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Effect of Forced Casting Joints on the Mechanical Properties of Self-compacting Concrete Incorporating Cement Waste

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Abstract* - This research aims to study the effect of forced casting joints (FCJ) on the mechanical properties of concrete samples made by self-compacting concrete (SCC) incorporation cement waste (CW). FCJ is different from known concrete construction joints like: settlement and expansion joint, which the design engineer put that in mind, during the design phase, where the location of FCJ in SCC and conventional concrete cannot be determined but expected to occur, so guidelines must be provided about FCJ indication during the design and execution stages of concrete construction. Mixtures of SCC were designed as replacement CW;(0% to 100%)of cement weight, In addition, effects FCJ on of concrete samples made from SCC, samples were casted at the (quarter, middle, three quarter and full) of samples height. The results were investigated and it indicates that, in case of delaying in the time period for casting the second layer and increase of CW in concrete mixtures there are a great effect on the mechanical properties of SCC.

***Index Terms* - Cement Waste, Delay in Casting Concrete, Forced Concrete joints.**

I. INTRODUCTION

SCC is an innovative special concrete that doesn't require any vibration process during its placing, SCC is ability to flow under the effect of its own weight, enables it to fill formworks with complicated shapes and congested reinforcement area also keeps its stability without segregation or bleeding, and the excellent quality for concrete surface. SCC requires a mineral Admixture and super plasticizers with coarse and fine aggregates [1-5]. But placing process of concrete may be difficult due to many reasons: pouring large amount of concrete or glitch of one of mechanical machines such as the station concrete mixing, concrete truck, concrete pumps, and concrete mixer in site casting which lead to the occurrence of this joint at non-expected places [6, 7]. Location of concrete joints is generally predetermined by designer engineer, forced separation is different from known separators like: settlement joint and expansion joint, which the design engineer put in mind during the design stage [8], there effect on concrete strength at presence the horizontal FCJ [9, 10]. Also there a difference between joints in Self-Compacting Concrete and conventional concrete, where its location in Self-Compacting Concrete cannot be determined and the design engineer cannot consider that during the design stage of building construction [11, 12]. it is known too that Forced Joints in conventional concrete happen at a specific place, whether in the area of zero moment or area of a zero shear [13], that differs with Self-Compacting Concrete which is the horizontally joint, where the degree of liquidity is very high [14]. Forced Joints are one of concreting problem that occur during the process of casting concrete, which possibly can affect the properties of mechanical concrete, because the delay of casting of second layer to complete the first layer, so should be using bond materials [15], This investigation showed that the pouring delay causes FCJ which lead to loss in concrete properties.

II. EXPERIMENTAL PROGRAM

A. Materials

The physical, mechanical and chemical properties of the used materials were determined according to Egyptian Specifications and standards. The used of Portland cement was CEM I 42.5 N. A commercial FA was purchased locally from metallurgical to be used as a mineral additive; CW was kept stored for 15 months while exposed to moistures and sun heat. Properties of cement, LSP and FA are shown in Table (1) and Chemical properties of cement waste are stated in Table (2) with XRD test Figure (1). The used fine aggregate (sand) was local natural sand also the coarse aggregate was crushed stone with maximum size of 10 mm with Specific gravity 2.7 and absorption (1.53%), superplasticizer (SP) was used to lower the water/binder ratio and increase the slump flow (workability), Addibond 65 as bond materials ASTM C 631 Grout consists of a cementations mix with white color and density 1.04 kg/l mixed with ratio of water (water/grout) 3:1 to produce liquid mortar, that is used for the bonding between the new and old concrete.

