Research Result

Influence of Addition of RCA and Fly Ash On Strength Properties of Glass Fiber Reinforced Multi Blended Concrete

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ABSTRACT

Waste arising from construction and demolition constitutes one of the largest waste streams within the developed and developing nations. The use of recycled coarse aggregate (RCA) and fly ash (FA) is one of the approaches towards this need. Use of RCA and FA in concrete can be useful for environmental protection and economical aspects. In this experimental study the natural coarse aggregate is replaced with recycled coarse aggregate at different percentage and the mechanical strength of concrete is tested. In addition the fly ash is introduced as replacement of Cement and also glass fibers are added to improve the quality of concrete and tensile strength. Cylinders and cubes are casted by replacing coarse aggregate with 0%, 25%, 50%, 75% and 100% recycled coarse aggregate. In addition 0% 5% 10% 15% & 20% of fly ash 0.05% glass fibers is introduced as replacement of Cement to improve the quality of concrete. Here the effect of replacement of fly ash and addition of glass fibers on the properties of recycled aggregate concrete is studied and compressive strength & split tensile strength is compared with normal concrete without fly ash. The target strength is achieved in compression at 20% replacement of fly ash, 0.05% addition of S-Glass fibers and in tension at 10% replacement of fly ash, 0.05% addition of S-Glass fibers.

KEYWORDS

Recycled aggregate, recycled coarse aggregate concrete, fly ash, Glass fiber, Compressive strength, Split tensile strength

1. INTRODUCTION

Concrete any construction activity requires several materials such as concrete, steel, brick, stone, glass, clay, mud, wood, and so on. However, the cement concrete remains the main construction material used in construction industries. For its suitability and adaptability with respect to the changing environment, the concrete must be such that it can conserve resources, protect the environment, economize and lead to proper utilization of energy. To achieve this, major emphasis must be laid on the use of wastes and byproducts in cement and concrete used for new constructions. The utilization of recycled aggregate is particularly very promising as 75 to 80 percent of concrete is made of aggregates. In order to reduce the usage of natural aggregate, recycled aggregate can be used as the replacement materials. As innumerous numbers of materials are used as replaced for natural aggregate, some of them are slag, power plant wastes, recycled concrete, mining and quarrying wastes, waste glass, incinerator residue, red mud, burnt clay, sawdust, combustor ash and foundry sand. These materials are generally from buildings, roads, bridges, and sometimes even from catastrophes, such as wars and earthquakes.

FRP in Structural Engineering

In the last 20 years, composite materials have been developed into economically and structurally viable construction material for buildings and bridges. Fig.1.5 Typical stress-strain in tension for types of FRP bars and steel. Today, FRP are used in structural engineering in a variety of forms: reinforcement material for new concrete construction, strengthening material for existing structures, and structural members for new construction. FRP material can be used in new construction as internal rebars, prestressing tendons, and stay in-place formwork. The surface of the FRP rebars are either sand coated, helically wound spiral outer surface, indented, braided, or with ribs. Figure 1.4 shows some commercially available FRP rebar with different surface textures

2. LITERATURE REVIEW

Adeyemi Adesina, Paul O.Awoyera (2022) Recycled aggregates have been increasingly considered for use in concrete, owing to the limited supply of natural aggregates coupled with the corresponding carbon footprint. However, despite the sustainability benefits of using recycled aggregates in concrete, its use in concrete is plagued with lower performance due to the physical properties of the recycled aggregates. One of the effective ways to improve the performance of concrete incorporating recycled aggregates is with the incorporation of fly ash (FA) which is also waste material. In this chapter the effect of FA on the mechanical properties of concrete incorporating recycled aggregates has been discussed.

