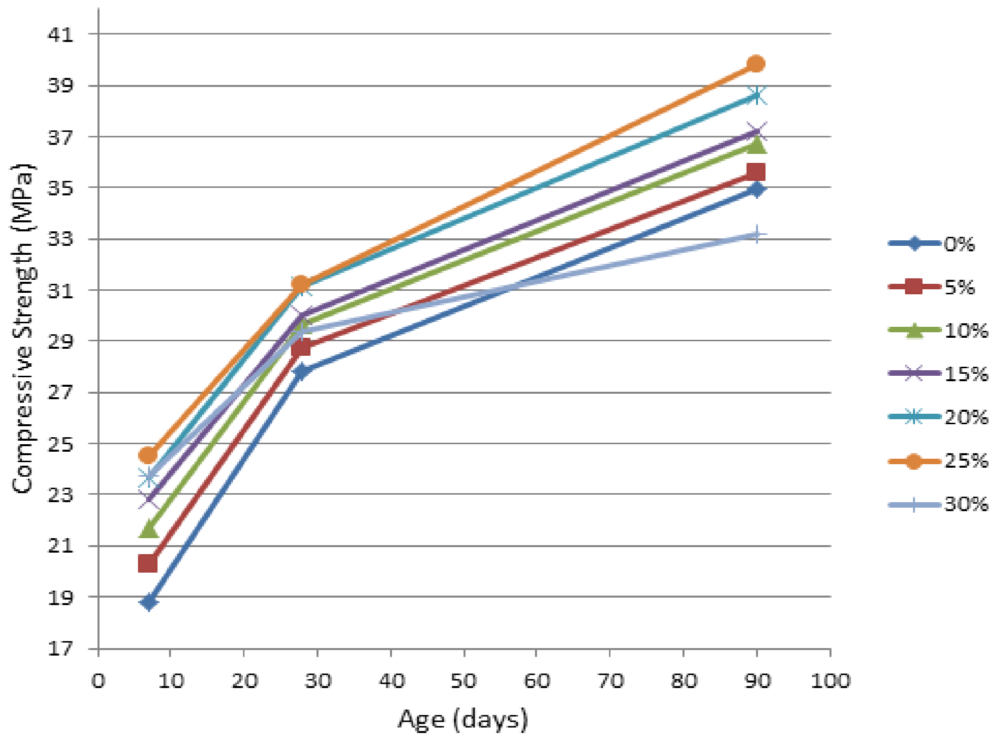


Fig. (4) Concrete Compresssvies stength development mixes of replacemed by ICW (1:1.5:3)

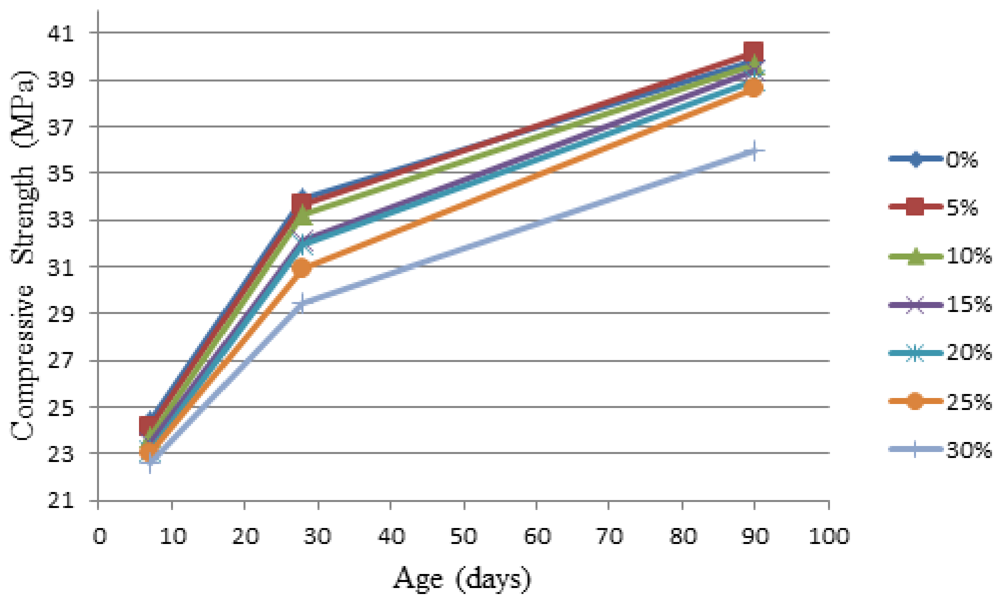


Fig. (5) Influence of replacing by ICW on the compressive strength of mortor 1:3.

