Experimental Research on Composite Cement with Glass Fibers

V. Phani Teja, K J Brahma chari, V. Ranga Rao

Abstract: ***By addition of composite cement and glass fiber to the cement matrix can impart the strength and durability to the concrete to some extent. Composite cement is intimate inter grounding mixture of Portland cement clinker (30 to 35%) by its weight, gypsum (3 to 5%), fly ash (15 to 35%) and GGBFS (20 to 50%). It produces strength to the concrete and durable. Alkali Resistant glass fibers are used due to its desired physical and mechanical properties regarding durability properties. This paper deals with experiment are carried out on compressive strength and tensile properties of concrete by incorporation of composite cement and glass fiber with certain proportions and are tested under universal testing machine. For this purpose, casting of cubes of size 150×150×150mm and cylinders of size, 150×300mm are cast and cured for normal 7, 28, 56 days. These are tested under the compressive testing machine and observe the behavior of concrete, bearing capacity to with stand the load during application of load and compared to the normal conventional concrete. This research is to provide the bearing strength capacity to the concrete by the addition of the glass fiber and composite cement introducing the alternate materials without compromising on strength and durability.***

Index Terms: Composite cement, Glass fiber, compressive strength, tensile strength.

I. INTRODUCTION

Concrete deterioration causes due to the wreathing actions and chemical attacks. This may lead to the serious failure of the structures and decreases the strength and durability of the concrete. The strength of the concrete or any other structures can increase by the addition of the mineral admixtures or supplementary cementitious materials and some proportions of glass fibers may increase the strength and durability of the concrete and reduces failure of the structure. The use of mineral admixtures is promising in light of their potential benefits on the durability and sustainability of reinforced concrete [6].

This paper deals with the uses of composite cement and the glass fibers regarding the compressive and tensile behavior of the concrete. Chlorides ion attacks and sulphate ions attack and the alkali-aggregate reaction can reduce the strength and decreases durability of the concrete. By using these alternate mineral admixtures to the cement matrix can helps in increases strength and make the concrete durable. By the addition of newly developing material like composite cement has a wide area of researches are going on. The composite cement is best for salt scaling in terms of concrete deterioration [2]. Composite cement is developed according to the Indian standards IS- 16415-2015 deals with the composite cement. It states that composite cement is intimate inter grounded mixture of Portland cement clinker or OPC with 35 to 65% by its weight, fly ash of 15- 35 % by its weight and ground granulated blast furnace slag of (20%-50%). Several researchers are going on by using this composite cement as a binding material and also the supplementary cementitious materials. By the addition of the glass fibers based on the good workability with cement, lightweight, fire resistance, good strength, and appearance.

Glass fiber is of different types some of them are E-glass fibers, AR-glass fibers, AE-glass fiber. In this context, AE-glass fibers are used because based on the literature survey. Glass fiber helps the concrete to increase the compressive strength until the indicated limit [1]. The physical and mechanical properties of this AR glass fibers Alkali resistance glass fibers are having good strength also controls the alkali-silica reaction in cement and aggregates. Because this alkali-silica reaction in cement causes the effect of concrete during the time passing on duty this reaction cracking and small pores are formed on the concrete structures when it is exposed to the environment due to this weathering effect causes the Steel gets corroded. the AR glass fibers are used because alkali in cement and silica in glass reacts in forming etching of concrete due to this AR-glass can control the certain reaction when its contacted into the cement and can increase the durability of the concrete structures. Based on the literature survey the glass fibers can increase the compressive strength with the addition not more than 2% to the total weight of the cement.

The mixing proportions of the glass fibers and composite cement are limiting the usage of the cement content and using the natural and eco-friendly waste products in the cement matrix, also uses as the binding materials literally impart the strength to the concrete and increase the durability and sustainability to some extent. The compressive strength values are marginally low at initial stages and improve later stage compared to the reference samples [4]. Based on the literature survey some of the research is going on composite cement as the supplementary cementitious material and the use of the glass fibers is gives the strength and decreases the internal chemical reaction when water mixes with cement. The Indian bureau recommends the codebook for the usage of the composite cement and special precautions are taken while using these materials. The whole project carried with the same kind of materials and with the addition of glass fibers based on the

Revised Manuscript Received on April 09, 2019.