Peem Nuaklonga Ampol Wongsaa Kornkanok Boonsermb Chanchai Ngohpokc Pitcha Jongvivatsakuld Vanchai Sataa Piti Sukontasukkule Prinya Chindaprasirtaf (September 2021) In this study, the micro carbon fiber (CF) was used to enhance the mechanical properties of fly ash geopolymer containing fine recycled concrete aggregate (RCA). Natural river sand was replaced with RCA at 0, 50, and 100% by volume. The CF was used as additive material by incorporating into the mixture at 0, 0.1, 0.2, and 0.3% by weight of fly ash. The results showed that the CF enhanced the mechanical properties of geopolymer containing RCA through the increased nucleation sites for geopolymerization reaction and the bridging effect of the fiber. For the mix with 100% RCA, the incorporation of 0.2% CF resulted geopolymer mortar with higher compressive and splitting tensile strengths.

Ripunjoy Gogoi, Divyah Nagarajan (june 2021)

The main purpose of this study was to evaluate fresh properties and mechanical characteristics of Glass fiber reinforced concrete (GR) containing Recycled aggregate and Fly Ash. It was utilized to replace Ordinary Portland Cement material at different percentages of 5, 10, 15, 20, and 25%. Glass fibers (6 mm length) have been incorporated in two different volume fractions of 0.5 and 1%. Experimental results proved that the addition of fly ash in concrete mixes decreased compressive strength test results at early ages; on the other hand, strength increased at later ages with reference mixes. The replacement of fly ash also showed decreased sorptivity, water absorption value, and increased acid resistance compared to control mixes. incorporation of glass fiber improved compressive strength test results of GR; however, fiber inclusion decreased fresh properties of GR mixes.

Zhuo Tanga,Wengui Lia Vivian,W.Y.Tamb and Zhiyu Luoa March (2020) By harnessing the benefits from both construction and demolition waste recycling and geopolymer binders, geopolymeric recycled aggregate concrete (GRAC) can contribute to the green and eco-friendly construction material products. In this study, the compressive behavior of GRAC based on fly ash and slag was experimentally investigated under both quasi-static and dynamic loadings. Quasi-static compressive tests were performed by using a high-force servo-hydraulic test system, while dynamic compressive tests were carried out by using a Ø80-mm split Hopkinson pressure bar (SHPB) apparatus. The compressive properties of GRAC under dynamic loading, including stress-strain curves, energy absorption capability, and failure modes were obtained and compared with those under quasi-static loading. The results show that the compressive properties of GRAC exhibit a strong strain rate dependency.

Sasui Sasui, Gyuyong Kim, Jeongsoo Naa, Arievan Riessen, Marijana Hadzima-Nyarko June (2021) This study incorporates fine waste glass (GS) as a replacement for natural sand (NS) in fly ash (FA) and/or ground granulated blast furnace slag (GGBS) based alkali activated mortar (AAm). Tests were conducted on the AAm to determine the mechanical properties, water absorption, apparent porosity and the durability based on its resistance to Na_2SO_4 5% and H_2SO_4 2% concentrated solutions. Whereas the microstructure and chemical composition of AAm was analyzed by SEM-EDX to support results obtained from the experimental tests. The study revealed that the effects of GS depends on the ratio of binders used to synthesize the mortar.

S. R. Rabadiya S. R. Vaniya (June 2015) Concrete made from glass fiber and recycled coarse aggregate as partial replacement of coarse aggregate will be studied for workability, compressive strength, tensile strength, and modulus of elasticity. I will use recycled coarse aggregate as partial replacement of coarse aggregate by different percentage for making concrete of different grade from lower to higher like M-20.The percentage replacement will be 0%, 10%, 20%, 30%, 40%, 50% and 60% with natural coarse aggregate. I will prepare cubes, cylinders, beams and finally slump test, compressive strength test, splitting tensile strength test and flexural strength testwill be conducted to obtain the necessary results.

Purella Suresh, M. Lakshmi Kumar,M. K. M. V Ratnam (December 2016) High Strength Concrete: The term high-strength concrete (HSC) is generally used for concrete with compressive strength higherthan 41 MPa. ACI Committee had defined High Strength Concrete (HSC) is the concrete that can attain specified compressive strength for design of at least 41 MPa, or more. With the development of high grade cement and availability of proper mineral admixtures and chemical admixtures, it has become quite common to adopt concrete with compressive strength of 60 MPa and above. Development of high strength concrete has made it possible to build taller and long span structures.

