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UTILIZATION OF WHITE CEMENT IN CONCRETE MIX CONTAINING SRPC

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Abstract — **This paper discuss the effect of white cement on concrete properties such as fresh properties (slump), mass transport properties (Isat- sorptivity) and mechanical properties (compressive- splitting tensile). The thermal gravimetric analysis (TGA) of cement paste containing various blending of white cement with SRPC is also investigated. Concrete specimens were prepared with SRPC, water, sand and dolomite of 10 mm maximum nominal size. The blending of white cement with SRPC were 0, 10, 20,30,40,50 and 100% at w/c = 0.50. The effect of 10% SF on compressive strength of concrete made with various percentage of white cement to SRPC is also considered. The results indicated that, 30 % percentage of white cement to SRPC exhibited peak slump, the maximum compressive and splitting strength were observed at 30 % percentage of white cement to SRPC .Also, the lowest values of Isat and sorptivity were occurred at 30 % percentage of white cement to SRPC which agree with the results of compressive and splitting strength. 10 % SF has an adverse effect on compressive strength of concrete containing various percentage of white cement.**
Keywords— **white cement-concrete-blending-SRPC-mass transport-compressive strength-silica fume.**

1. Introduction

White cement is often used in architectural concrete, both precast and cast in place. Applications include precast curtain walls and facing panels, terrazzo surfaces, cement paint, tile grout and decorative concrete. White cement is a Portland cement typically made to conform to the specifications of ASTM C150 for Type I or Type III cements, but the manufacturing process is controlled so that the finished product is white in color. This is achieved by a careful selection of raw materials containing negligible amounts of iron oxide (not more than 0.5% by weight) and manganese oxide ; the substances that give cement its gray color (1).Suitable raw materials are chalks and lime stones having low iron contents and white iron- free clay (2,3). White Portland cement produces more Ca $(OH)_2$ in hydration, which results in alkalization and carbonization, color aging on the surface of colored Portland cement and concrete (4). Chandra and Jornstrom (5) studied the effect of types of cement on fluidity of mortar, he reported that no significant difference on the fluidity of mortars made with white cement or OPC up to 0.45 w/c, whereas at 0.50 w/c , the fluidity of white cement increased compared to OPC. The highest fluidity of white cement is attributed to the lower C_3A+C_4AF and alkali content and higher SO_3. Hamad (6) studied the influence of cement type on slump and setting time , he indicated that, greater slump and shorter times of initial and final setting of mixes prepared with white cement compared to OPC. Hamad (6) also investigated the impact of white cement on compressive and splitting tensile strength of concrete, he reported that greater compressive strength of white cement compared to OPC, while the splitting tensile strength of gray cement was slightly greater than that of white cement. Lubeck et al (7) discussed the effect of 50% and 70% slag by mass of white cement and gray cement on compressive strength of concrete, they concluded that, the mixtures with 100 % WPC showed higher compressive strength than those with 100% grey Portland cement up to an age of 28 days. At 91 days, the compressive strength values were similar .The strength of concrete made with white cement mixtures increased more quickly than that of concrete containing grey cement. At 7 days the strength of white cement was between 63 % and 85% of the strength observed at 91 days, while the strength of grey cement mixtures was between 54% and 72% of strength at 91 days. As the percentage of slag in the mixture increased, the compressive strength decreased for white and OPC. The results agree with the results reported by (8-11). Petkova et al (12) reported that neat white cement is characterized by loss of mass below 5%, a part of which due to dehydration of both crystal water and structural water from the decomposition of C-H and C-S-H , and the other to the de-carbonization of calcite.

Escalante and Sharp (13) reported that Portland cement is a poly- phase material containing silicates (alite and belite), aluminate, ferrites and sulfates, whose hydration is complex and difficult to study due to the many factors involved. Some are intrinsic to the cement itself, such as its composition and fineness or specific surface. While others are related to hydration conditions, including w/c, absence or presence of admixtures. It is noted that most of the study on white cement in concrete has been focused on the hydration of neat white cement, effect of it on fresh, mechanical properties of concrete and impact of slag on efficiency of white cement. This study focused on the benefits of white cement (higher fineness and higher compressive strength at 28 days, compared to SRPC) by blending it with SRPC by various ratios to reduce the cost, the effect of this blending on various properties of concrete (fresh-mechanical – mass transport- microstructure) and it is a need to recognize the optimum % blending of white cement with SRPC.

