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Evaluation the Performance of Self Compacted Concrete with Polypropylene

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***Abstract* – Self Compacted Concrete (SCC) is very flowable concrete that do not need compaction. SCC is high flow or workability and it fills molds and congested spaces around reinforcement under its own weight. This is also called workability or filling ability (meaning it fills a form easily).**

(SCC) performance was evaluated using cubes and cylinders with various levels of admixtures and adhesives. Results for cubes and cylinders show highest maximum load and average stress for G40 and G50 concretes.

***Keywords* – Self Compacting Concrete, Maximum Load, Stress.**

I. Introduction

For several years, the problem of durability of the concrete structures was a major topic of interest.

The creation of durable concrete structures requires adequate compaction by skilled workers.

However, the graduate reduction in the number of skilled workers leads to a reduction in the quality of construction and a waste cost and time for vibrating and repairing concrete after hardening [1].

Testing of (SCC) was first completed in 1988 using materials available in the local market. Since then, several investigations were carried out to achieve an appropriate mix design for a standard concrete, which is comparable to normal concrete. SCC is defined as the concrete mix that do no need additional compaction. SCC is self compacting due to its weight and flows like "honey" and has nearly a horizontal concrete level after placing.

With regard to its composition, self-compacting concrete consists of the same components as conventionally vibrated normal concrete, which are cement, aggregates, water, additives and admixtures.

However, the high amount of super plasticizer for reduction of the liquid limit and for better workability, the high powder content as "lubricant" for the coarse aggregates, as well as the use of viscosity-agents to increase the viscosity of the concrete should be taken into account.

In principle, the properties of the fresh and hardened SCC, which depend on the mix design, should not be different from normal concrete.(SCC) should have a slump flow (SF) of approximately . Larger than 65 cm after pulling the flow cone [1, 2].

II. Advantages of Using Self-Consolidating Concrete

SCC can be placed at a faster rate with no mechanical vibration and less screening, resulting in savings in placement costs. Also, it provides Improved and more uniform architectural surface finish with little to no remedial surface work, ease of filling restricted sections and hard-to-reach areas.

SCC opens Opportunities to create structural and architectural shapes and surface finishes not achievable with conventional concrete, improved consolidation around reinforcement and bond with reinforcement, improved pump ability, improved uniformity of in-place concrete by eliminating variable operator-related effort of consolidation, labour savings, shorter construction periods and resulting cost savings. Quicker concrete truck turn-around times, enabling the producer to service the project more efficiently, Reduction or elimination of vibrator noise, potentially increasing construction, Minimizes movement of ready mixed trucks and pumps during placement, Increased jobsite safety by eliminating the need for consolidation.

There are three types of SCC mixes: 1) High powder content and a high-range water reducing admixture (HRWRA), 2) Low powder content, HRWRA, and a viscosity-modifying admixture, and 3) Moderate powder content, HRWRA, and a moderate dose of VMA.

The powder referred to here is all the fine materials, including cement, fly ash, and ground granulated blast furnace slag, silica fume, and ground limestone filler. This thickenss of the mix, keeping the coarse aggregate stable in the matrix and also contributes to slump flow. Here are some things to understand the materials in an SCC mix:

The fraction of coarse aggregate in the mix will be much lower (about 30%) and the size will be smaller (about ½ inch maximum).

The amount of Portland cement will typically be low—less than 300 pounds/cubic yard, or less than half of the total cementations materials . Other cementations materials will be high—fly ash in the range of 20 to 40% of total cementations materials; slag in that range also, and often some silica fume. The powder, which includes the cementations materials, may be supplemented with ground limestone.

The water-cementations materials ratio is often quite low—as low as 0.27 in some mixes, although 0.4 is more typical. Viscosity-modifying admixture (VMA) increases the viscosity to keep the mix stable. Without a lot of powder in

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the mix, VMA is used to thicken the mix and prevent segregation. "The quarries ship what they want but the ready-mix producers need to have a mix that works every day and the VMA keeps it consistent." In other parts of the country, though, well-graded, high-powder mixes tend to be the norm [3].

High-range water reducers for SCC mixes have recently been mostly those based on Polycarboxylates, which have an incredible ability to increase slump at low dosages. Polycarboxylates, though, have created problems with foaming and adding unwanted air to the mix, so a de-foaming agent is added. This has not always been successful, although the admixture manufacturers are getting much better. There have also been some problems with sudden slump loss. Chemical, recommends that for longer haul distances, the producer should consider using a naphthalene-based HRWRA instead of Polycarboxylates. Keep in mind that SCC mixtures are a little complicated, requiring just the right balance between all the materials, water, and admixtures.