S. Niranjani, S. Rajagopalan, S. Rajalakshmi, The usage of natural aggregate is getting more and mo re intense with the advanced development in infrastructure area. In order to reduce the usage of natural aggregate, recycled aggregate can be used as replacement materials. Three series of mixes with 25%, 50% and 75% replacement of natural aggregate(NA) with recycled aggregate(RA) were prepared to study the strength and durability characteristic of concrete. In each series fly ash(FA) were replaced with 10% by the weight of cement and silica fume(SF) were replaced with 7.5% by weight of cement and glass fiber with 0.3% is added to the concrete by weight of fine aggregate.

3. OBJECTIVES

A review of prior studies on using recycled coarse aggregate (RCA) in place of natural coarse aggregate (NCA) According to their analysis, fly ash has the potential to produce durable concrete by improving the mechanical properties of concrete.

1. Increase the economy of the construction with using the cheaper material as a replacement of the cement.
2. To compare the hardened properties of concrete with different amount of recycled aggregates such as 25%, 50%, 75% and 100%.
3. To compare the hardened properties of concrete with different amount of 0% 5% 10% 15% & 20% of fly ash as replacement of Cement to improve the quality of concrete.
4. In additional, 0.05% of glass fibers are added to concrete to create glass fiber-reinforced concrete (GFRC).

5. To utilize IS 10262:2009 to create the mix design for M30 grade concrete and using the slump cone test to determine the workability.

4. METHODOLOGY

The following methodology has been adopted in order to achieve the aforementioned goals. The goal of this study is to find a productive method for making high performance concrete with aggregate made of industrial byproducts like recycled aggregates, fly ash and glass fibre.

Using the mix design in IS 10262:2009, an attempt will be made to determine the ideal mix proportion of the substitute materials in place of cement, fine aggregate, and coarse aggregate. The specimens have the following dimensions: cubes measure 150 mm x 150 mm x 150 mm, cylinders measure 150 mm x 300 mm, and prisms measure 100 mm x 100 mm x 500 mm. The results of the experimental tests can be used to determine the concrete's compressive strength.

The ideal replacement level mix for the concrete must be determined for further research based on the compressive strength of a single combination mix. For experimental testing of conventional and replacement material concrete, a total of 43 specimens will be cast, 43 cubes for compressive strength of concrete.

The compressive strength at ages 7 and 28 days, curing are to be found with the optimal replacement level for the binary and ternary combination mixes.

5. MATERIALS USED AND EXPERIMENTAL VIEW

5.1 Cement

Cements in a general sense are adhesive and cohesive materials which are capable of bonding together particles of solid matter into a compact durable mass. For civil engineering works, they are restricted to calcareous cements containing compounds of lime as their chief constituent, its primary function being to bind the fine (sand) and coarse (grits) "aggregate particles together Cements used in construction industry may be classified as hydraulic and non hydraulic. The latter does not set and harden in water such as non-hydraulic Lime or which are unstable in water, e.g. Plaster of Paris. The hydraulic cement set and hardens in water and give a product which is stable. Portland cement is one such. For the current experimental investigation, Ordinary Portland cement of 53 grades conforming to IS: 12269-1987 was used for this entire study.

Table no.01 Tests on Cement

S. No	Properties	Value	Permissible limit as per IS:12269-1987
1	Specific Gravity	3.14	Varies from 3.1 to 3.15
2	Initial setting time	63 min	Should not be less than 30 Min
3	Final setting time	321 min	Should not be more than 600 Min
4	Fineness test	1% retained	<10%

5.2 Fine Aggregate

Fine aggregates are essentially any natural sand particles won from the land through the mining process. Fine aggregates consist of natural sand or any crushed stone particles that are ¼" or smaller. This product is often referred to as 1/4'" minus as it refers to the size, or grading, of this particular aggregate.