2. Experimental program

2.1 Materials

Two Types of cement ,Sulphate resistance Portland cement and white cement used in this investigation were delivered from "Beni- suef cement company", Type CEMI 42.5 N.

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Testing of cement was carried out per the Egyptian Standard Specifications ESS2421/2005 (14). The chemical and physical analysis of these cements is presented in Table 1. Natural siliceous sand with fineness modulus 2.73 was used as a fine aggregate. Dolomite with 10 mm M.N.S was used as a coarse aggregate, the physical properties of dolomite is presented in Table 2. Silica fume was delivered from Edfo city, Egypt. Tap water used for mixing and curing.

TABLE [1] Chemical and physical analysis of cement types.

Property	SRPC	White cement
Chemical composition,%		
SiO_2	20.42	23.4
Al_2O_3	3.79	5.2
Fe_2O_3	4.49	0.25
CaO	63.31	65.8
MgO	1.88	0.5
Na_2O	0.36	0.1
K_2O	0.19	0.5
SO_3	2.37	2.2
Bouge compounds,%		
C_3S	63.84	48.4
C_2S	8.64	30.86
C_3A	2.46	13.4
C_4AF	13.65	0.76
Initial setting time, min.	135	90
Final setting time, min.	300	255
Specific surface,m^2/kg	360	430

TABLE 2 Physical properties of dolomite.

24-hour water absorption ,%	Specific gravity	Unit weight Kg/ m^3
0.98	2.65	1665

2.2 Mixture proportions

Fourteen mixtures were tested in this research made with percentage of white cement to SRPC= 0,10,20,30,40,50 and 100% .Dolomite of 10 mm M.N.S mixed with cement, sand and water, the mix was 400 Kg cement, 1200Kg dolomite, 10%S.F as a partial replacement of cement and 600 Kg sand per cubic meter of concrete at w/c = 0.50. These constituents of concrete were mixed in mixer for two minutes, and then placed in cube moulds 10×10×10 cm for Isat, sorpitivity and compressive strength testing, whereas, the specimens for splitting tensile testing were cylinders 10x20 cm. cylindrical specimens 5 cm diameter and 0.50 cm height were used for thermo-gravimetric analysis (TGA). Table 3 presents the masses of materials used (kg/m^3) and the corresponding costs per m^3 for each of the mixtures.

Table[3] Composition of the concrete mixtures (Kg/m^3) at w/c= 0.50 and costs per m^3 of concrete.

Mix code	White cement	SRPC	Sand	Dolomite	S.F	Cost L.E
W-0	0	400	600	1200	-	360
W-10	40	360	600	1200	-	380
W-20	80	320	600	1200	-	400
W-30	120	280	600	1200	-	425
W-40	160	240	600	1200	-	450
W-50	200	200	600	1200	--	465
W-100	400	0	600	1200	-	555
W_S-0	0	360	600	1200	40	370
W_S-10	36	324	600	1200	40	390
W_S-20	72	288	600	1200	40	410
W_S-30	108	252	600	1200	40	435
W_S-40	144	216	600	1200	40	460
W_S-50	180	180	600	1200	40	475
W_S-100	360	0	600	1200	40	565

2.3 Testing

In this research work, slump test carried as workability, whereas, the following tests on hardened concrete were carried out:

(a) Compressive strength: The compressive strength test was carried out according to the Egyptian Standard Specifications ESS 1658/2006(15).To evaluate concrete compressive strength at test ages of 7 and 28 days.

(b) Splitting tensile strength: The splitting tensile strength test was carried out at 28 days age according to the Egyptian Standard Specifications ESS1658/2006(15).

(c) Initial surface absorption test (Isat): At age of testing (28 days) , the tested cubes were oven dried at 105˚ C until reaching constant weight. Then, the dried specimens were left in a closed container for 24 hours until full stabilization. To avoid the effect of moisture, silica gel was put in small pots in the same container beside the specimens. The test period (2 hours), this test was carried out according to BS 1881: part 208-1996(16).