III. Mix Design

SCC looks very different from conventional concrete while mixing. Concrete producers must “retrain their eyes” for this very fluid mixture as it turns corners and fills forms. Traditionally, concrete with the fluidity of SCC has had a very high water-to-cement ratio, which would lower compressive strengths and compromise durability. Properly designed SCC can save time and labor without sacrificing performance.

Two important properties specific to SCC in its plastic state are its flow ability and stability. The high flow ability of SCC is generally attained by using high-range water-reducing (HRWR) admixtures and not by adding extra mixing water. The stability or resistance to segregation of the plastic concrete mixture is attained by increasing the total quantity of fines in the concrete and/or by using admixtures that modify the viscosity of the mixture. Increased fines contents can be achieved by increasing the content of cementititious materials or by incorporating mineral fines [4, 6].

The grading of available aggregate sources cannot be optimized for cohesive mixtures or with large source variations. A well distributed aggregate grading helps achieve SCC with reduced cementations materials content and/or reduced admixture dosage. While SCC mixtures have been successfully produced with 1 ½ inch (38 mm) aggregate, it is easier to design and control with smaller-sized aggregate. Control of aggregate moisture content is also critical to producing a good mixture.

SCC mixtures typically have a higher paste volume, less coarse aggregate, and higher sand-to-coarse aggregate ratio than typical concrete mixtures. SCC mixtures can be designed to provide the required hardened concrete properties for an application, similar to regular concrete. If the SCC mixture is designed to have a higher paste content or fines compared to conventional concrete, an increase in shrinkage may occur [7].

Table 1: Typical range of SCC mix composition

Constituent	Typical range by mass (kg/m^3)	Typical range by volume ($liters/m^3$)
Powder	380-600	160-240
Paste		300-380
Water	150-210	150-210
Coarse aggregate	750-1000	270-360
Fine aggregate (sand)	Content balances the volume of the other constituents, typically 48 – 55% of total aggregate weight	
Water/Powder ratio by Volume	0.85-1.10	

Performance

SCC gives architects more design flexibility. SCC's unique characteristics give architects much more flexibility for vertical and horizontal applications [8, 9]. SCC flow ability allows for more complex and aesthetic concrete design features. Unlimited opportunities exist with innovative options for color and texture of exposed surfaces. Perhaps most importantly, SCC produces exposed surfaces that are virtually defect free, allowing concrete's beauty to shine.

High performance concrete requires high-performance admixtures, and full lines of concrete additives exist to make durable and cost effective SCC. Placement efficiencies can increased by 300% and labour costs can be reduced by 70%. Architects and engineers will benefit from increased design flexibility without sacrificing performance or increasing placement costs.

Self-Compacted Concrete

SCC is very flowable concrete that do not need to be consolidated to fill forms or flow. Placed flat, like for a slab, it is virtually self-leveling. It looks a little like lumpy pancake batter. The consistency is measured by what's called slump flow, where we measure the width of the puddle left when a slump cone is filled and lifted. Slump flow for SCC varies from 19 to 30 inches. But self-consolidating concrete is NOT simply concrete that flows. If that's all there was to it, we could just use lots of water. The currently accepted definition of what makes good SCC has three parts: Then, of course, there is SCC after it gets hard. And, magically, it is not much different than conventional concrete. In fact, since we use superplasticisers (high-range water reducers) to achieve the flow ability, and lots of fines, we can often proportion the concrete for very low water-cement ratios and get very high strengths and low permeability [2].

Methodology

The methodology includes testing types of concrete mixes with and without additives. A total of 60 samples were tested in laboratory for several properties of concrete.

The test blocks used were 300x150 mm cylinders (150 mm in diameter and 300 mm high) and 150x150x150 mm cubes. Both cylinders and cubs are for compressive strength.

Concrete mixture is composed of aggregate (Coarse, Medium, Crushed & Silica), then we added Ordinary Portland cement and Additives (Super plasticizer (GLENIUM 51)) and Water with continuous cranking by using a mixer.

The samples were kept in water tanks under laboratory condition for 28 days until testing. All the strength results are the average of three specimens for each concrete mix [5].

Fig. 1. Cylinders and cubes used in this project.

Materials and Experimental Method

The main objectives of this research are to study of Self Compacted Concrete properties & Effects. Other objectives of this project are study the effect of polypropylene monofilament fibers on concrete mechanical properties and enhance the concrete binder to improve and enhance the overall mix concrete properties and performance.