V. Phani Teja, P. G. Student, Structural Engineering, Department of Civil Engineering, Koneru Lakshmaiah Education Foundation, Guntur District, A. P., India.

K J Brahma Chari, Assistant Professor, Structural Engineering, Department of Civil Engineering, Koneru Lakshmaiah Education Foundation, Guntur District, A. P., India.

V. Ranga Rao, Professor, Structural Engineering, Department of Civil Engineering, Koneru Lakshmaiah Education Foundation, Guntur District, A. P., India.

good physical and mechanical properties cross-checking the strengths of the conventional control mix.

By the usage of the composite cement, the combination of the Portland cement, fly ash and ground granulated blast furnace slag. The composite materials mean the usage of the two or more materials which are combined to produce the same physical effects. The fly ash is more durable when compared to that of the OPC when it exhibits lower permeability when compared to the OPC [3]. It early age strength is reduced because of the fly ash is in the place of cement [7]. The compressive and tensile strength of the organic cement is helps to improve its strength regardless of By the usage of the composite cement, the combination of the Portland cement, fly ash and ground granulated blast furnace slag. The composite materials mean the usage of the two or more materials which are combined to produce the same physical effects. The fly ash is more durable when compared to that of the OPC when it exhibits lower permeability when compared to the OPC [3]. It early age strength is reduced because of the fly ash is in the place of cement [7]. The compressive and tensile strength of the organic cement is helps to improve its strength regardless of the physical and chemical properties [8].

II. ADVANTAGES OF USING COMPOSITE CEMENT AND GLASS FIBERS

Nowadays the concrete deterioration is becoming challenging problems. The concrete structures are damaging over certain time.

Lack of knowledge, usage of the quality materials in the construction cause a decrease in the strength and durability of the structures

To overcome this problem the usage of the composite materials or mineral admixtures which are eco friendly as the binder materials due to the pozzalonic properties durability factors can be increased.

There is need of controlling the heat of hydration, chemical attacks, weathering action, carbonation, sulphate attack by the usage of the natural pozzolanic material and based on the studies glass fibers incorporation project is carried out.

III. NEED OF THE PRESENT STUDY

The present study is all about the usage of the composite cement and fibers combined as the binder materials. Finding the relevant solutions to the control of deterioration of the concrete and helps in protecting the structural integrity and sustainability for a long time.

IV. RESEARCH SIGNIFICANCE

The objective of this study is on the structural applications on the concrete beams with the combined effect of the composite cement and glass fibers on the strength and durability of the concrete.

Without compromising on the strength and durability these materials have the good resistance to the chemical attacks and the acid attacks.

The materials that are used as the binding material that are mixed under the recommended proportions and tests are carried out on the specimens to get whatever the possible outcomes of the results and that are recorded.

To provide the chemical resistance to the reinforced concrete structures by the incorporation of the composite cement and glass fibers without compromising on the strength and durability

V. MATERIALS

In this study, we had done the performance and structural behavior of the specimens by using the materials.

A. Composite cement

Composite cement is the newly developing material in which with the cement as the binder material two or more natural pozzalonic materials which are eco friendly materials like fly ash and ground granulated blast furnace slag is used to produce the high strength concrete and also increase the durability of the concrete.

The combination of cement with fly ash and ground granulated blast furnace slag are taken according to the weight percentages to the total weight of cement which is done under the mix design with recommendations of the Indian standards IS 16415-2015.

B. Fly ash

Fly ash is the waste industrial by product which is obtained by the thermal power plant. Fly ash is the pulverized fuel ash which is obtained by the burning of the coal in the thermal power plant. Fly ash is of two types. They are class-C and class-F fly ash. As per the recommendations the entire work used the class-f fly ash due to its similar properties regarding the increases in durability.

