A COMPARISON STUDY OF INITIAL SURFACE ABSORPTION PROPERTY FOR CONVENTIONAL AND SELF COMPACTING CONCRETES [+]

دراسة مقارنة بين خاصية الامتصاص السطحي الابتدائي للخرسانة العادية والخرسانة الذاتية الرص

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Abstract :

In this study ,an experimental investigation is carried out to compare the initial surface absorption (ISA) as well as compressive strength between self compacting concrete (S.C.C) and ordinary concrete . Two series of mixes were cast , one belonged to ordinary concrete while the second was for (S.C.C). Additives included in these mixes were limestone dust and Super plasticizer of retarding effect called (Glenium 51) with a ratio by weight of cement of (2 %).The tests performed on the fresh state of both types of concrete were , slump , slump flow , T 50 cm , U – box flow , flow time of V funnel, as well as , flow time of V funnel at T = 5 sec . In the hardened state , initial surface absorption , and compressive strength were measured for both types of concrete.Results indicated Slump flow of S.C.C was about (8) times more than that of conventional concrete , while ISA of S.C.C was about (5) times less than that of conventional concrete . S.C.C . Compressive strength of S.C.C was about (25 %) higher than that of conventional at age (28) days , but at age of (14) days , both types of concrete showed same compressive strength .

المستخلص:

في هذه الدراسة ، تم انجاز تحري عملي لمقارنة خاصية الامتصاص السطحي الابتدائي إضافة إلى مقاومة الانضغاط بين الخرسانة الذاتية الرص والخرسانة العادية .تم صب نوعين من الخرسانة ، الأولى تنتمي إلى الخرسانة العادية بينما الثانية تنتمي إلى الخرسانة الذاتية الرص . تم استخدام المضافات في هذه الخلطات وهي مادة غبار الحجر الجيري و (الملدن الفائق نوع Glenium 51) ذو التأثير المبطئ بنسبة وزنيه مساوية إلى (٢ %) من وزن السمنت في صناعة الخرسانة الذاتية الرص .أن الفحوصات التي تم أجراؤها في حالة الخرسانة الطرية لنوعي الخرسانة هي فحوصات الهطول ، انسياب الهطول ، الزمن المستغرق للوصول لجريان (٥٠) سم ،زمن الجريان من الصندوق الحرف U ،زمن الجريان خلال القمع بالإضافة إلى زمن جريان الخرسانة في القمع خلال الزمن (٥ دقيقة). أما في الحالة المتصلبة للخرسانة فقد تم فحص الامتصاص السطحي الابتدائي ومقاومة الانضغاط لنوعي الخرسانة باستخدام مكعبات قياس (١٥) سم .أشارت النتائج إلى كون جريان الهطول في الخرسانة الذاتية الرص أكثر بمقدار (٨)مرات من الهطول في الخرسانة العادية، بينما كان مقدار ألامتصاص السطحي الابتدائي في الخرسانة الذاتية الرص أقل بمقدار (٥) مرات عنه في الخرسانة العادية. مقاومة الانضغاط في حالة الخرسانة

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الذاتية الرص كانت (٢٥) % اكبر من نظيرتها في حالة الخرسانة العادية الرص وذلك في العمر (٢٨) يوم ولكن كانت مقاومة الانضغاط متساوية تقريبا لنوعي الخرسانة بالعمر (١٤) يوم. .

Introduction

Self Compacting Concrete (S.C.C.) as a highly flow able ,non segregating concrete that can spread into place ,fill the form work ,and encapsulate the reinforcement with out any mechanical consolidation [1] **.** (S.C.C.) was processed by Okamara in Japan 1986, to achieve a durable concrete, without the need for skilled work to maintain the required compaction . (S.C.C.)can be compacted into every corner of a framework , purely by means of its own weight . Contractors are currently exploring the use of (S.C.C.) because it may produce members with homogenous quality even in highly congested ,narrow members , such as, prestesses concrete members. The use of(S.C.C.) is characterized by its flow ability , segregation resistance as mentioned before as well as passing ability and mold surface finishing .