The mixture contains ordinary Portland cement (THABET), coarse aggregate (Basalt materials), medium aggregate (Basalt materials), crushed aggregate (Basalt materials), Fine aggregate (silica sand), Additives: Super plasticizer (GLENIUM 51) and Polypropylene fibbers, and Water [10].

Aggregate Tests

Tests on aggregates used in concrete mix were performed on materials prepared for mix design purposes and the tests are Los Angeles test, specific gravity test.

The abrasive charge shall consist of steel spheres averaging approximately 46.8mm in diameter and each weighing between 390 and 445 g, the results of abrasion charge depending upon the grading of the test sample as in Table 1

The aggregate specific gravity test is used to calculate the specific gravity of coarse and fine aggregate samples by determining the ratio of the weight of a given volume of aggregate to the weight of an equal volume of water.

Specific gravity is a measure of a material's density (mass per unit volume) as compared to the density of water at 73.4°F (23°C). Therefore, by definition, water at a temperature of 73.4°F (23°C) has a specific gravity of 1. The results are shown in Table 2.

Table 2. Properties of used aggregate

Test	Coarse aggregate	Fine aggregate	Filler
Specific Gravity	2.7	2.75	2.635
water absorption%	1.61%	2.712%	2.3%
Loss Angeles test	24%	—	—

Polypropylene Fiber Monofilament

Polypropylene is a plastic polymer, of the chemical designation C3H6. It is used in many different settings, both in industry and in consumer goods. It can be used both as a structural plastic and as a fiber.

With polypropylene as its raw material, this fiber is produced by special technology. The products has net-like structure with many fiber monofilaments connected. When added to concrete, the horizontal structure in fiber monofilament can be destroyed during the course of stirring owing to friction and rubbing, and the fiber monofilament or net-like structure will fully stretch, thus the concrete is reinforced by a great number of polypropylene fibers. As a new type concrete-strengthening fiber.

Admixtures

An admixture is any material, other than water, aggregate, and cement, that is added to concrete during batch mixing or at the job site. Admixtures are used to reduce the total amount of water, to modify properties of concrete, or to help control set.In this study we use Glenium 51. Glenium 51 is a high performance concrete superplasticiser based on modified polycarboxylic ether GLENIUM.51 has been primarily developed for applications in the ready mixed and precast concrete industries where the highest durability and performance is required. GLENIUM. 51 is free from chlorides and complies with ASTM C494 Types A and F. GLENIUM. 51 are compatible with all Portland cements that meet recognized international standards.

The normal dosage for GLENIUM. 51 is between 0.5 and 1.6 litres per 100 kg of cement (cementations material). Dosages outside this range are permissible subject to trial mixes.

Engineering Properties

Self-compacting concrete and traditional vibrated concrete of similar compressive strength have comparable properties and if there are differences. The primary test used in the field for SCC is slump flow, although there are other field tests currently in use. Here is a brief description of each—

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more information can be found in the appropriate ASTM test method specifications

Slump Flow

Flow ability is measured with the slump flow test, which has been standardized as ASTM C 1611, "Slump Flow of Self-Consolidating Concrete." This test starts like a standard slump test, although many testing technicians will turn the cone upside down to make it easier to fill. When the cone is lifted, the SCC spreads out like pancake batter. The slump flow is measured as the diameter of the pancake. Typical SCC mixes have slump flows ranging from 18 to 30 inches.

Fig. 2. Slump Test Result for grade 50 (G50) SCC sample

Results and Recommendations

By using the compression tester to find the maximum load carried by the specimens of all mixes of concrete, and after calculating the compressive strength and strain. The results were as shown in the following tables

A. Test Cubes

A summary of results of testing cubes is given in Table 3.