5.3 Coarse Aggregate

For this study, two types of coarse aggregates were used for the preparation of concrete i.e. Natural coarse aggregate (NCA) and Recycled coarse aggregate (RCA).

Natural coarse aggregate for this study, locally available crushed stone aggregate of size 20 mm were used and the following tests were carried out on NCA.

Table no.02Tests on Natural Coarse Aggregate

S. No	Particulars of test	Test results
1	Type	Crushed
2	Specific gravity	2.76
3	Fineness modulus	7.3
4	Water absorption	0.82%

5.4 Recycled Coarse Aggregate (RCA)

Recycled coarse aggregate were prepared by crushing the M30 grade manufactured cubes. The cubes were cured for 28days and broken into smaller pieces by hammer then sieved to collect maximum size of 20mm and minimum size of 10mm. The following tests were carried out on RCA.

Table no 03 Tests on RCA

S. No	*Particulars of test*	*Test results*
1	Specific gravity	2.6
2	Fineness modulus	6.87
3	Crushing value (%)	17.23
4	Impact value (%)	20.61

5.5 Water

In this study portable water conforming to IS: 456-2000 was used for casting and curing.

5.6 Fly ash

Fly ash particles are typically spherical ranging in diameter from 1 to 150 microns. The type of dust collection equipment used largely determines the range of particles size in any given fly ash. The fly ash from the boilers where mechanical collectors are used is coarser than fly ash from electrostatic precipitators. Specific gravity of fly ash is 2.13

Table no. 04Tests on Fly ash

S.No	Properties	Value
1	Specific Gravity	2.13
2	Fineness	290 m^2/kg
3	Bulk density	1150 kg/m^3
4	Colour	Light gray

5.7 Glass Fiber

Glass fibre reinforced concrete (GFRC) is made up of glass fibres, cement hydration products, or cement and sand. Glass fibres are employed as concrete reinforcement. In Russia, glass fibres were first utilised to strengthen cement and concrete. The highly alkaline Portland cement matrix, however, corroded them. As a result, the UK and other nations have developed alkali resistant glass fibres. Glass fibres can be found as concrete, wool, ropes, chopped strand mats, continuous rovings, woven fabric, and ropes. To shield glass fibres from Portland cement's alkali attack, epoxy resin compounds have also been tested on them.

Table no 05: Properties of S-Glass Fibers

Fiber Type	*S-Glass fiber*
Density (gm/cm3)	2.53
Elastic Modulus (G pa)	89
Tensile Strength (M pa)	4600
Diameter In Microns	10
Length In mm	6
Percent Elongation	5.2

6. MIX DESIGN

6.1 Concrete Mix Design M30 Grade with Fly ash as Partial replacement to Cement

Concrete mix design is a process that involves choosing the right ingredients for concrete and their appropriate ratios with the goal of preparing concrete as affordably (value engineered) as possible while maintaining a certain minimum strength, desired workability, and durability. The most affordable and widely accessible mineral admixture, fly ash, can replace some of the cement in a concrete mix, producing concrete with excellent fresh, hardened, and durable properties. As per IS: 456, the maximum replacement of cement with fly ash has a capping of 35%. As we decide to go for a concrete mix design, collect the following data before hand as few design stipulation are freezed on the basis of these data.

Table no 06 : Mix Proportion without RCA, different % of fly ash and S-Glass fiber

S. No.	*%fly ash*	*S-glass Fibers*	*Mix proportions(Kg/m)*					
			Cement	*Fly ash*	*FA*	*NCA*	*S-glass Fibers*	*Water*
1	**0%**	**0.05%**	**394**	**0**	**589**	**1213**	**1.2**	**197**
		0.10%	**394**	**0**	**589**	**1213**	**2.4**	**197**
		0.15%	**394**	**0**	**589**	**1213**	**3.6**	**197**
2	**10%**	**0.05%**	**354**	**40**	**589**	**1213**	**1.2**	**197**
		0.10%	**354**	**40**	**589**	**1213**	**2.4**	**197**
		0.15%	**354**	**40**	**589**	**1213**	**3.6**	**197**
3	**20%**	**0.05%**	**314**	**80**	**589**	**1213**	**1.2**	**197**
		0.10%	**314**	**80**	**589**	**1213**	**2.4**	**197**
		0.15%	**314**	**80**	**589**	**1213**	**3.6**	**197**