The basic components for the mix composition of (S.C.C) are the same as those used in conventional concrete . Mineral and chemical admixtures are necessary to be used in the mixture to obtain the required properties of fresh concrete in (S.C.C.)**.** A comparison between conventional and (S.C.C.) concrete is explained in Table (1) below ;

Mix in Gradient	Conventional Concrete %	S.C.C. %
cement	10	10
Aggregate 0 - 2 mm	20	35
Aggregate 2 - 16 mm	50	30
Filler	-	10
Water	10	10
Air	2	1
Admixture	-	1

In general , the fines content in (S.C.C.) is much higher than in conventional concrete for stability requirements .The cement content is often in the range of (450-500)kg/$m^{3.}$

Kennedy [2] proposed the "Excess Paste Theory " which explains the fact of the need for higher content of cement .This theory relates the higher cement content not for cover the surface area of the aggregates , but also to provide well dispersion for the aggregates .The well dispersion aggregates leads to better workability which is ,the main characteristic of fresh (SCC) **.** The properties of fresh (SCC) is closely related to the " rheological " properties of the material [1, 2] .

Rheology is the science of deformation and flow of the material which is concerned with the relation ship between stress , strain ,rate of strain with time .To quantify the workability of (SCC)**,** two aspects should be considered . First is the " Shear Viscosity " and , second is " Yield Stress " .These two aspects depend on the micro structure of the cement paste matrix . Shear viscosity and yield stress of the matrix *must be reduced* to attain higher deformability and workability for fresh mix .

Bingham model [3] describes the rheological behavior of fresh (SCC) . The Bingham model is as follows :-

$\tau = \tau_0 + \eta\gamma$
Where :
τ_0 : Yield stress viscosity
η : Viscosity
γ :Shear strain rate

From the formula above it is obvious that flow can not occurred unless overcoming the yield stress . Once the concrete starts to flow " shear stress " increases linearly with the increase in the strain rate as defined by " Plastic Viscosity" .

Two targets must be provided by the designers , the first , in reducing yield stress (τ_0) as possible as to achieve " Newtonian Material Behavior " with zero yield stress and higher concrete mobility . The second is , to increase viscosity to be segregating resistance.
(SCC) is designed with limited nominal maximum size of the coarse aggregate and higher ratio of fine to coarse aggregate . Water to cementations ratio must kept as low as possible with using higher amount of High Range Water Reducing Admixtures [4 . 5 . 6] .

In general , rounded and crushed aggregates can be used successfully in (SCC) production with a maximum size of (10-20) mm .Well graded and good quality aggregate must be used to ensure good bond between the aggregate and matrix . [5]

In hardened state of (SCC) , it is expected that well designed , homogenous , mobile and segregation resisting ,are reflected in its ability to fill framework better without the need for vibration .This will encourage minimal interfacial zones to develop between the coarse aggregate and matrix .The micro structure of (SCC)is expected to be improved promoting strength , permeability and durability . (S.C.C.) has many advantages over conventional concrete which can be summarized as follow : [7]

1. Eliminating the need for vibration .
2. Decreasing the construction time and labor cost .
3. Reduction the noise pollution .
4. Improving the filling capacity of highly congested structure members .
5. Improving the interfacial transitional zone between cement paste and aggregate or reinforcement .
6. Decreasing the permeability and improving durability of concrete .
7. Facilitating constructability and ensuring good structure performance .

Research Significance:

Limited data exist regarding the effect of self compacting upon some important properties of this type concrete . This study is focused mainly upon the absorption of the surface directly and the inner body indirectly . The absorption of the outer zone is of great interest , because this zone which protects the steel reinforcement , and the porosity of the inner body are important also , which affect the other properties of this type of concrete. Surface absorption is measured directly using the " Initial surface Absorption" (ISA) technique, while ," strength " is measured as an indirect indication about the inner porosity of the concrete body and , it is the most important property which , must be investigated . These tests are compared with those corresponding in conventional concrete .

Experimental work:

1- cement :Ordinary Portland cement of AL-Kaseem cement is used in this work. This cement is available in the local market . The physical and chemical properties are carried out according to the IQS 5-1984 in Institute labs. Table (2) and Table (3) below explain the tested properties .

Table (2): Physical Properties of cement

property	Test result	IOS 5-84 limits
Gravity(gm/cm^3)	3.15	>3.12
I.S.T.(min)	138	> 45
F.S.T.(hrs.)	8	<10 hrs
Fineness Blain (cm^2/gm)	3200	>2300
Soundness(Autoclave %)	0.2	<0.8
Compressive strength (Mpa) (3 days)	18	>15
(7 day s)	25	>23

Table (3): Chemical Properties o f Cement

Oxide	Test result	I.Q.S 5-84 limits	
CaO	61.7	-	
SiO_2	20.5	-	
Al_2O_3	6.0	-	
Fe_2O_3	3.3	-	
MgO	4.3	< 5	
SO_3	2.2	<٢,٨	
I.R.	٠,٩	<١,٥	
L.O.I	1.8	<٤	
Main compound %			
C_3S	$C_٢S$	C_3A	C_4AF
٤٤	٢٦	١٠	١٠

2- Filler : limestone dust filler is used in the study . The filler is highly pure lime . Its fineness and the main cement Oxide of chemical properties are measured according to B.S.7979 , and results are tabulated in the Table (4) .