Table 3: Compressive Strength for Cubes and Average Normal Stress

GRADE	Symbols	Cube	Maximum load kN	Stress MPa	Average Stress MPa
G20	Aa1	√	384.3	17.1	20.05
	Aa2	√	516.8	23	
	Ac1	√	499	22.21	21.765
	Ac2	√	479.7	21.32	
	Ae1	√	719.61	32	33.75
	Ae2	√	800.2	35.5	
G30	Ba1	√	826.8	36.75	33.7
	Ba2	√	689.7	30.65	
	Bc1	√	950	42.3	41.15
	Bc2	√	898.4	40	
	Be1	√	1076	47.82	46.19
	Be2	√	1003	44.56	
G40	Ca1	√	960.3	42.6	43.08
	Ca2	√	980.1	43.56	
	Cc1	√	1154	51.29	50.18
	Cc2	√	1104	49.07	
	Ce1	√	1303	61.47	58.505
	Ce2	√	1250	55.54	
G50	Da1	√	1115.1	49.56	49.83
	Da2	√	1125.3	50.1	
	Dc1	√	1152	52	53.78
	Dc2	√	1250	55.56	
	De1	√	1304	57.97	57.675
	De2	√	1291.2	57.38	
G35	Ea1	√	890.2	39.5	38.95
	Ea2	√	865.2	38.4	
	Ec1	√	971.3	43.17	43.345
	Ec2	√	979.2	43.52	
	Ee1	√	1043	46.36	46.29
	Ee2	√	1040	46.22	

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B. Testing of Cylindrical Samples

Results of testing of cylindrical samples are given in Table 4.

Table 4. Compressive Strength for Cylinders Average Stress

Grade	Symbols	Cylinder	Maximum load kN	Stress MPa	Average Stress MPa
G20	Ab1	√	380.2	21.5	22.05
	Ab2	√	400.3	22.6	
	Ad1	√	306.6	17.35	18.865
	Ad2	√	360.2	20.38	
	Af1	√	480.6	27.2	27.5
	Af2	√	491.2	27.8	
G30	Bb1	√	455	26	25.65
	Bb2	√	449.6	25.3	
	Bd1	√	450	25.4	25.2
	Bd2	√	442	25	
	Bf1	√	577	33	36
	Bf2	√	687.7	39	
G40	Cb1	√	610.2	34.6	34.8
	Cb2	√	654.1	35	
	Cd1	√	727	41.4	41.7
	Cd2	√	741.3	42	
	Cf1	√	878	50	48.75
	Cf2	√	820	47.5	
G50	Db1	√	650.4	37	41.575
	Db2	√	816	46.15	
	Dd1	√	875	49.5	43.05
	Dd2	√	648	36.6	
	Df1	√	870	49.21	49.555
	Df2	√	879	49.9	
G35	Eb1	√	455.1	26	29.13
	Eb2	√	570.1	32.26	
	Ed1	√	739	42	42
	Ed2	√	741	42	
	Ef1	√	595.1	33.66	33.73
	Ef2	√	598	33.8	

RESULTS AND DISCUSSION

For grade (20 MPa), the stress results for the samples without adding (Glenium 51+ polypropylene) (zero) was (20.05 MPa), while the stress results for the samples with adding (Glenium 51(43mil)+ polypropylene(16.5 gr))was equal to (21.76 MPa) with an increase percentage about (8%) from the zero (Glenium 51+ polypropylene) stress value. The stress results for the samples with adding (Glenium 51(86mil)+polypropylene(33gr)) were (33.75 MPa) with an increase percentage about (67%) from the zero (Glenium 51+ polypropylene) stress value, and with an increase percentage about (55%) from the (Glenium 51+ polypropylene) stress value.

For grade (30 MPa), the stress results for the samples without adding (Glenium 51+ polypropylene) (zero) was (33.7 MPa), while the stress results for the samples with adding (Glenium 51(48mil)+ polypropylene(16.5 gr))were (41.15 MPa) with an increase percentage about (23%) from the zero (Glenium 51+ polypropylene) stress value. The stress results for the samples with adding (Glenium 51(96mil)+ polypropylene(33gr)) were (46.19 MPa) with an increase percentage about (37%) from the zero (Glenium 51+ polypropylene) stress value, and with an increase percentage about (12%) from the (Glenium 51+ polypropylene) stress value.

For grade (35 MPa), the stress results for the samples without adding (Glenium 51+ polypropylene) (zero) were (38.95 MPa), while the stress results for the samples with adding (Glenium 51(52.5mil)+ polypropylene(16.5 gr))were (43.345MPa) with an increase percentage about (11.2%) from the zero (Glenium 51+ polypropylene) stress value. The stress results for the samples with adding (Glenium 51(105mil)+ polypropylene(33gr) were (46.29 MPa) with an increase percentage about (18.8%) from the zero (Glenium 51+ polypropylene) stress value, and with an increase percentage about (6%) from the (Glenium 51+ polypropylene) stress value.

