Indian J.Sci.Res. 17(2): 268 - 273, 2018

ISSN: 0976-2876 (Print)
ISSN: 2250-0138(Online)

EXPERIMENTAL INVESTIGATION ON CONCRETE SUBJECTED TO DIRECT SHEARING

[1]Nesakumar. R, [2] Nelson Sheriff. S,[3]Gulam Mohammed Moinuddin
[1]Department of Structural Engg, Prathyusha Engg. College, Thiruvallur
[2,3] Department of Structural Engineering,B.S. Abdur Rahman University,Vandalur

Abstract- This dissertation describes an experimental investigation to evaluate the shear strength and behavior of concrete. The main purpose of this investigation is to determine the direct shear strength of concrete using various by-products and to find out shear failures of the specimens which were tested under Universal Testing Machine (UTM). The specimen we use is push-off specimen and in order to increase the performance and to identify the shear behavior it has been used. Under 14 combinations we have casted and the combinations are done with controlled concrete (CC with no replacements) and the replacement proportions are G10, GP10/5, GP10/10, GS10/1, S10, SP10/5, SP10/10, SS10/1, R10, RP10/5, RP10/10, RS10/1, CCS1. And the above proportions are done by volume. The ad-mixtures we use are natural ad-mixtures like rice husk ash, some recyclable materials like plastics (PP) and by-products like silica fume. Due to enormous growth in concrete, aggregates are facing crisis so, it is found that using of recyclable plastic materials will give results to solve environmental issues caused by plastics. So we have partially replaced fine aggregates with plastics and also with steel fibres to enhance strength. Concrete containing silica fume is a pozzolanic material for high performance of concrete and concrete containing rice husk ash will have more durable and it will be the key to long service life to concrete structures. So we have partially replaced cement with silica fume and rice husk ash. The above ad-mixtures we have choose is also for eco-friendly and economical terms. The procedure involves casting, de-moulding, curing and testing. In order to observe shear failure accurately the curing of the specimen should be done for 28days. Moreover, throughout the study using of steel fibers with concrete gives more durability, strength and longlife-span.

Keywords– UTM, Supplementary Cementitous Materials, workability, compressive strength, direct shear

I. Introduction

Concrete is one of the most extensively used construction material in the world with two billion tons placed worldwide each year. During the past few decades the potential of Portland cement in terms of its effective performances has been enhanced through the use of Supplementary Cementitous Materials (SCM). Also, as environmental concerns, stemming from the high energy expanse and CO_2 emission associated with cement manufacture, have brought about pressures to reduce cement consumption through the use of SCMs. As a result, the use of new admixtures has dramatically increased within the concrete industry. To know the shear behaviour of Structural elements in both reinforced and unreinforced concrete, such as columns and beams in tangential action, it is necessary to consider the pure shear acting either alone or with tension.

The research focuses on the mechanism of shear transfer in concrete alone by developing an experimental procedure. To determine the influence of the orientation of the surface of the shear failure on the force slip relationship. Indeed the major difficulty lies in developing an experimental procedure scientifically reliable to adequate. The push-off specimen is most widely used to study the influence of direct shear strength. It represents the shear behaviour of concrete and relatively easy for industrial purpose. Cement is one of the most energy intensive construction material and its production involves very high temperature(1400ºC to 1500ºC)processing an leads to the uncontrolled quarrying of natural resources and emission of CO2(green house gas).Many efforts are being made to reduce the use of Portland cement in construction.

These efforts include the utilization of supplementary cementations materials as well as use of alternate materials in place of Portland cement. Civil engineers have to design and construct more durable structures for sustainability. Thus, design methods are needed to prevent harmful cracks in concrete under service loads. In the event that concrete member is subjected to an excessive shear load, the concrete sustains an initial crack, and the crack then propagates within the concrete member. Therefore evaluating the shear property of concrete elements in detail must be important. It may be difficult and uneconomic for investigations using many large members to evaluate shear cracking load in detail. A simple test method for concrete elements has been developed for evaluation of shear cracking and may contribute to shear design studies using new reinforcing materials. The simplified testing method for pure shear employs only simple jigs and a universal testing machine. The testing method converts un-axial load in to shear force and can provide shear forces to each side of a square concrete element.