Table (1) Chemical, mechanical and physical properties of cement, FA and LSP

Component/property			Cement	FA	LSP
Chemical composition (%)	SiO_2		22.0	42.14	0.45
	Al_2O_3		6.5	19.38	0.33
	Fe_2O_3		3.5	4.64	0.14
	CaO		61.5	26.96	52.35
	MgO		2.4	1.78	1.05
	K_2O		0.6	1.13	0.02
	SO_3		2.5	2.43	-
	Na_2O		0.44	-	.06
	Loss on ignition		2.4	1.34	42.50
	Insoluble residue		0.9	-	0.20
mechanical and physical	Specific gravity		3.15	2.21	2,.71
	Specific surface area (cm^2/g)		3,550	2900	2500
	Setting time (min.)	Initial	135	-	-

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		Final	195	-	-
	Compressive strength (N/mm²)	3-days	26.2	-	-
		28-days	48.6	-	-

Table (2) Chemical properties of CW

	Component/property	Cement waste
Chemical Composition (%)	Silicon Oxide Si O2	69.88
	Calcium Silicate Ca2 Si O4	6.14
	Calcium Silicate Oxide Ca2 Si O4	2.90
	Silicon Si	0.28
	Calcium Silicate Oxide Ca3 Si O5	1.43
	Sodium Peroxide Na O2	1.27
	Calcium Silicate Ca3 Si O5	1.87
	Calcium Silicate Oxide Ca3 Si O5	2.97
	Calcium Silicate Ca Si O3	1.42
	Calcium Magnesium Aluminum Oxide Silicate Ca54 Mg Al2 Si16 O90 / 54 Ca O ·16 Si O2 · Al2 O3 · Mg O	1.76
	Potassium Iron Silicate K2 Fe2 Si0.29 O4.58	3.26
	Sodium Iron Oxide Na2 Fe O4	1.62
	Iron Oxide Fe2 O3	0.67
	Calcium Silicate Ca2 Si O4	1.21
	Calcium Aluminum Iron Oxide Ca2 Al1.38 Fe0.62 O5 / Ca2 (Al0.69 Fe0.31)2 O5	2.31

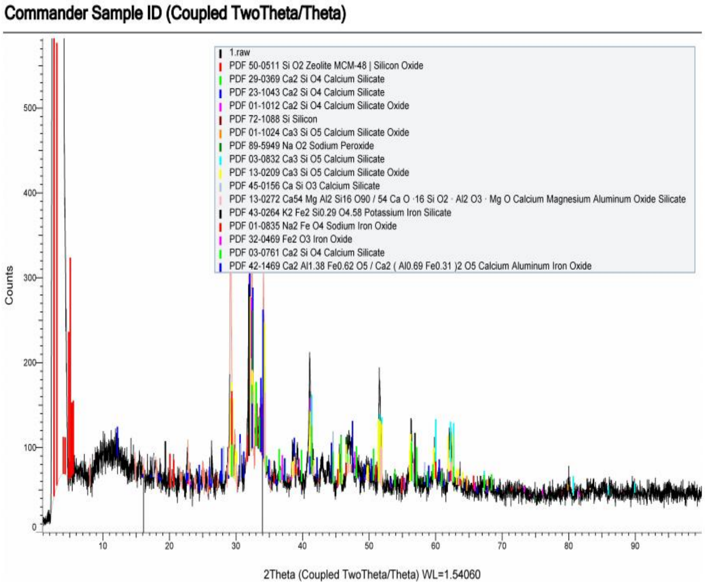

Fig (1) XRD scanning of cement waste

B. Mix Design and Casting

Total number of nine concrete mixtures, Used CW as replacement (0, 5, 10, 15, 20, 25, 50, 75 and 100 %) by weight of cement content 400 kg/m^3, Table (3) demonstrates the proportioning of various concrete mixtures materials. Furthermore, all concrete mixtures contain water reducing SP 2% by weight of cement. The coarse to fine aggregate ratio was 55:45. The effect of joint location is the main variable in this study. Four different locations are considered: at the quarter, middle, three quarter and full of specimens shows in Figure (2, 3 and 4).