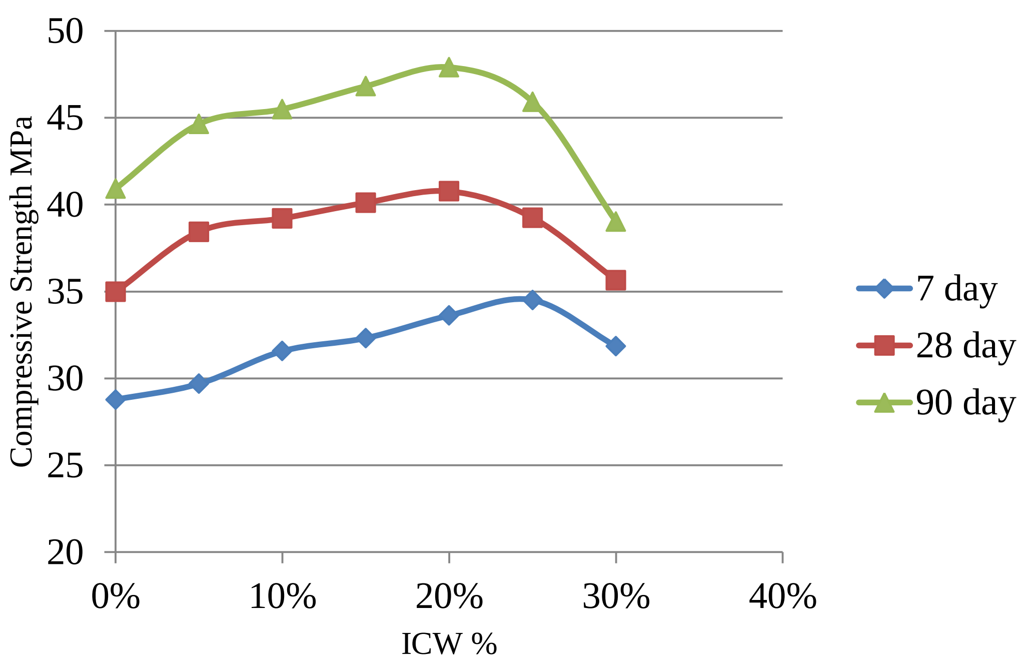


Fig. (6) Influence of replacing by ICW on the compressive strength of mortor1:2.

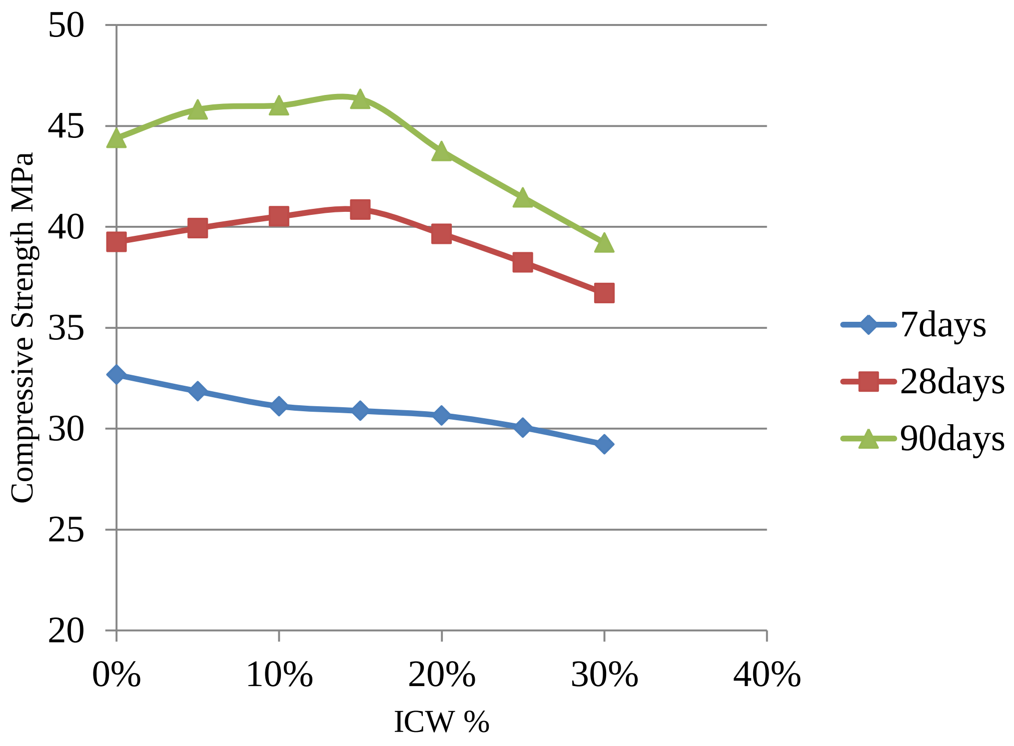


Fig. (7) Influence of replacing by ICW on the modulus of rapture of concrete (1:2:4)