[1]**Corresponding Author**

II. Direct shear strength

Direct shear strength test were carried out on push-off specimen of size 150mm×150mm×450mm at the age of 28days curing, using 100tonne capacity UTM TUE-C-1000 Instrument. Shear strength of concrete is determined by push-off specimen mould suggested by ACI material journal ACI, Vol.94 No.6 p.p.592-601. The specimen was tested with side-face reinforcement.

III. Objective

This study Attempts to estimate the shear strength of push-off specimen. By considering and using various by products as replacements and to observe the different modes of shear failure. It shows the required design mix to gain required strength in structure under various methods. By this study structures are constructed with minimum shear failure at low cost

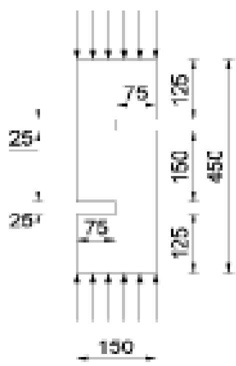

Figure 1:Front view of push off specimen without reinforcement

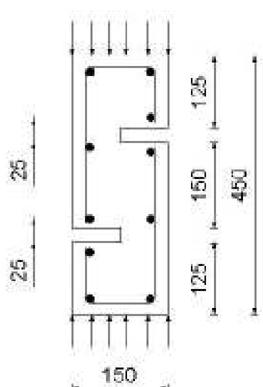

Figure2: Front view of push off specimen with side reinforcement

IV. Material investigation

Cement is a binder, a substance used in construction that sets and hardens and can bind other materials together. In this project **53grade OPC** is used for experimental study. Generally 53grade cement is a prime brand cement with a remarkably high C3S (Tri Calcium Silicate) providing long-lasting to concrete structures.

Construction aggregate, or simply "aggregate", is a broad category of coarse particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geo-synthetic aggregates. Aggregates are the most mined materials in the world. Aggregates are a component of composite materials such as concrete and asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material.

Aggregates are inert granular materials such as sand, gravel or crushed stone that are an end product in their own right. They are also the raw materials that are an essential ingredient in concrete.

The maximum size of coarse aggregate used was 20mm. Coarse aggregates are particle greater than 4.75mm, but generally range between 9.5mm to 37.5mm in diameter. They can either be from primary, secondary or recycled source.

GGBS is obtained by quenching molten iron slag (a by-product of iron and steel making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. Concrete containing GGBS cement has a higher ultimate strength than concrete made with Portland cement.

Silica Fume is a by-product of producing silicon metal or ferrosilicon alloys. Silicon metal and alloys are produced in electric furnaces. The raw materials are quartz, Coal, and woodchips.

Steel Fibres are made of cold drawn steel wire with low content of carbon or stainless steel wire (SS 302 / SS 304) fiber-replacement normal concrete is mostly used for on-ground floors and pavements, but can be considered for a wide range of construction parts like beams, pillars, and foundations etc..,

As one of the greatest inventions in 20th century, plastic has brought huge benefit in human life. The productive use of waste material represents a means of alleviating some of the problems of solid waste management.

Rice Husk Ash is produced by burning outer shell of the paddy that comes out as waste product during milling of rice. Each ton of paddy produced about 200kg of husk and this rice husk can be effectively converted through controlled burning.

Fresh water available from local sources was used for mixing and curing of all the mixes tried in this investigation.

V. Experimental procedure

From the **M-25 grade** mix design the specimens were casted using controlled concrete and by using various ad-mixtures and by-products. The numbers of casted specimens are 28 under both shear and compression. The casted specimens are