Table (4):- Chemical Properties of Limestone Dust

Oxide	Test result %
CaO	53.1
SiO_2	١,٤
Al_2O_3	٠,٧
Fe_3O_3	٠,٢
MgO	٠,١
SO_3	٣,٢
L.O.I	٤٠,٦

3- Fine aggregate **:** Al Akhaidar sand is used in this study . Its specific of gravity was (2.6) and sulphate content was(0.2%). The grading of the sand is compatible with Zone(2) of fine aggregate grading according to the IOS 45-84. Table (5) illustrates its gradation .

Table (5):- Gradation of Fine Aggregate

Sieve size (mm)	%passing	IOS 45-84 Limits%
٤,٧٥	١٠٠	٩٠-١٠٠
٢,٦٣	٨٠	٧٥-١٠٠
١,١٨	٦٤	٥٥-٩٠
٠,٦	٣٩	٣٥-٥٩
٠,٣	٣٢	٨-٣٠
٠,١٥	١	٠-١٠

4- .Coarse Aggregate :- AL-Nebaee rounded aggregate is used in this study with a maximum aggregate size (14)mm . Its specific of gravity was (2.7) and the sulphate content was(0.1 %). Table (6) shows the gradation of the aggregate which conforms to IOS 45-84 .

Table (6) :- Gradation of Coarse Aggregate

Sieve size (mm)	%passing	IOS 45-84 Limits%
١٤	٩٨	95 - 100
١٠	٣٢	30 - 60
٤,٧٥	١٠	0 – 10
٢,٣٦	٠	0 - 5

5- Super plasticizer **:-** super plasticizer is an important component to produce high workable and stable fresh mix (Gleniume 51) was used in this study which is highly effective super plasticizer with hardening retarder as subsidiary effect . Gleniume51 has a powerful plasticizing effect as it has added by (2-5)% by weight of cement .In this study (2%) by weight of the cement is added to ensure the required flowability and good porosity as recommended by manufacturer . The addition time was at the end of the mixing process

while we have a fresh mix of about (80 mm) initial slump. The addition process at this time is more effective to achieve flowable concrete of final slump of (160 mm upward). Table (7) gives some technical description about Gleniume51 .

Table(7) : Typical Properties of (Sp)

Main action	Concrete super plasticizer
Subsidiary effect	Hardening retader
From	Viscous liquid
Co lour	Light brown
Relative density	1.1 at 20C°
Viscosity	128 ± 30 Cps at 20C°
Ph. value	٦,٦
Transport	Note classified as dangerous
Labeling	No hazard table required

6- Mix Proportions : Table (7) shows mix proportions used in this study for conventional concrete and S.C.C. Mix proportion for S.C.C. is used conforming with the international limitations . The design for conventional concrete is based on the basic of medium slump (80-100) mm with a required strength of (30 Mpa) at the age of (28 days). From Table (8) we can see that , fines material was about (1050)kg/m^3 and the fine aggregate and coarse aggregate were fixed to (40 and 50)% of motor volume and solid volume of concrete respectively. Water powder ratio is assumed to be (0.5) as recommended by literatures . [8 , 9]

Table (8) : Mix Proportions for Conventional and S.C . Concretes

Material	Content kg/m^3 (Conventional)	Content kg/m^3 (S.C.C.)	Limitations According to DIN 1045 kg/m^3 (S.C.C.)
Cement	٤٥٠	٤٥٠	(450-500)
Fine Aggregate	675	٤٥٠	(325-525)
Fillers	-	١٥٠	(50-150)
Coarse Aggregate	990	٧٥٠	(750-920)
Sp (Liter/100 kg) Cement	-	٢٣	-
Water	٢٠٠	٢٠٠	-

7- Mixing Process **:** Coarse aggregate with one third of water is added to a mechanical tilting –mixer of (0.05m^3)volume .The materials are mixed to about (2 min). Mixture of filler and cement is added with one third of water to the mixer and thoroughly mixed to about (1 min) .

After that fine aggregate and the remaining water is added and mixed gradually while the provided aqueous plasticize is added to ensure higher workability .The total time of mixing is not exceed(5 min) to be able to measure workability and casting without the risks of slump loss.