(d) Sorptivity test: The specimen preparation was carried out as the same of Isat , the test was carried out using a plastic container filled with water to a depth 20 mm .Steel bars of 16 mm diameter were rested on the bottom of the container such that, the water was just above the top surface of the steel bars .The specimens were weighted using digital electric balance of 0.05 gm accuracy. All surfaces around the chosen surface were then greased to about 2 cm .The weights of the specimens were measured after removing the surface water at periods of 15 minutes up to 2 hours. The total amount of water absorbed was then monitored .The sorptivity of the tested specimens was calculated using the following equation (17):

$i = A + s\,t^{0.5}$ ……………………..(1) , where

A, is constant,

i, is the increase in mass in g/mm^2,

t, is the time, measured at which the weight is determined,

S, is the sorptivity in mm/sec $^{0.5}$

(e) Thermo-gravimetric analysis (TGA): TGA was carried out on cylindrical cement paste specimens (50 mm diameter and 5 mm height), with different replacement of white cement to OPC to determine the amount of hydration product in cement mixes. These specimens were cast in PVC mould and after the end of curing period (28) days, the specimens were weighted in saturated surface dry (SSD) condition, and then the specimens were put in an electric with surface temperature up to 1200° C. The weight of specimens were recorded at various temperatures (105,250,450,600,700,900 and 950), then the weight loss resulted from the decomposition of matrix were used for calculation their different phases of hydration products. This method was followed by (18) and (19) ,where C-S-H decomposes at range 105-250°, C-H decomposes at range of 450-600, all non evaporable water(NEW), bound water release at 950° C. The test specimen, age of testing and standard are presented in Table 4.

TABLE [4] The test specimens and age of testing

Test	Test specimen	Age of testing
Compressive strength	100 mm cube	7and 28days
Splitting tensile strength	Cylinder of 100 mm diameter and 200 mm length	28 days
Isat	100 mm cube	28 days
Sorptivity	100 mm cube	28 days
TGA	5 cm diameter,0.5 cm thickness	28 days

3. Test results and discussions

3.1 Slump

The effect of % blending of white cement with SRPC on slump is presented in "Fig. 1" .It is apparent from this Figure that, 30% percentage of white cement to SRPC exhibit highest slump whereas, the lowest value of slump observed at 100% white cement, generally up to 30% blending white cement with SRPC increased the slump, after this percentage the slump start to decrease. This result is contrary to the result obtained by (5) and (6) that reported that white cement led to increasing the slump compared to OPC.

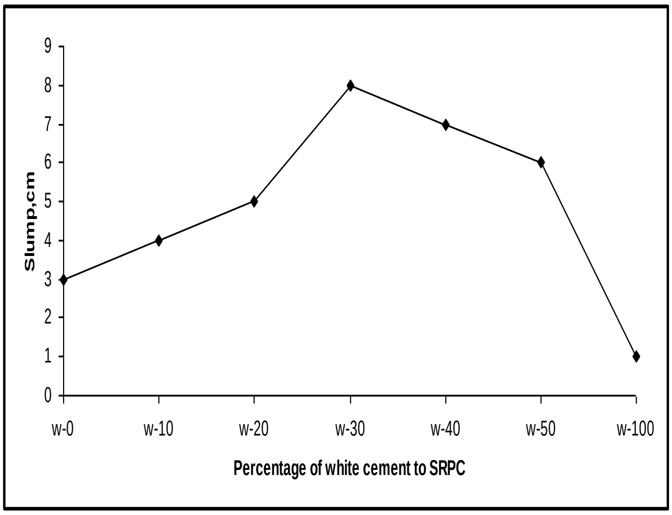

Figure 1. Effect of percentage of white cement to SRPC on concrete slump.

3. 2Hydration of Cement

Table 5 represents the impact of percentage of white cement to SRPC on hydration products of cement, it is apparent that the maximum decomposition of weight due to C-S-H observed at 20% percentage of white cement to OPC, whereas, the maximum decomposition of weight due to C-H obtained at 30 % percentage of white cement to SRPC. At 50 % blending of white cement with SRPC exhibit maximum NEW, otherwise, minimum NEW is observed at 100% white cement.

TABLE[5] Decompositions due to C-S-H, C-H and NEW, bound water,% for different mixes.