The class-F fly ash is designed according to the ASTM-C618. The anthracite and bituminous are the main constituents. The class-f is a deficit of the calcium content when it compared to the class-c.

Table I informs about the Chemical composition of pulverized fuel ash used

Table I: Chemical composition of pulverized fuel ash used

Compound	Content, %WT
SiO_2	59
Al_2O_3	21
Fe_2O_3	3.7
CaO	6.9
MgO	1.4
SO_3	1
K_2O	0.9
LOI	4.62

Table II informs about the Physical composition of pulverized fuel ash used Cement

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

Table II: Physical composition of pulverized fuel ash used Cement	
Color	**Whitish Grey**
Bulk Density(g/cm$^{3)}$	0.994
Specific gravity	2.288
Moisture (%)	3.14
Average particle size (µm)	6.92

Cement is the controlled blend of calcium silicates and calcium aluminates which are grounded into the fine powder and the with the addition of small percentages of the gypsum. The whole work is done by the 53 grade of the cement that means the strength is not less than the 53 KN/mm2 after the 28 days of the curing.

The ordinary Portland cement of 53 grade conforming to the IS- 8112 was used for entire work.

C. Ground granulated blast furnace slag

Ground granulated blast furnace slag (GGBS) is obtained from the molten iron slag which is obtained by the iron and steel making from that blast furnace in water or steam. It is of glassy materials when that material is grounded into the fine powder called slag.

Due to its good pozzolanic properties and less cheap than the cement exhibits good quality against durability in the terms of sustainability resistance to the chemical attacks and acid attacks everything which damages the durability of the concrete structures it can resist the damage and imparts strength to the concrete.

Not only the external attacks it can resist the internal chemical changes that are thermal cracking which is caused by the alkali silica reaction in the concrete due to this reaction cracking will appear then it forms corrosion of steel due to harmful gases enters through the cracks. This reaction will be reduced by using GGBS.

D. Glass Fibers

Glass fibers or fiber glass obtained from the glass manufacturing process. When the molten glass is melted and drawn into the thin fibers or filaments which are later cut in 12mm or 6mm according to the desired size and length. At the beginning these glass fibers used for the reinforcement of the concrete which are usually called as the glass fiber reinforced concrete.

In that problem, problem arises due to the durability problem because it is more brittle in nature due to the alkalinity of the cement motor. Later on, introduces the AR-glass fibers which are resistance to the alkali-silica reaction and causes the brittleness of the concrete.

By replacing the glass fibers reduced corrosion with the steel reinforcement which is used instead of the steel strands. It becomes the cost effective only it can be used in the proper way so that it can pretend and gains stability against all attacks.

It can also control the oxidation occurs when it exposed to the moisture and starts corrosion the volume of the bars increased to 2 to 5 times ultimately leads to the crack since the concrete is weak in tension.

E Coarse aggregate

The coarse aggregates were used form our university batching plant and were confined to the IS-383 was used. The flakiness and elongation index was maintained. Depending on the arresting of the voids where casting with 10 mm and 20 mm of coarse aggregates was used combined with 40% of 10 mm and 60% of 20 mm sizes from the total weight of the aggregates done after the mix design confirming to the IS- 456:2000.

F. Fine aggregates

The river sand particles are used as the fine aggregates according to the recommendation of IS- 383 code book. The fine aggregates are sieved and removed the deleterious materials which are present in it.

G. Admixtures

The super plasticizer is used in our laboratory with 0.5 % of the volume. According to the ASTM C-494 recommended. These are high water reducing agents which can reduce water by about 20%. For the particles which are combined in this water requirement super plasticizer for good workability because glass fibers, fly ash, GGBS requires the addition of the super plasticizers to gain the high strength with the desired proportions.

VI. METHODOLOGY & PROCEDURE

Based on the materials used in the entire work that is the composite cement with the combination of the OPC, fly ash, GGBS, and the glass fibers exhibit the same kind of the physical and chemical properties regarding the increase the strength of the concrete mainly the reason behind the use of these the natural pozzolanic materials which are co2 free and limits the usage of the cement. The three proportions were taken accordingly which satisfies the standards recommended by IS- 16415- 2015.