Table (3) Concrete mixes proportions

Materials / No	Cement kg/m3	Sand kg/m3	Crushed stone kg/m3	FA kg/m3	L S P kg/m3	CW kg/m3	SP kg/m3	Water kg/m3	W/b
Mix 0	400	726	886	60	60	0	8	208	0.4
Mix 1	380	726	886	60	60	20	8	208	0.4
Mix 2	360	726	886	60	60	40	8	208	0.4
Mix 3	340	726	886	60	60	60	8	208	0.4
Mix 4	320	726	886	60	60	80	8	208	0.4
Mix 5	300	726	886	60	60	100	8	208	0.4
Mix 6	200	726	886	60	60	200	8	208	0.4
Mix 7	100	726	886	60	60	300	8	208	0.4
Mix 8	0	726	886	0	60	400	8	208	0.4

FA: fly ash
CW: cement waste
LSP: lime stone powder
W/b: water to binder (cement + fly ash + lime stone powder) ratio

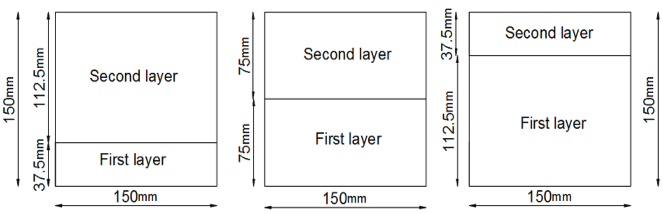

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Fig (2) Cubes Samples with FCJ at quarter, middle and three quarters