Table no 07: Mix Proportion with RCA, 10% replacement of fly ash and 0.05% addition of S-Glass fibers

RAC Mix	*% replacement (RCA)*	*Mix proportions(Kg/m³)*						
		Cement	*Fly ash (10%)*	*S-Glass fibers (0.05%)*	*FA (Sand)*	*NCA*	*RCA*	*Water*
M30	**25%**	**354**	**40**	**1.2**	**589**	**910**	**303**	**197**
	50%	**354**	**40**	**1.2**	**589**	**607**	**606**	**197**
	75%	**354**	**40**	**1.2**	**589**	**310**	**903**	**197**
	100%	**354**	**40**	**1.2**	**589**	**0**	**1204**	**197**

Table no 08: Mix Proportion with RCA, 20% replacement of fly ash and 0.05% addition of S-Glass fiber

RAC Mix	*% replacement (RCA)*	*Mix proportions(Kg/m³)*						
		Cement	*Fly ash (10%)*	*S-Glass fibers (0.05%)*	*FA (Sand)*	*NCA*	*RCA*	*Water*
M30	**25%**	**314**	**80**	**1.2**	**589**	**910**	**303**	**197**
	50%	**314**	**80**	**1.2**	**589**	**607**	**606**	**197**
	75%	**314**	**80**	**1.2**	**589**	**310**	**903**	**197**
	100%	**314**	**80**	**1.2**	**589**	**0**	**1213**	**197**

7. RESULTS AND DISCUSSIONS

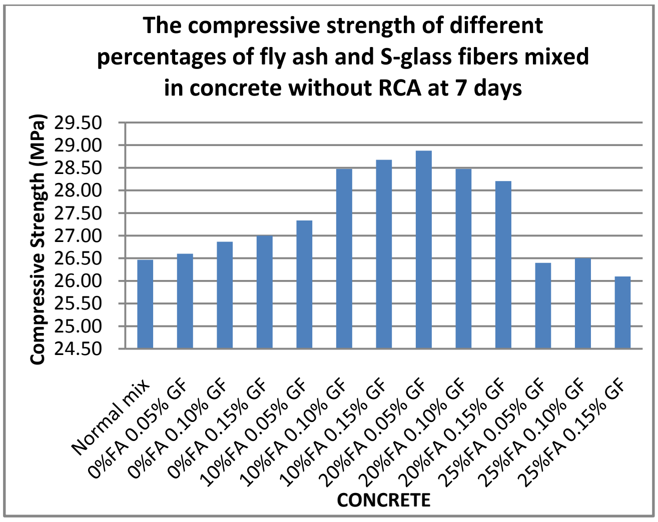
7.1 Compressive Strength

The experimental results obtained after the curing of 7 days and 28 days are shown in the table 8.1 & 8.2. Figures 8.1 & 8.2 represent the compressive strength for 7 days & 28 days without RCA and Figure 9 represent the compressive strength for 7 days &28 days Replacement of RCA (0% to 100%) with 20% fly ash and 0.015% S-Glass fibers. The compressive strength is decreased with the increase in percentage of recycled aggregates. At 28 days 100% replacement of RCA with addition of fly ash achieves strength of 32mpa where as target mean strength of M30is 38.9mpa. In short period of time this strength can exceed to the strength of natural aggregate concrete.