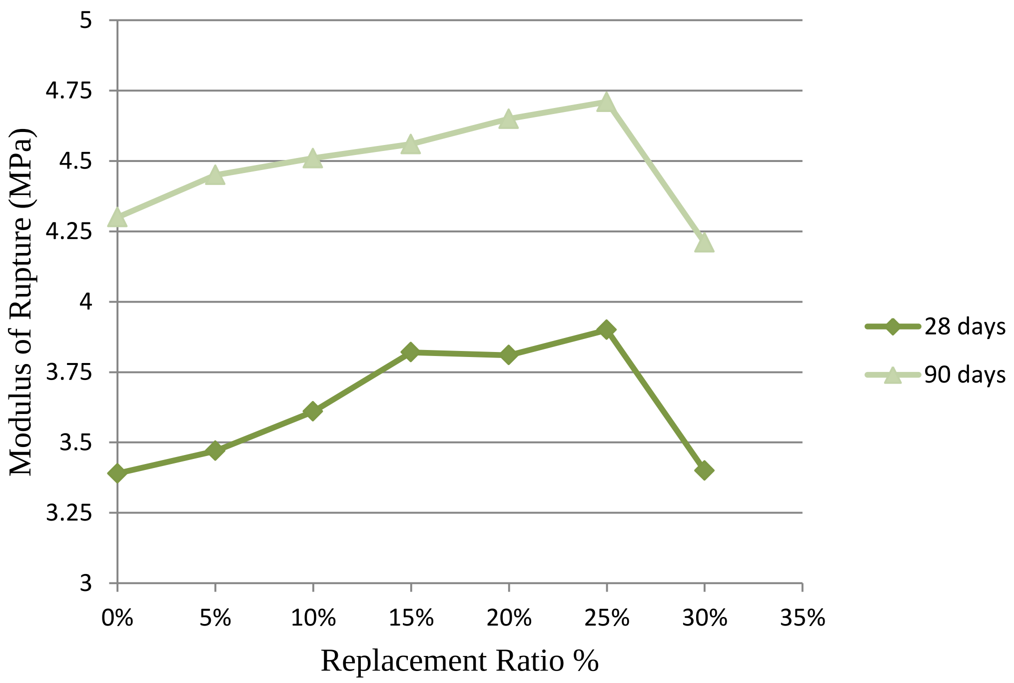


Fig. (8) Influence of replacing by ICW on the modulus of rapture of concrete (1:1.5:3)