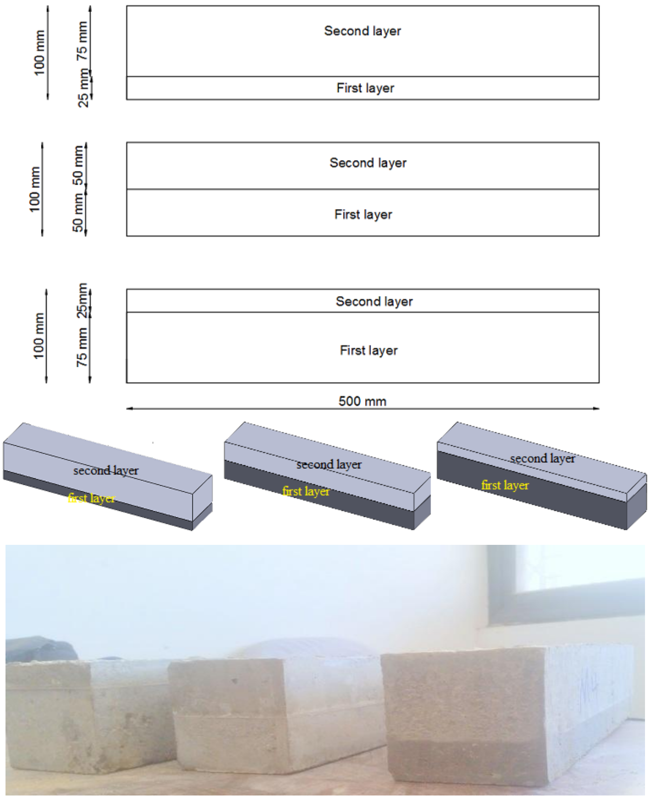

Fig (3) Beams Samples with FCJ at quarter, middle and three quarters

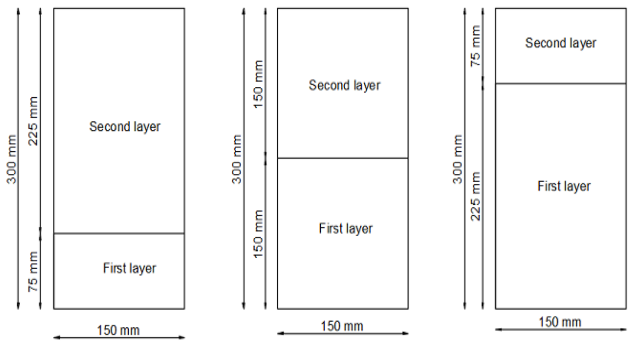

Fig (4) Cylinders Samples with FCJ at quarter, middle and three quarters

III. RESULTS AND DISCUSSION

A. Fresh Properties

The measured fresh properties of all mixes are summarized in Table (4) and Figures (5), the results are slump flow, and slump flow time at T 50cm, V-funnel test (Flow Time), L-box test (Blocking Ratio), J-ring an GTM screen stability (segregation resistance).Slump flow and blocking ratio of SCC decreased when CW as replacement increased. As a result of changing CW from 0.0 to 100% by replacement of cement, the slump flow and blocking ratio changed from 790 to 400 mm and 1 to 0.45% respectively. Segregation ratio decreased with the AWA dosage decreased. For example, because of changing CW from 0.0 to 100% by replacement of cement, the segregation ratio changed from 5% to 17% respectively.

Fig (5) Fresh concrete

Table (4) Fresh concrete properties

Materials	Slump flow (mm)	Slump flow (mm) (S) T50cm [a]	J-ring (mm)	V-funnel T10[b] (s)	V-funnel T5min[c] (s)	L-Box ratio(H2/H1)[d]	Sieve stability %
Mix 0	790	2	10	10	13	1	5%
Mix 1	700	3	12	10	14	0.95	6%
Mix 2	660	3.5	13	11	15	0.93	6%
Mix 3	62	4	14	12	15	0.9	10%

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	0					1	
Mix 4	590	5	16	11	13	0.90	15%
Mix 5	550	7	17	10	12	0.75	15%
Mix 6	450	-	17	10	12	0.6	16%
Mix 7	400	-	18	10	11	0.5	16%
Mix 8	400	-	20	10	11	0.45	17%

[a]T50cm: time taken for concrete to reach the 500 mm spread circle
bTf: V-funnel flow time after keeping the concrete in funnel for 10 sec
cT5min: V-funnel flow time after keeping the concrete in funnel for 5 min
dH/,H2: Heights of the concrete at both ends of horizontal section of L-box after allowing the concrete to flow.

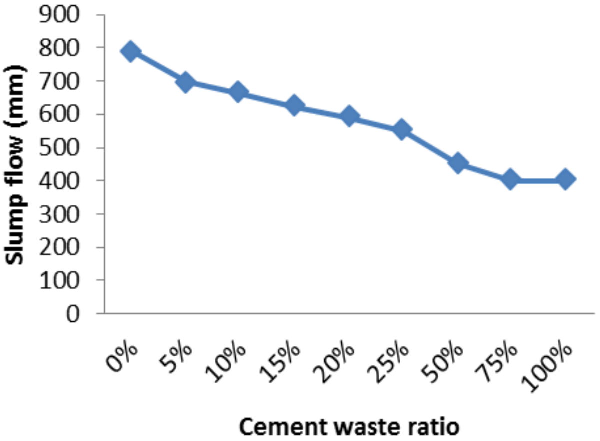

Fig (6) Relation between slump flow and cement waste

B. Hardened Properties

1. Effect of cement waste

The compressive strength results at 7 and 28 days of concrete mixtures with replacement cement waste ratio in range of (5%-100%) of cement content were presented in Figure (7).

It was observed that the compressive strength of concrete mixtures with percentage of replacement ratios of CW (5%, 10%, 15%, 20%, 25%, 50%, 75% and100%) were decreased by (2.5%, 5%, 7.5%, 10%, 12%, 26%, 37% and 50%) respectively, at 28 days comparing with control mixture. due to the occurrence of sizes changed and chemical changed for CW compared nature cement.

The flexural strength results at 7 and 28 days of concrete mixtures with replacement cement waste ratio in range of (5%-100%) of cement content were presented in Figure (8).