7.1.1 Compressive Strength of concrete without RCA

Table NO 09: The compressive strength of different percentages of fly ash and S-glass fibers mixed in concrete without RCA at 7 and 28 days

S. No.	%fly ash (replacement of Cement)	S-glass Fibers	Compressive Strength (M pa)	
1	Normal mix	0%	26.47	39.5
2	0%	0.05%	26.6	39.7
		0.10%	26.87	40.1
		0.15%	27	40.3
3	10%	0.05%	27.34	40.8
		0.10%	28.48	42.5
		0.15%	28.68	42.8
4	20%	0.05%	28.88	43.1
		0.10%	28.48	42.5
		0.15%	28.21	42.1
4	25%	0.20%	26.4	41.3
		0.25%	26.5	40.7
		0.30%	26.1	40.3

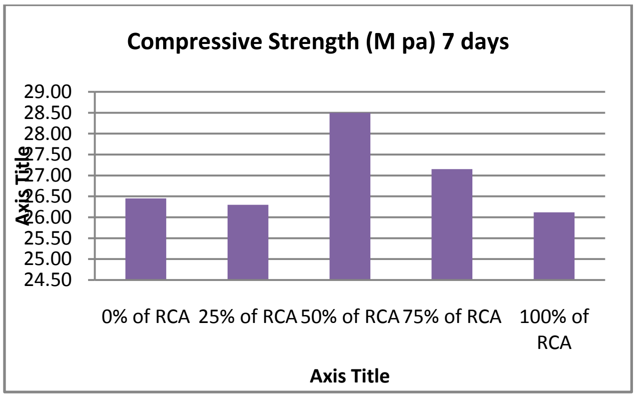


Graph 01: The compressive strength of different percentages of fly ash and S-glass fibers mixed in concrete without RCA at 7 days

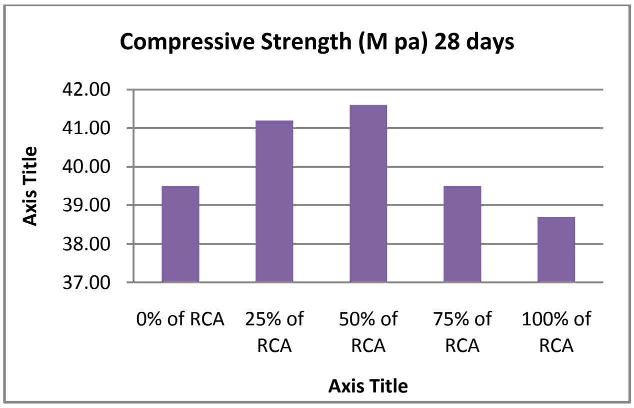
7.1.2 Compressive Strength of concrete with RCA

Tableno03: The compressive strength of different percentages of 10% fly ash and 0.05% S-glass fibers mixed in concrete with RCA at 7 and 28 days

Optimum		*% of RCA*	*Compressive Strength (M pa)*	
Fly ash	*S-Glass fibers*		*7 days*	*28 days*
10%	0.05%	0	26.45	39.5
		25	25.4	38.6
		50	27.5	40.8
		75	28.15	41.25
		100	27.1	40.1



Graph 02: The compressive strength of different percentages of 10% fly ash and 0.05% S-glass fibers mixed in concrete with RCA at 7 days



Graph 03: The compressive strength of different percentages of 10% fly ash and 0.05% S-glass fibers mixed in concrete with RCA at 28 days

VIII CONCLUSIONS

The following conclusions are made from the study:

1. Using recycled aggregates and fly ash, the target mean strength of M30 grade concrete can be achieved without lowering the water-cement ratio.

2. The strength of concrete decreases as the percentage of recycled aggregate increases . This may be due to the loose mortar surrounding the recycled aggregate, which prevents the cement paste and aggregate from properly bonding.
3. 30 MPa is typically used for a variety of structural applications. At 28 days, fly ash and 100% replacement of RCA resulted in strength of 32 MPa.
4. Compressive strength is increased at 20% fly ash, 0.015% S-Glass fibres, and 50% RCA replacement for NCA.
5. The target mean strength for M30 grade concrete was attained when 50% RCA, 20% fly ash, and 015% S-Glass fibers were substituted for natural aggregate.