For grade (40 MPa), the stress results for the samples without adding (Glenium 51+ polypropylene) (zero) were (43.8 MPa), while the stress results for the samples with adding (Glenium 51(60mil)+ polypropylene(16.5 gr))were (50.18MPa) with an increase percentage about (14.5%) from the zero (Glenium 51+ polypropylene) stress value. The

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stress results for the samples with adding (Glenium 51(120mil)+ polypropylene(33gr)) were (58.5 MPa) with an increase percentage about (33.5%) from the zero (Glenium 51+ polypropylene) stress value, and with an increase percentage about (16.5%) from the (Glenium 51+ polypropylene) stress value.

For grade (50 MPa), the stress results for the samples without adding (Glenium 51+ polypropylene) (zero) were (49.83 MPa), while the stress results for the samples with adding (Glenium 51(62mil)+ polypropylene(16.5 gr))were equal to (53.78MPa) with an increase percentage about (8%) from the zero (Glenium 51+ polypropylene) stress value. The stress results for the samples with adding (Glenium 51(124mil)+ polypropylene(33gr)) was equal to (57.67 MPa) with an increase percentage about (16%) from the zero (Glenium 51+ polypropylene) stress value, and with an increase percentage about (7.2%) from the (Glenium 51+ polypropylene) stress value.

For grade (20 MPa), the strain results for the samples without adding (Glenium 51+ polypropylene) was (0.0021), while the strain results for the samples with (Glenium 51(43mil)+ polypropylene(16.5) gr) was equal to (0.0036) with a increase percentage about (71.4%) from the zero polymer strain value. The strain results for the samples with (Glenium 51(86mil)+polypropylene(33gr)) was equal to (0.00043) with a decrease percentage about (98%) from the zero adding (Glenium 51+ polypropylene) strain value, and with an decrease percentage about (88%) from the (Glenium 51(43mil)+ polypropylene(16.5) gr) strain value.

For grade (30 MPa), the strain results for the samples without adding (Glenium 51+ polypropylene) was (0.00219), while the strain results for the samples with (Glenium 51(48mil)+ polypropylene(16.5) gr) was equal to (0.00395) with a increase percentage about (80.4%) from the zero polymer strain value. The strain results for the samples with (Glenium 51(96mil) +polypropylene (33gr)) were (0.00232) with a decrease percentage about (6%) from the zero adding (Glenium 51+ polypropylene) strain value, and with an decrease percentage about (41.3%) from the (Glenium 51(48mil)+ polypropylene(16.5) gr) strain value.

for grade (35 MPa), the strain results for the samples without adding (Glenium 51+ polypropylene) were (0.001), while the strain results for the samples with (Glenium 51(52.5mil)+ polypropylene(16.5) gr) were (0.00155) with a increase percentage about (55%) from the zero polymer strain value. The strain results for the samples with (Glenium 51(105mil)+polypropylene(33gr)) were (0.0015) with a increase percentage about (50%) from the zero adding (Glenium 51+ polypropylene) strain value, and with an decrease percentage about (3.22%) from the (Glenium 51(52.5mil)+ polypropylene(16.5) gr) strain value.

for grade (40 MPa), the strain results for the samples without adding (Glenium 51+ polypropylene) were (0.00054), while the strain results for the samples with (Glenium 51(60mil)+ polypropylene(16.5) gr) were (0.00285) with a increase percentage about (427.7%) from the zero polymer strain value. The strain results for the samples with (Glenium 51(120mil)+polypropylene(33gr)) were (0.00204) with a decrease percentage about (277.7%) from the zero adding (Gleniuezultsm 51+ polypropylene) strain value, and with an decrease percentage about (28.4%) from the (Glenium 51(60mil)+ polypropylene(16.5) gr) strain value.

For grade (50 MPa), the strain results for the samples without adding (Glenium 51+ polypropylene) were (0.001), while the strain results for the samples with (Glenium 51(62mil)+ polypropylene(16.5) gr) were (0.00155) with a increase percentage about (55%) from the zero polymer strain value. The strain results for the samples with (Glenium 51(124mil)+polypropylene(33gr)) were (0.001505) with a increase percentage about (50.5%) from the zero adding (Glenium 51+ polypropylene) strain value, and with an decrease percentage about (3%) from the (Glenium 51(63mil)+ polypropylene(16.5) gr) strain value.