Code mix.	Weight loss due to decomposition of C-S-H,%	Weight loss due to Decomposition of C-H,%	NEW, bound water,%
W-0	8	6.1	30.7
W-10	6.8	7.7	30.9
W-20	8.7	5	31.8
W-30	5	8.7	31
W-40	6.2	8.1	32
W-50	6.3	7.8	32.8
W-100	6.9	6.1	29.5

3.3 Mass transport properties

3.3.1 Initial surface absorption test

The influence of percentage of white cement to SRPC on flow rate by Isat is presented in "Fig.2" , it is observed from this Figure that, compared to grey cement white cement increased the flow rate ,whereas, 30% percentage of white cement to SRPC exhibit lowest value of flow rate.

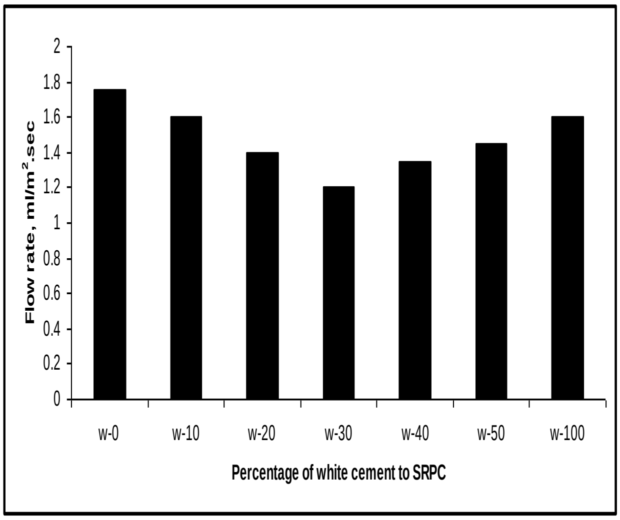

Figure 2.Effect of percentage of white cement to SRPC on flow rate of concrete.

3.3.2 Sorptivity

The effect of percentage of white cement to SRPC on sorptivity of concrete containing its is presented in" Fig. 3" , it is observed from this Figure that, compared to grey cement ,white cement increased the sorptivity ,whereas, 30% percentage of white cement to SRPC exhibit lowest value of sorptivity.

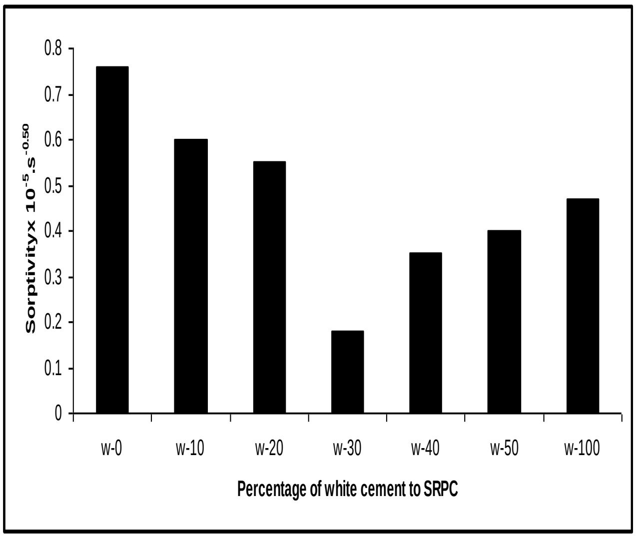

Figure 3.Effect of percentage of white cement to SRPC on sorptivity of concrete.

3.4 Compressive strength

"Figs . 4 , 5" represent the impact of percentage of white cement to SRPC on compressive strength, it is apparent from these Figures, that increasing the age, the compressive strength of concrete containing various percentage of white cement to SRPC developed, compared to grey cement neat white cement increased the compressive strength by 8%, this result is agree with the result obtained by Lubeck et al (7).The maximum compressive strength is observed at 30% percentage of white cement to SRPC ,this result may be attributed to the lowest values of flow rate and sorptivity observed at 30% percentage of white cement to SRPC. Also, this result agrees with the result obtained by TGA, where the maximum C- H observed at 30% percentage of white cement to SRPC. Compared to grey cement,10% S.F increased the concrete compressive strength, whereas, introducing S.F in white cement mixes led to decreasing the concrete compressive strength, especially above 20% white cement to SRPC .This result may be attributed to the lower c4AF in white cement.