The experimental work was carried out by casting of the cubes, cylinders, and beams. Cube specimens of size 150×150×150 mm, cylinders of size 150×300 m. The mix design followed by the M35 grade of concrete which are done accordingly to the IS- 1026-2002 and IS- 456-2000 code recommendations for the mix designs. The mix proportions are taken by the total weight of the cement.

Table III: Nominal mix design					
Grade designation	**Cement (Kg)**	**Water (Kg)**	**w/c (Kg)**	**FA (Kg)**	**CA (Kg)**
M35	400	180	0.45	687.58	1168.7

There are two mixes are taken by the replacing and limiting the cement proportions and by the incorporation of the glass fiber with 0.5% by the total weight and special procedure is followed by the calculation of the amount of the glass fibers. The mix-1 proportion is followed by the 40% of the cement, 30% of the fly ash, 30% GGBS has been added. The next proportion is followed by the 50% cement, 25% fly ash, 25% GGBS was added to another mix. The final proportion of the mix-1 was followed by 60% cement, 20% fly ash, 20% GGBS were added with the addition to the 0.5% of glass fibers.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

Then the mix- 2 proportions are same as for the mix-1 but without the addition of the glass fibers. These two, mix proportions are tested and both results are compared to the conventional concrete. The results are recorded according to the bearing strength

First of all moulds of cast iron and it is thick enough to prevent distortion is prepared specimen of size 150×150×150 mm moulds and cylinders specimens of size 150×300 mm.

Fig.1 shows the cubes and cylinders that are used for the preparation of moulds.

Fig. 1: Cube and Cylinders

After the mixes are prepared and casted in cubes and cylinders and beams. It is compacted by the taming bar of 16 mm and 0.6 mm long should be tamped not less than 25 strokes per layer and for the beams vibrator is used for the proper compaction.

Then these casted moulds are placed on the vibration table for the perfect compaction not more than 1 minute to get the desired condition because slurry will come out of the moulds

After casting has done and curing period is done for the 7, 28, 56 days for the strength performance tests. The curing process is done at the temperature of 25° to 30° degree inside the curing tank specified intervals. For each interval the specimens are taken out of the curing tank for the testing purpose.

Then compression test and tensile behaviour of the specimens are done both under compression testing machine. These both tests are performed for the purpose of the calculating the bearing strength of the specimens, yield strength, tensile strength, modulus of elasticity etc.

The test procedure is done by placing the specimens between the two plates then the load is applied until the specimens get failed. Then the deformation versus applied load is calculated.

VII. RESULTS AND DISCUSSIONS:

The tests were performed under the compressive testing machine for cubes and for cylinders split tensile test is performed. This compressive strength test most commonly used test to check the ultimate failure of the specimens and how much strength is acquired by the specimen has been noted.

While mixing the glass fiber special attention is required it should me mixed carefully nor more than the one minute because it breaks.

At the 7 days and 28 days testing there are average results recorded and improvement in the strength was observed over this period.

Fig. 3, 4 & 5 shows the compressive strength test results for the cubes that are casted for Mix 1 proportion and cured in water for 7, 28 and 56 days respectively.

Fig. 6, 7 & 8. shows the Split tensile strength test results for the cylinders that are casted for Mix 1 proportion and cured in water for 56, 28 and 7 days respectively.