It was observed that the flexural strength of concrete mixtures with percentage of replacement ratios of CW (5%, 10%, 15%, 20%, 25%, 50%, 75% and100%) were decreased by (5%, 9%, 13%, 17%, 21%, 34%, 47% and58%) respectively at 28 days comparing with control mixture.

The tensile strength results at 7 and 28 days of concrete mixtures with replacement cement waste ratio in range of (5%-100%) of cement content were presented in Figure (9).

It was observed that the tensile strength of concrete mixtures with percentage of replacement ratios of CW (5%, 10%, 15%, 20%, 25%, 50%, 75% and100%) were decreased by (4%, 10%, 14%, 18%, 22%, 36%, 48% and 60%) respectively at 28 days comparing with control mixture.

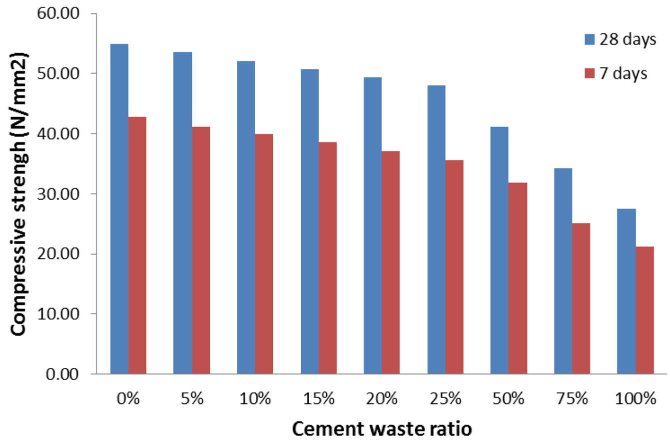

Fig (7) Relation between Compressive strength and cement waste

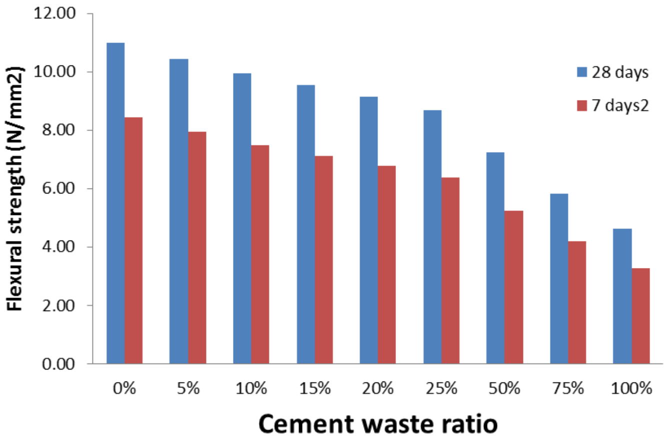

Fig (8) Relation between flexural strength and cement waste

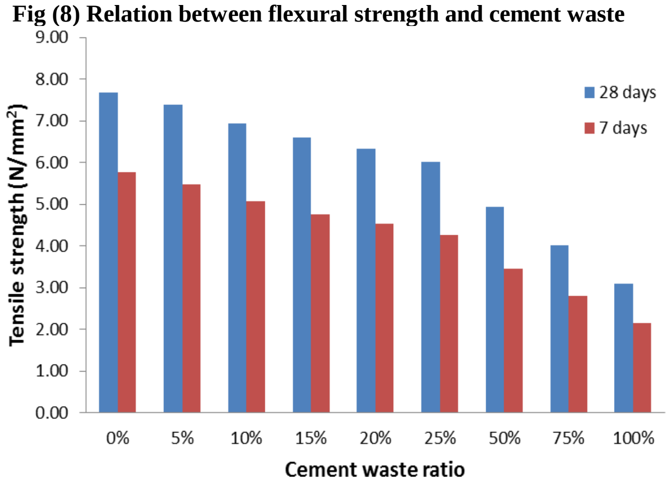

Fig (9) Relation between tensile strength and cement waste

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2. Effect of varied joints

The compressive strength results at 28 days of concrete with FCJ at quarter, middle, three quarter were presented in Figure (10).It was observed that the compressive strength of concrete with FCJ at (quarter, middle, three quarter) were decreased by (23%, 17% and 22%) respectively at time 24 hours comparing with control mixture. Due to the occurrence of separation between concrete layers, where are designed of the concrete elements as one layer, while in the case presence FCJ became two layers.