- **MIX CC** – In this casting by using plain controlled concrete it has been casted.
- **G 10** - In this casting cement has been partially replaced with 10% of ground granulated blast furnace slag (GGBS)
- **GP 10/5** - In this casting cement has been partially replaced with 10% of GGBS and Fine aggregates (F.A) has been partially replaced with 5% of plastics.
- **GP 10/10** – In this casting both cement and F.A has been partially replaced with cement and plastics.
- **GS 10/1** - In this casting cement has been partially replaced with 10% of GGBS and overall concrete has been partially replaced with 1% of steel fibers by using overall weight calculation.
- **S 10**- In this casting cement has been partially replaced with 10% of Silica fume.
- **SP 10/5** - In this casting cement has been partially replaced with 10% of cement and F.A has been partially replaced with 5% of plastics.
- **SP 10/10** - In this casting both cement and F.A are partially replaced with 10% of cement and plastics.
- **SS 10/1** - In this casting cement has been partially replaced with 10% of cement and overall concrete has been partially replaced with 1% of steel fibers by using overall weight calculation.
- **R10** - In this casting cement has been partially replaced with 10% of Rice Husk Ash (RHA)
- **RP 10/5** - In this casting cement has been partially replaced with 10% of rice husk ash and F.A has been partially replacement with 5% of plastics.
- **RP 10/10** - In this casting both cement and F.A has been partially replaced with rice husk ash and plastics.
- **RS 10/1** - In this casting cement has been partially replaced with 10% of rice husk ash and overall concrete has been partially replaced with 1% of steel fibers by using overall weight calculation.
- **CCS 1** - In this casting the controlled concrete has been partially replaced with overall 1% of steel fibers.

Compressive strength of concrete out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one can judge that whether concreting has been done properly or not. For the compression test the specimens are **150 x 150 x 150**. This concrete is poured in the mould and tempered properly so as not to have any voids. After 28 days these moulds are removed and test specimens are immersed in water for curing. The top surface of the specimens should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen.

These specimens are tested under compression testing machine after 28 days curing. Load should be applied gradually at the rate of **140kg/sq.cm per minute till the specimen fails**. Load at the failure divided by the area of specimen gives the compressive strength of concrete. Mix the concrete either by hand or in a laboratory batch mixer.

VI. Shear test

The device consists of a fixed lower part and an upper mobile one. A constant vertical force is applied on top of the shear box and a horizontal force is applied on the mobile part of the box. During the shear test, the horizontal and vertical displacements a well as the forces are completely controlled. The box dimensions are **150 × 150 × 450 mm**. This model can be adapted to concrete specimens.

The main disadvantage of using such a test for the shear of concrete is the presence of gaps between the concrete and the inner wall of the shear box because of the phenomena of hardening and shrinkage of concrete after casting.

So, the poor contact between the specimen and the box can lead to a non-uniform distribution of stress and affects the nature of the results.

In addition, the friction between the lips of the crack after the peak leads to a stiffening behaviour of the structure and does not reflect the behaviour in brittle shear despite the full opening of the crack.

As the applied load increases on a beam, the location and orientation of shear cracks change. Furthermore, crack width and crack angle are not constant along a crack. For this reason, the strains in the reinforcing elements, such as steel stirrups, are not uniform along the crack.

The concrete contribution to shear strength and determine the inclination of the compressive strut within the variable truss model for slender RC shear-critical beams with stirrups using the modified compression field theory in place of the conventional statistical regression of experimental data,

The expression for the concrete contribution to shear strength was derived, and the inclination of compressive struts was determined. A simplified explicit expression for shear strength was then provided, with which shear strength can be calculated without extensive iterative computations. This method was then verified using the available experimental data of 209 RC rectangular beams with stirrups and compared with the current methods from the American Concrete Institute and the Canadian Standards Association.

The test specimens are stored in moist air for 24hours as a initial settling time period of concrete and after this period the specimens are marked and removed from the moulds and kept submerged in clear fresh water under the curing tank temperature until taken out prior to test.

TABLE I. Workability test results

Sl.No	Specimen	Slump (mm)
1	Mix CC	82
2	G 10	64
3	GP 10/5	67
4	GP 1O/10	75
5	GS 10/1	58
6	S 10	60
7	SP 10/5	65
8	SP 10/10	72
9	SS 10/1	54
10	R 10	60
11	RP 10/5	68
12	RP 10/10	71
13	RS 10/1	56
14	CCS 1	52

TABLE II. VEE-BEE Results

Specimen	VB – degrees
Mix CC	08
G10	12
GP 10/5	11
GP 10/10	10
GS 10/1	15
S10	13
SP 10/5	10
SP 10/10	12
SS 10/1	16
R10	14
RP 10/5	12
RP 10/10	11
RS 10/1	18
CCS 1	16

The comparative study on various materials is done to obtain the different shear strengths and their properties. We have casted 14 combinations at the age of 28days curing. The comparative study is done because every by-product has their own characteristics and their properties and in order to differentiate it the study has been done.