8- . Tests performed : The tests performed on the fresh concrete were slump flow and T50 cm, U-box flow (H_1-H_2) and the V-funnel time and the increase in the flow time in V funnel at T= 5 min to ensure filling ability , passing ability and segregation resistance . All of these test , are performed in fresh state of (S.C.C.) , and the conventional fresh concrete is tested for slump only . Table (9) shows the result of these tests for fresh state of conventional and (S.C.C.).

Table(9): Test Results of Fresh Concrete

Property	Concrete type	Test result	Limitations
Slump	Conventional	90	(80-100)
Slump flow	SCC	٧٦٠	(650-800)mm
T50 cm slump flow	SCC	3.5 cm	(2-5)SCC
U-box (H_1-H_2)	SCC	٢٠	(0-30)mm
V_{Funnel}	SCC	٨	(6-12)SCC
$V_{Funnel\ at\ T5\ min}$	SCC	١٠	+3 Sec max

In the hardened state, initial surface absorption (ISA) is tested on cubes specimens size (15*15*15)cm at the ages (1,3,7,28) days .The technique consists a small plastic pipe , fixed from one end to a glass funnel to provide a head of water of (20) cm . This head is only slightly greater than that which would be caused by driving rain . The other end is fixed to graduated scale . This scale measures the quantity of the absorbed water from the surface. A metal cup is fixed to the tested surface of concrete . The duration for the absorption is selected to be (2 hrs.) . The same specimens are tested thereafter at the ages(3 , 7 , and 28 days)to determine their compressive strength.(ISA) is performed according to the B.S. 1881 :part 5-70 , while compressive strength is performed according to B.S. 1881: part 116 : 83 .

Figure (2) shows the trends of (ISA) for the different tested ages of the both types concretes , while Figure (3) shows the behavior of strength for both types concretes at the investigated ages .

Results and Discussion :

1. Fresh concrete state :

From Table (8) we can say that the conventional and (SCC) were made successfully according to the slump and workability requirements .Slump flow for (S.C.C.) is about (8) times more than slump of conventional one , and this is related to the well-dispersion of water and more mortar available to minimize the frictional forces between the coarse aggregate .Mortar played as a lubricating agent to maximize the flowability of fresh (SCC) [3].

2. Hardened Concrete State :

Figure (1) which shows the (ISA) for the conventional and (S.C.C.)concretes , explains that the absorption of SCC is less than that of conventional one at the same ages (1,3,7, and 28)days .Figure also indicates for sharp drops in the absorption at the ages (3 to 28 days) for (S.C.C.) concrete as compared with those of conventional concrete .The behaviors are inverted for the ages (1 to 3) days .These behaviors indicate to the well performance of (S.C.C.) at later ages investigated . The explanation for that, may be related to the gradual effect of filler in (S.C.C.) as pore filler especially at later ages [10] . This will accompany with good mold finishing and reflected positively on the surface absorption . from the Figure , the (ISA) at the age of (28) days was about (0.15 ml/ m2/sec.) for (S.C.C.) , is regarded low as mentioned in the standards [11] , while , the corresponding was about (0.5 ml/m2/sec), which is regarded in this standard high .finally , Surface absorption for (S.C.C.) can be regarded better as compared with conventional concrete , especially at the age of (28) days .