Figure (11), It was observed that the flexural strength of concrete with FCJ at (quarter, middle, three quarter) were decreased by (28%, 22% and 26%) respectively at time 24 hours comparing with control mixture.

Figure (12).It was observed that the tensile strength of concrete with FCJ at (quarter, middle, three quarter) were decreased by (25%, 19% and 24%) respectively at time 24 hours comparing with control mixture.

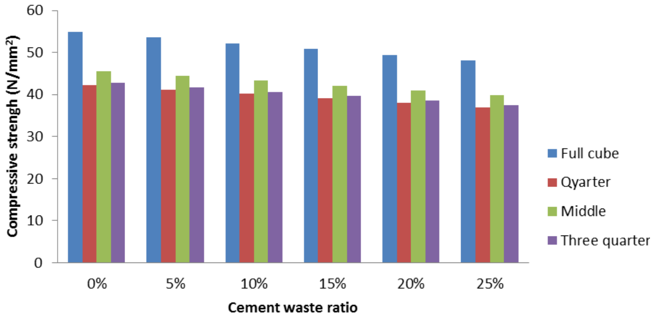

Fig (10) Relation between Compressive strength and varied joints

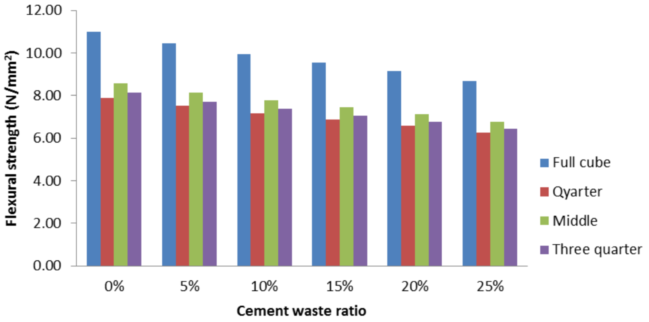

Fig (11) Relation between flexural strength and varied joints

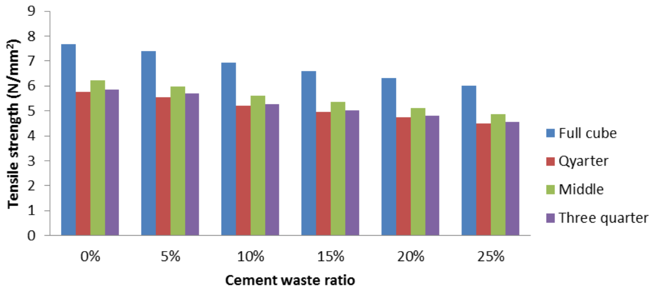

Fig (12) Relation between tensile strength and varied joints

IV. CONCLUSION

The results of the experimental work on different SCC mixes incorporating cement waste and dimensions in order to investigate the effect of horizontal crack and compressive strengths of SCC with horizontal crack or construction joint have been considered in this research. The following conclusions can be drawn:

- From Experimental study it is observed that, in the case of replacement with cement waste to 15% of cement content results were acceptable for workability.
- Slump flow and blocking ratio of SCC decreased when CW as replacement increased. As a result of changing CW from 0.0 to 100% by replacement of cement, the slump flow and blocking ratio changed from 790 to 400 mm and 1 to 0.45% respectively
- Taking care should be taken into consideration for construction joint erection of SCC where a reduction of compressive strength of SCC was reduced by (17-23%).
- Taking care should be taken into consideration for construction joint erection of SCC where a reduction of flexural strength of SCC was reduced by (22-28%).
- Taking care should be taken into consideration for construction joint erection of SCC where a reduction of tensile strength of SCC was reduced by (19-25%).