And it is not so easy to cast 14 specimens in a single study though we have done and this research mainly focuses on how the by-product materials has been used in the concrete, how it works while it gets mixed, at what range the shear strength values gets differed, and finally by using a particular combination we can deduct failure obtain more strength to the structure and economically also it works. The partial replacements are done with Ground Granulated Blast Furnace Slag (GGBS), Silica Fume, Steel Fibres and we have used recyclable materials like Plastics and Rice Husk Ash(RHA).

TABLE III. Compaction factor results

Specimen	Compaction factor
Mix CC	0.932
G10	0.928
GP 10/5	0.934
GP 10/10	0.938
GS 10/1	0.910
S10	0.929
SP 10/5	0.936
SP 10/10	0.938
SS 10/1	0.912
R10	0.927
RP 10/5	0.934
RP 10/10	0.937
RS 10/1	0.915
CCS 1	0.917

TABLE IV. Cube Compression test results

Sl.no	Specimen	Compression
1	Mix CC	31.56
2	G 10	35.67
3	GP 10/5	34.86
4	GP 1O/10	33.78
5	GS 10/1	42.22
6	S 10	36.84
7	SP 10/5	34.98
8	SP 10/10	34.07
9	SS 10/1	42.87
10	R 10	33.87
11	RP 10/5	33.12
12	RP 10/10	32.48
13	RS 10/1	40.72
14	CCS 1	41.46

Figure 3: Testing Push-off Specimen

TABLE V. Direct Shear strength results

Sl.no	Specimen	Shear KN/mm^2
1	Mix CC	4.75
2	G 10	4.98
3	GP 10/5	4.10
4	GP 1O/10	3.87
5	GS 10/1	5.23
6	S 10	4.82
7	SP 10/5	4.37
8	SP 10/10	3.81
9	SS 10/1	5.41
10	R 10	4.87
11	RP 10/5	4.22
12	RP 10/10	3.64
13	RS 10/1	5.35
14	CCS 1	5.12

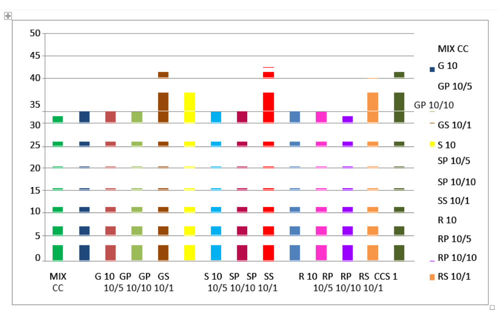

Figure 4: Compression test values in chart

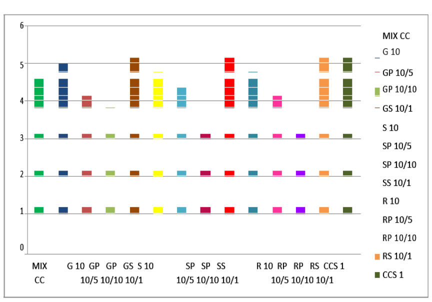

Figure 5: Shear values in chart

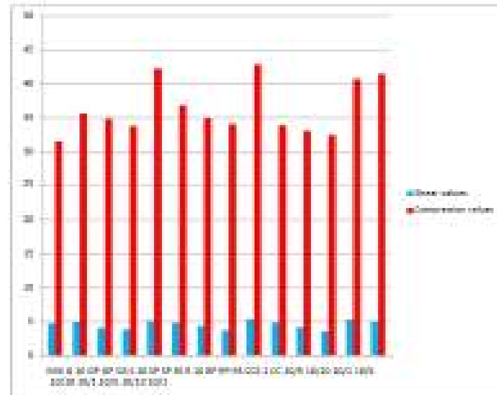

Figure 6: Comparative study between shear and compression values

VII. Conclusions

Based on the results of experimental investigations in this thesis, the following conclusions can be made,