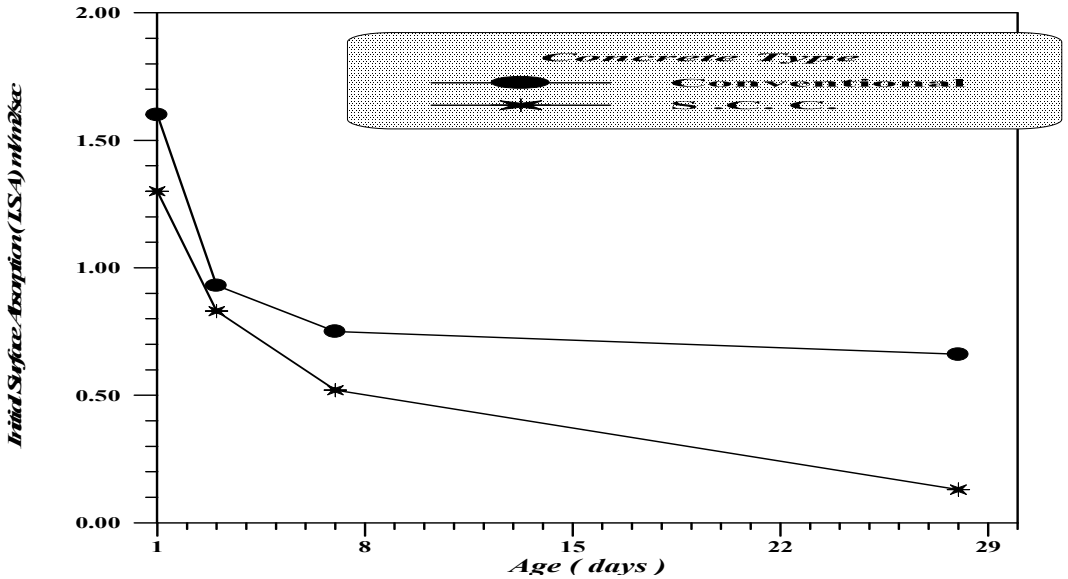

Fig. (1) Relation between I.S.A and Age for Convent
ional Concrete and S.C.C

Figure (2) shows the behavior of both types concretes in compressive strength . we can see that (SCC) is more adequate for strength requirement at the ages of (7 to 28) days . It was about (40)% more than the strength of conventional concrete at the age of (28) days .The conventional concrete is designed to achieve (30 MPa) at (28 days) age and it had about (32) MPa. (S.C.C.) in the same content of cement gained strength of about (35 up to 42) MPa .This trend of the strength is agreed with the behavior of this concrete in its fresh state [12] . More homogenous and well dispersion of cement particles led to less voids and reflected positively on its strength [13 , 14] . Compressive strength for both type of concretes were unique at the age of (14) days as obvious from the Figure .

We can say that porosity and permeability are measured directly by (ISA) and indirectly by its compressive strength as compressive strength was a reflection of concrete density .

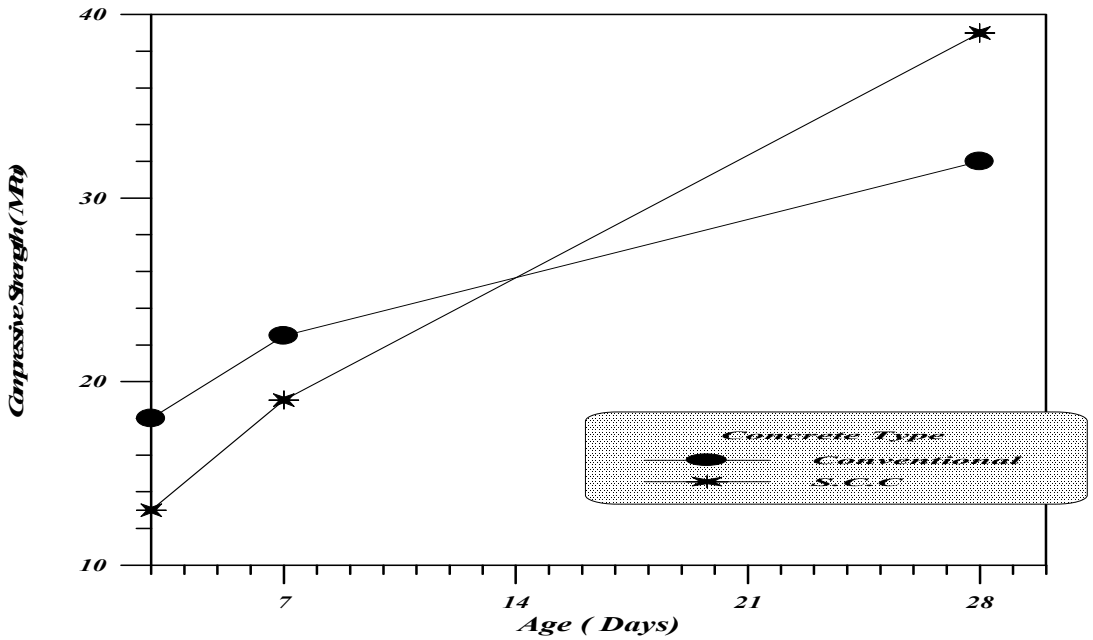

Fig.(2) Relation between Compressive Strength and Age for Conventional Concrete and S.C.C

Conclusions :

According to the materials properties used and circumstance of tests ,the following conclusion can be drown :

1. S.C.C. can be produced successfully from the available material used which is conformed to the international standards .
2. workability of SCC was about (8) times more than conventional as measured by slump flow .
3. S.C.C. was better than conventional concrete on the basis of (ISA) especially at the age of (28) days , S.C.C. was less absorbed to water as measured by (ISA) by about (5) times than that corresponding in conventional concrete.
4. On the basis of (ISA) , (S.C.C.) can be classified as low absorbent concrete , while conventional concrete is classified as high absorbent one .
5. Compressive strength of S.C.C. is about (40)% more than that of conventional concrete measured at the age of (28) days .
6. Compressive strength was about the same in both type of concretes at the age (14) days .

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