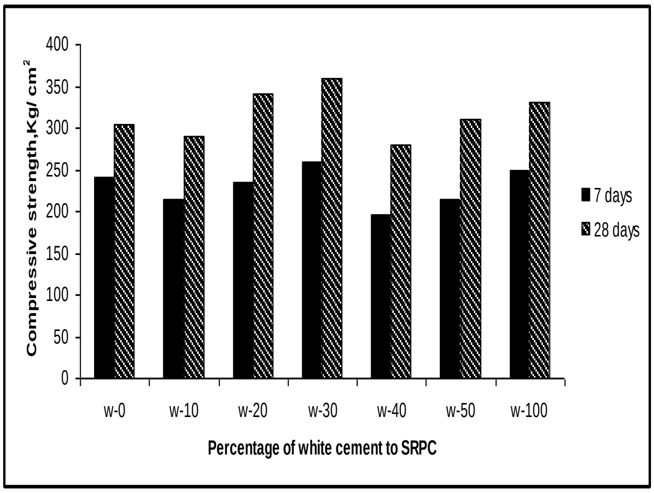

Figure4. Influence of percentage of white cement to SRPC on concrete compressive strength at various ages.

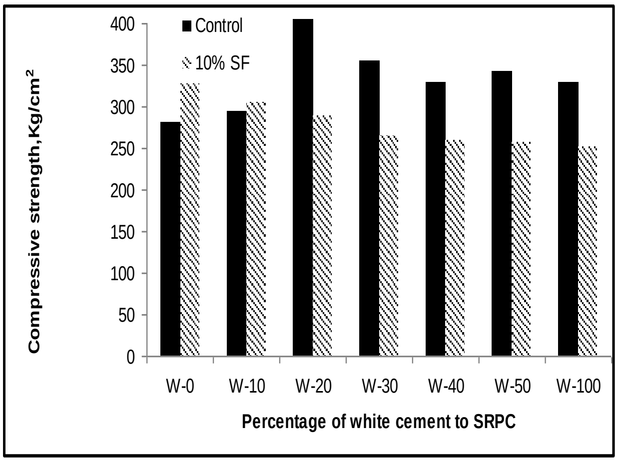

Figure 5.Effect of SF on compressive strength of concrete containing various percentage of white cement to SRPC at 28 days.

3.5 Splitting tensile strength

"Fig. 6" represents the impact of % blending of white cement with SRPC on splitting tensile strength, it is apparent from this Figure, that the peak splitting tensile strength is exhibited at 30% percentage of white cement to SRPC, this result agree with the results obtained by Isat and sorptivity where lowest values of flow rate and sorptivity observed at 30% percentage of white cement to OPC. Also, this result agrees with the result obtained by TGA,where the maximum C- H observed at 30% percentage of white cement to SRPC. The splitting tensile strength of gray cement was greater than that of white cement, these results agree with the result obtained by (6).

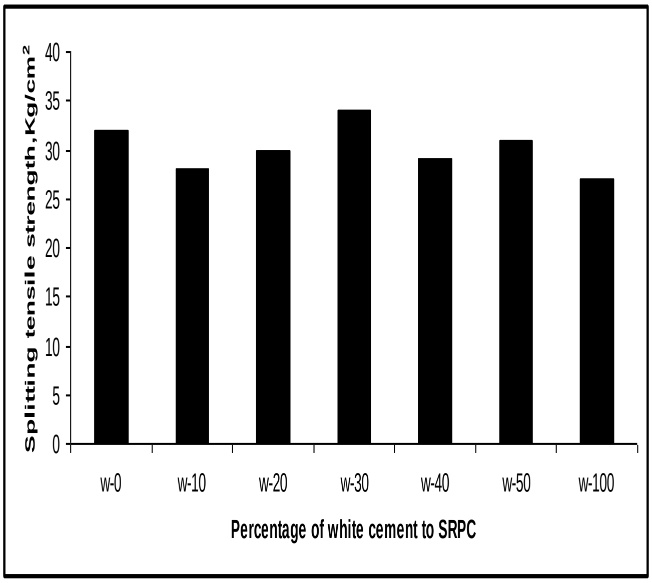

Figure6. Influence of percentage of white cement to SRPC on concrete splitting tensile strength at 28 days.