Stress strain results are shown in Fig. (1)

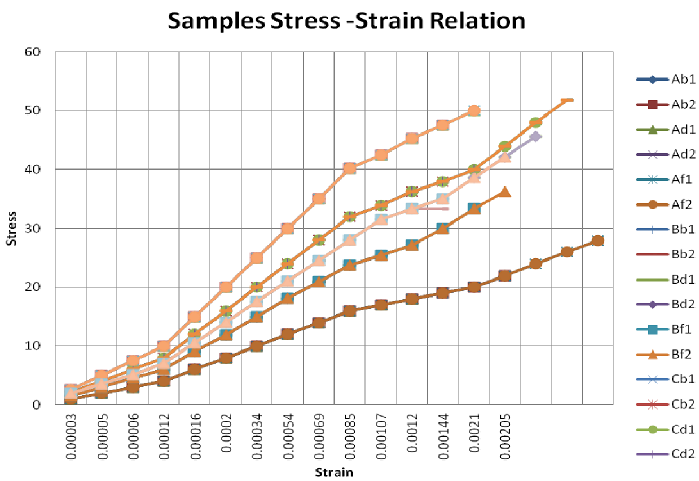

Fig. 1. Stress- strain relations for analyzed samples

Table 5. The Ratio between Stress of Cylinders ($f_c^{/}$) and Stress of Cubes (f_{cu})

Range 0.75-0.85									
Symbols	**f_{cu} Mpa**	**symbols**	**f_c Mpa**	**f_c/f_{cu}**	**Symbols**	**f_{cu} Mpa**	**symbols**	**f_c Mpa**	**f_c/f_{cu}**
Aa1	17.1	Ab1	21.5	1.257	Cc2	49.07	Cd2	42	0.856
Aa2	23	Ab2	22.6	0.983	Ce1	61.47	Cf1	50	0.813
Ac1	22.21	Ad1	17.35	0.781	Ce2	55.54	Cf2	47.5	0.855
Ac2	21.32	Ad2	20.38	0.956	Da1	49.56	Db1	37	0.747
Ae1	32	Af1	27.2	0.850	Da2	50.1	Db2	46.15	0.921
Ae2	35.5	Af2	27.8	0.783	Dc1	52	Dd1	49.5	0.952
Ba1	36.75	Bb1	26	0.707	Dc2	55.56	Dd2	36.6	0.659
Ba2	30.65	Bb2	25.3	0.825	De1	57.97	Df1	49.21	0.849
Bc1	42.3	Bd1	25.4	0.600	De2	57.38	Df2	49.9	0.870
Bc2	40	Bd2	25	0.625	Ea1	39.5	Eb1	26	0.658
Be1	47.82	Bf1	33	0.690	Ea2	38.4	Eb2	32.26	0.840
Be2	44.56	Bf2	39	0.875	Ec1	43.17	Ed1	42	0.973
Ca1	42.6	Cb1	34.6	0.812	Ec2	43.52	Ed2	42	0.965
Ca2	43.56	Cb2	35	0.803	Ee1	46.36	Ef1	33.66	0.726
Cc1	51.29	Cd1	41.4	0.807	Ee2	46.22	Ef2	33.8	0.731

Slump Test Results

Slump test was conducted on samples because it describes concrete mix and the ability of a fresh mix to fill gaps. Slump test results are given in Table 6

Table 6. Result of slump test for Self Compact Concrete (SCC)

Grade	SCC%	Slump(mm)
20	0.75	25
	1.5	Collapse
35	0.75	32
	1.5	Collapse
50	0.75	Collapse
	1.5	Collapse

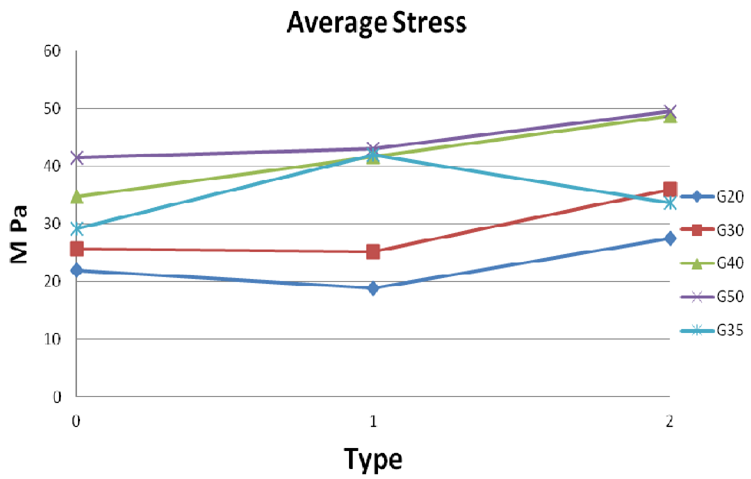

Fig. 2. Average stress for a range of grades

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