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REFERENCES

[1] Yogesh Aggarwal, Surinder M Gupta "Self-Compacting Concrete - Procedure for Mix Design" Leonardo Electronic Journal of Practices and Technologies ISSN 1583-1078 Issue 12 p. 15-24, June 2008.

[2] Nan Sua, Kung - Chung Hsub, His - Wen Chaic "A Simple Mix Design Method for Self-Compacting Concrete" Cement and Concrete Research 31 1799–1807, 2001.

[3] Uysal, Kemalettin Yilmaz, "Effect of mineral admixtures on properties of self-compact in concrete", Cement & Concrete Composites 33, 771–776, June 2011.

[4] Shreyas Panduranga Setty "The Effects of Construction Practices on Concrete Construction Joint Performance" Master of Science in Civil Engineering presented, Construction Engineering University on May 27, 2016.

[5] Rafat Siddique "Properties of self-compacting concrete containing class F fly ash" Materials and Design 1501–1507, Journal 32 (2011).

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 7 Issue 6, December 2017

[6] H. A. Mohamadien "the impact of the time when casting the second layer of concrete on its mechanical properties" Journal of Engineering Sciences, Assiut University, Faculty of Engineering, Vol. 41, No. 3, , pp. 919 – 929 May 2013.

[7] S. Ishihara, H. Mihashi "Experimental Study on the Mechanical Behavior in Construction Joints of Concrete Structures" AEDIFICATIO Publishers, D-79 J 04 Freiburg, Germany May 2001.

[8] Nagib N. Gerges, Camille A. Issa, Samer Fawaz, "The Effect of Construction Joints on the Flexural Bending Capacity of Singly Reinforced Beams" Case Studies in Construction Materials 5, 112–123, may 2016.

[9] Ashraf M. Heniegal, "Investigation of Cracks in Self Compacting Concrete by Using Ultrasonic Pulse Velocity", Journal of Engineering Sciences, Assiut University, Vol. 37, No. 1, pp.63 -84 , January 2009.

[10] V. R Rathi, P. K. Kolase, "Effect of Cold Joint on Strength Of Concrete" International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization)Vol. 2, Issue 9, September 2013.

[11] Frank Dehn, Klaus Holschemacher and Dirk Weiße, "Self-Compacting Concrete (SCC) Time Development of the Material Properties and the Bond Behavior", Institute fur Massivbau und Baustofftechnologie, Universidad Leipzig master 2000.

[12] P.L. Domone, "A Review of the Hardened Mechanical Properties of Self-Compacting Concrete", Elsevier journal and Cement & Concrete Composites 29 1–12, 2007.

[13] Zena Waleed Abass "Effect of Construction Joints on Performance of Reinforced Concrete Beams" Al-Khwarizmi Engineering Journal, Vol. 8, No. 1, PP 48- 64, 2012.

[14] Qais Abdul-Majeed "Evaluation of Transverse Construction Joints of Reinforced Concrete Beams" Eng. & Tech. Journal, Vol.28, No.14, 2010.

[15] Ahmed F. Al hallaq "Improving Bond Strength between Concrete over Layers" degree of master the Islamic University-Gaza, Faculty of Engineering Civil Engineering Department 2014.

[16] A. Torres, A. Ramos-Cañón 1, F. Prada-Sarmiento, M. Botía-Díaz, Mechanical behavior of concrete cold joints, Revista Ingeniería de Construction RIC, Vol 31 No 3 2016. www.ricuc.cl.

[17] Arbelàez, J., Rigueira, V., Marti, V., Serna, R., Pinto, B., Bond Characteristics of Prestressed Strand in Self-Compacting Concrete, 3rd International RILEM Symposium on Self-Compacting Concrete, 684-691 (2003).

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