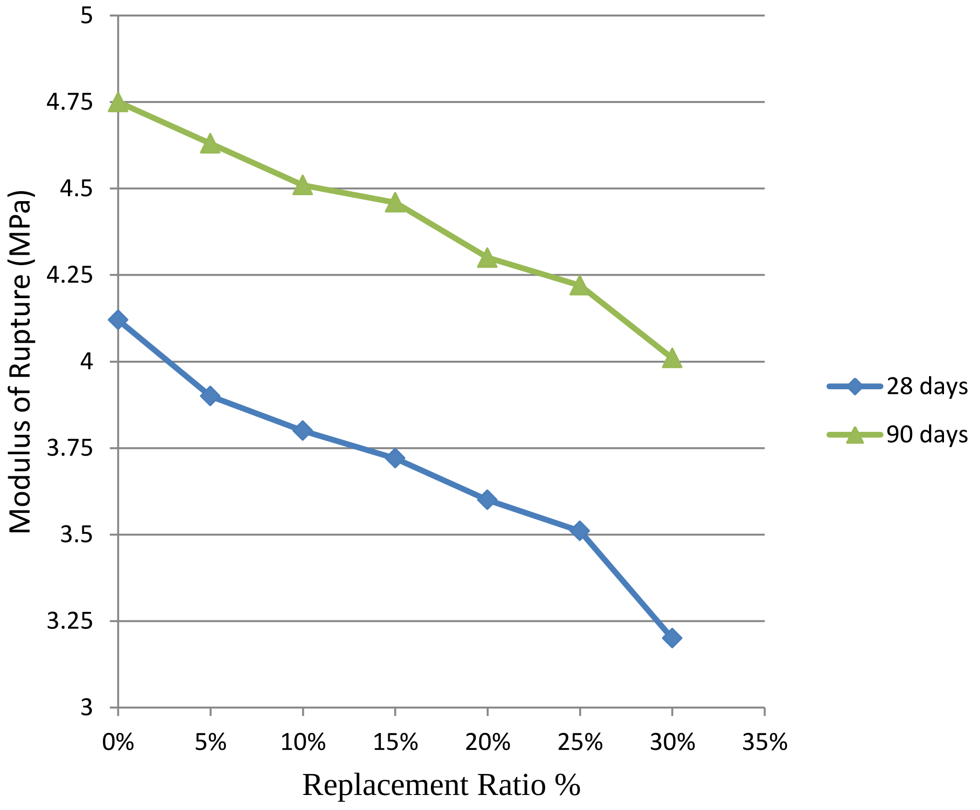
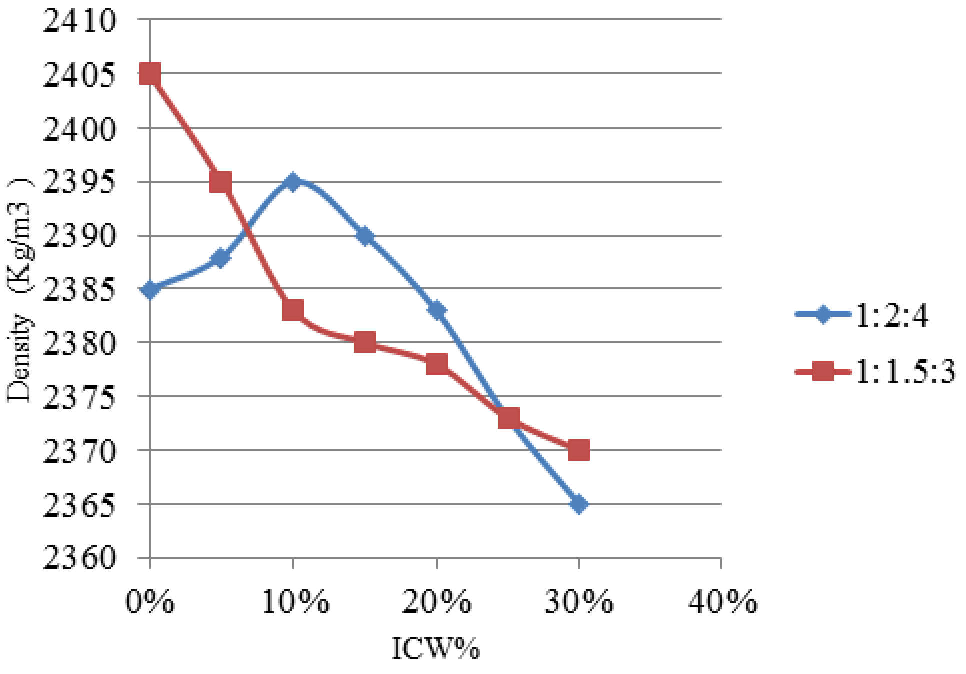


Fig. (9) Influence of replacing by ICW on the 28 days concrete density.



دراسة تأثير الأستبدال الجزئي للرمل بفضلات افران معامل الأسمنت على الخواص الميكانيكية والفيزيائية للخرسانة والمونة

خلد احمد جاسم البياتي

معاون رئيس مهندسين، مختبر بابل الانشائي، المركز الوطني للمختبرات والبحوث الانشائية

KholdAlbaity@gmail.com

الخلاصة

ان المشاكل التقنية والاقتصادية الناشئة من نقل فضلات صناعة الأسمنت من المعمل الى الخارج، اضافة الى ضررها الكبير على البيئة المجاورة، يبرر ضرورة اجراء البحث على تلك المواد.لذا تهدف هذه الدراسة الى تحري امكانية استخدام فضلة صناعة السمنت في اعمال الخرسانة والمونة كبديل جزئي عن الرمل. ان النسب المستخدمة من فضلات صناعة الأسمنت من 5 % – 30 % او وزن من حجم المونة والخرسانة على التوالي. ان استخدام فضلات صناعة الأسمنت كبديل جزئي عن الرمل زاد من مقاومة الانضغاط للخلطات الفقيرة للأسمنت نسبيا خصوصا عند الاعمار المبكرة بينما يكون له تاثير معاكس على مقاومة الانضغاط للخلطات الغنية بالأسمنت. ان اضافة 25% من فضلات صناعة الأسمنت الى الرمل وزنا في الخلطات الفقيرة للأسمنت يؤدي الى تحسين مقاومة الانضغاط بنسب تتراوح بين 30 % و20 % في الخرسانة والمونة لعمر سبعة يوم على التوالي. إن تاثير اضافة فضلات صناعة الاسمنت على مقاومه الانضغاط لخلطات الخرسانة والمونه للاسمنت المقاوم للاملاح أعلى من الاسمنت البورتلاندي العادي كما نوقش من قبل عده باحثين. اما الخواص الاخرى للخرسانة تتضمن معاير التصدع والكثافة فقد ابدت سلوكا مشابها لمقاومة الانضغاط.

الكلمات الداله: – فضلات صناعة الأسمنت، الخرسانة، مونة.