4. Conclusions

Based on this experimental study, the following conclusions can be drawn:

1-Percentage of white cement to SRPC up to 30% led to enhancing the slump however, at percentage above 30% the slump starts to decrease, and for neat white cement mix, the slump is lower than that of neat SRPC concrete.

2- 30% percentage of white cement to SRPC increased C- H to maximum value.

3- Compared to different % percentage of white cement to SRPC, 30% white cement to SRPC decreased the flow rate and sorptivity to lowest values.

4-Percentage of white cement to SRPC enhanced the compressive strength, the maximum compressive strength observed at 30% white cement.

5-Introducing S.F in concrete containing % white cement to SRPC above 20% led to decreasing the concrete compressive strength.

6- The maximum splitting tensile strength occurred at 30% percentage of white cement to SRPC.

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Refrences

[1] S.H., Kozmatka, W.C.,Panarese, "Design and Control of Concrete Mixtures; Portland Cement Association":Skokie,IL,1988.

[2] D.F. Orchard, "Concrete Technology", Vol.1,John Wiley,Sons:New York,1962.

[3] S.,Mindess ,J.F.Young," Concrete";Prentice Hall:Engle-Wood Cliffs,NJ,1981.

[4] C., Xibi, W.,Zhaogi, "The Production and application of special cement",326,Architectural Publishing Company.

[5] S.,Chandra, J.,Bjornstrrom, "Influence of cement and superplasticizers type and dosage on the fluidity of cement mortars-PartI",Cement and Concrete Research,Vol.32,pp.1605-1611,2002.

[6] B.S,Hamad, "Investigations of chemical and physical properties of white cement concrete",Advanced Cement Based Materials,Vol.2,pp.161-167, 1995.

[7] A., Lubeck, D.S., Gastaldini Barin , H.C .,Siqueira," Compressive strength and electrical properties of concrete with white Portland cement and blast furnace slag", Cement and Concrete Composite, Vol.34,pp.392-399,2012.

[8] P.A.M, Basheer, P.R.V Gillece, , A.E, Long W.J.McCarter,"Monitoring electrical resistance of concretes containing alternative cementitious materials to assess their resistance to chloride penetration".Cement and Concrete Composite,Vol.24, pp.437-449,2002.

[9] J.,Khatib ,JJ. ,Hibberet "Selected engineering properties of concrete incorporating slag and metakaoline",Concrete and Building Materials, Vol.19,pp.460-472,2005.

[10] K.Y., Yeau, E.K, Kim,"An experimental study on corrosion resistance of concrete with ground granulate blast-furnace slag",Cement and Concrete Composite,Vol.35, pp.1391-1399,2005.

[11] A.E., Oner, S., Akyuz,"An experimental study on optimum usage of GGBS for the compressive strength of concrete", Cement and Concrete Composite,Vol. 29, pp.505-514,2007.

[12] V., Petkova, V., Stoyanov., and Y., Pelovski, "TG-DTG-DTA in studying white self-compacting cement mortars" ,Journal Therm Anal Calorim,Vol.109,pp.797-806,2012.

[13] IJ., Escalante-Garcia, JH Sharp," Effect of temperature on the hydration of the main clinker phases in Portland cements: part I, Cement and Concrete Research, Vol.28,pp.1245-1257,1998.

[14] ESS 2421/2005-Egyptian standard specification, cement-physical and mechanical testing.

[15] ESS 1658/2006- Egyptian standard specification, testing of concrete.

[16] B.S 1881: part 208-1996-Testing concrete-Recommendations for the determination of the initial surface absorption of concrete.

[17] C., Hall, "Water sorptivity of mortars and concrete: a review, Magazine of Concrete Research, Vol.41,issue 147,pp.51-61,1989.

[18] A.A , Rahman, F.P., Glasser , " Comparative studies of the carbonation of hydrated cements", Advanced in Concrete Research,Vol.2,No.6,pp.49-54,1989.

[19] G.E, Abdelaziz, " Microstructural analysis of surface and interface zones in concrete" ,ph.D.Thesis,Aston University,UK,250 pp,1998.