- The required shear strength can be achieved in concrete with recyclable by products.
- A significant increase in shear strength can be achieved by incorporating optimum quantity of GGBS and Steel Fibers.
- Among all recycled by-product combinations replacement concrete with **10% replacement of GGBS and 1% of Steel Fibers has a long life-span.**
- (GS10/1) gives significant results when it is being compared with all other GGBS combination replacements.
- The shear strength of 10% of GGBS with 5% of plastics increases when compared with 10% of GGBS with 10% of plastics respectively.
- The shear strength of 10% of GGBS increases when compared with 10% of GGBS with 5% of plastics respectively.
- The shear strength of 10% of GGBS with 1% of Steel Fibers increases when compared with 10% of GGBS replacement respectively.
- Thus the GS10/1 is better and gives good results rather than other combination replacements.
- Thus the investigation made with recyclable by-products proves that the suitable substitute for the replacement of cement and aggregates.

VIII. Suggestions

- The present study focused on **14 combinations** of cement and fine aggregates replacement. Hence investigations can be made on different target strength using different cement and F.A replacement materials to study the mechanical and durability characteristics.

- The grade of cement can be varied and studied can be made on workability, Strength and durability characteristics.
- Studies on workability, Strength and durability properties can be made by varying the super plasticizer dosage, keeping the w/b ratio constant.
- Moreover, throughout the study using of steel fibers with concrete gives more durability, strength and long life-span.

References

[1] H. EI Chabib, M. Nehdi, A. Said – OCT 2006 “Predicting the effect of stirrups on shear strength of reinforced normal-strength concrete (NSC) and high-strength concrete (HSC) slender beams using artificial intelligence” journal of Can. J. Civil Engineering Vol. 33.

[2] Imran A. Bukhari and Saeed Ahmed – SEPT 2007 “Evaluation of shear strength of high-strength concrete beams without stirrups” journal of Civil Engineering Department university of Engineering and Technology, Taxila, Pakistan.

[3] Saeed Ahmed, Attaullah Shah – NOV 2008 “Evaluation of shear strength of highstrength concrete corbels using strut and tie model (STM)” journal of 77,ArabianJournal for Science and Engineering volume 34 Number 2B.

[4] Saeed Ahmed, Attaullah Shah – NOV 2008 “Statistical model for the prediction of shear strength of high strength reinforced concrete beams” journal of The Arabian Journal for Science and Engineering, Volume 34, Number 2B.

[5] M. Hamrat, B. Boulekbache, M.Chemrouk, S.Amziane APR – 2009 “Shear Behavior of RC Beams without Stirrups Made of Normal Strength and High Strength Concretes” journalof Advances in Structural Engineering Vol. 13 No. 1 2010.

[6] Christopher suffern, Ahmed L Sayeed, Khalid Soudki – JULY 2010 “Shear strength ofdisturbed regions with corroded stirrups in reinforced concrete beams” journal of Can. J. Civ. Eng. Vol. 37.

[7] Abdelsamie Elmenshawi, Tom Brown, Nigel Shrive – AUG 2010 “A fuzzy logicapproach to predict seismic ductility and shear strength of reinforced concrete elements”journal of Can. J. Civ. Eng. Vol. 37.

[8] Sudheer Reddy L, Ramana Rao N.V, Gunneswara Rao T.D – MAR 2011 “Shear Response of Fibrous High Strength Concrete Beams without Web Reinforcement” journal of Sudheer Reddy, L..et al / Fibrous High Strength Concrete Beams without Web Reinforcement / CED, Vol. 13, No. 1.

[9] G. Appa Rao, S S Injaganeri – APR 2011 “Evaluation of size dependent design shearstrength of reinforced concrete beams without web reinforcement” journal of ACI ASCE Committee 326 1962 Shear and diagonal tension, J. Am. Concrete Institute, 277–333.

[10] Qyang Yu, Zdenek P. Basant, Hon.MASCE – MAY “Can Stirrups Suppress Size Effecton Shear Strength of RC Beams?” journal of STRUCTURAL ENGINEERING © ASCE / MAY 2011.

[11] Tarek K Hassan, Ahmed Mantawy, Judy Soliman, Ali Sharif, Sami H. Rizkallah – JUNE 2011 “Bond Characteristics and Shear Behavior of Concrete Beams Reinforced with High-Strength Steel Reinforcement” journal of Advances in structural engineering vol. 15 no.2