REFERENCES

[1] Dabhade A.N., Choudhari S.R., Gajbhiye A.R., “Experimental study of effects of fly-ash on recycled concrete”, International journal of applied engineering and technology ISSN: 2277-212X (online).

[2] AdeyemiAdesina1Paul O.Awoyera2 Influence of fly ash in physical and mechanical properties of recycled aggregate concrete https://doi.org/10.1016/B978-0-12-824105-9.00004-4

[3] 3.PeemNuaklongaAmpolWongsaaKornkanokBoonsermbChanchaiNgohpokcPitchaJongvivatsakuldVanchaiSataaPitiSukontasukkulePrinyaChindaprasirtaf September 2021, Enhancement of mechanical properties of fly ash geopolymer containing fine recycled concrete aggregate with micro carbon fiber https://doi.org/10.1016/j.jobe.2021.102403

[4] S. R. Rabadiya S. R. Vaniya (June 2015) Effect of Recycled Aggregate with Glass Fiber on Concrete Properties IJIRST International Journal for Innovative Research in Science & Technology| Volume 2 | Issue 01 | June 2015 ISSN (online): 2349-6010 All rights reserved by www.ijirst.org

[5] Purella Suresh, M. Lakshmi Kumar,M. K. M. V Ratnam (December 2016)

[6] A Study on Mechanical Properties of Fiber Reinforced High Strength Concrete using Recycled Coarse Aggregate” International Journal for Innovative Research in Science & Technology| Volume 3 | Issue 07 | December 2016 ISSN (online): 2349-6010 www.ijirst.org

[7] My le Nguyen James, Wonchang Choi and Taher Abu-Lebdeh, “Use of Recycled Aggregate and Fly Ash in Concrete Pavement”, American J. of Engineering and Applied Sciences 4 (2): 201-208, 2011.

[8] Shi-Cong Kou,Chi-Sun Poon, “Long-term mechanical and durability properties of recycled aggregate concrete prepared with the incorporation of fly ash”, Cement & Concrete Composites 37 (2013) 12–19.

[9] Mukesh Limbachiya, Mohammed Seddik Meddah, Youssef Ouchagour, “Use of recycled concrete aggregate in fly-ash concrete”, Construction and Building Materials 27 (2012) 439–449.

[10] M.L. Berndt, “Properties of sustainable concrete containing fly ash, slag and recycled concrete aggregate”, Construction and Building Materials 23 (2009) 2606–2613.

[11] Weerachart Tangchirapat, Chaiyanunt Rattanashotinunt, Rak Buranasing, Chai Jaturapitakkul, “Influence of fly ash on slump loss and strength of concrete fully incorporating recycled concrete aggregates”, J. Mater. Civ. Eng. 2013.25:243-251.

[12] Pierre Matar, Rouba El Dalati, “Strength of masonry blocks made with recycled concrete aggregates”, Physics Procedia 21 (2011) 180 – 186.

[13] Y. V. Akbari, N. K. Arora, M. D. Vakil, “Effect on recycled aggregate on concrete properties”, International Journal of Earth Sciences and Engineering ISSN 0974- 5904, Volume 04, No 06 SPL, October 2011, pp. 924- 928.

[14] A.K. Padmini, K. Ramamurthy , M.S. Mathews, “Influence of parent concrete on the properties of recycled aggregate concrete”, Construction and Building Materials 23 (2009) 829–836.

[15] C.S. Poon, Z.H. Shui, L. Lam, H. Fok, S.C. Kou, “Influence of moisture states of natural and recycled aggregates on the slump and compressive strength of concrete”, Cement and Concrete Research 34 (2004) 31– 36.

[16] S.W. Forster, “Recycled concrete as coarse aggregate in concrete”.WANG Zhen shuang, WANG Lijiu,CUI Zhenglong,ZHOU Mei, “Effect of Recycled Coarse Aggregate on Concrete Compressive Strength”, Trans. Tianjin Univ. 2011, 17: 229-234.