Fig. 2: Compression strength test

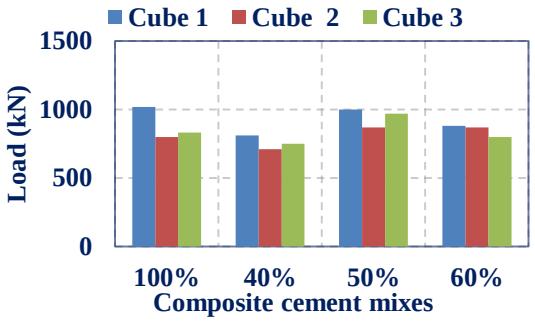

Fig. 3: Compression Strength test for 7 days

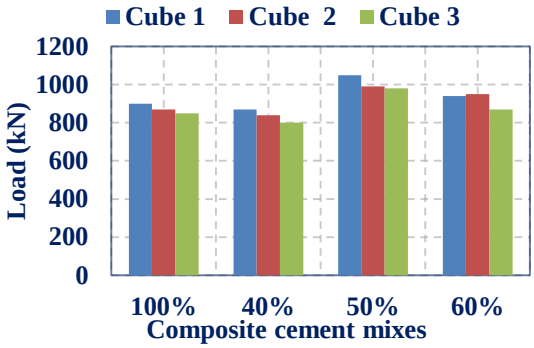

Fig. 4: Compression Strength test for 28 days

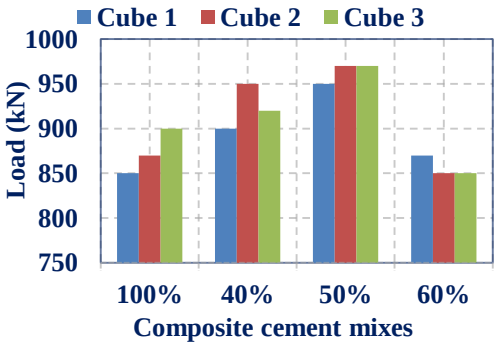

Fig. 5: Compression Strength test for 56 days

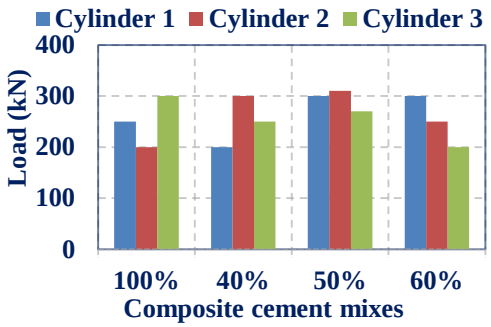

Fig. 6: Split tensile strength test for 56 days

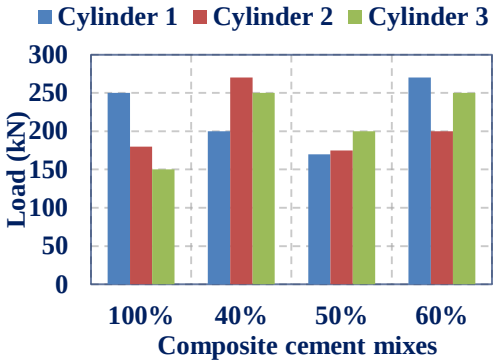

Fig. 7: Split tensile strength test for 28 days

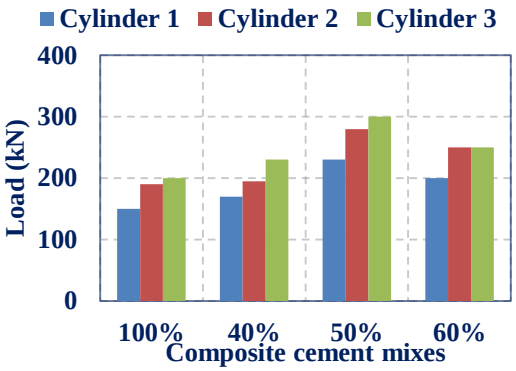

Fig. 8: Split tensile strength test for 7 days

Fig.9: After failure of the specimens

Fig. 10: Splitting of cylinder after testing

The physical performance of the specimens was evaluated by the mixing of cement blends with the composite cement and glass fibers for the for appropriate mix proportions. There is significant rise in the strength of the specimens which were tested for 7 and 28 days with the mix proportion with the 50 % OPC with 25% fly ash and 25% GGBS.

Fig. 11, 12 &13 shows the compressive strength test results for the cubes that are casted for Mix 2 proportion and cured in water for 7, 28 and 56 days respectively.

Fig. 14, 15 & 16. shows the Split tensile strength test results for the cylinders that are casted for Mix 1 proportion and cured in water for 7, 28 and 56 days respectively.

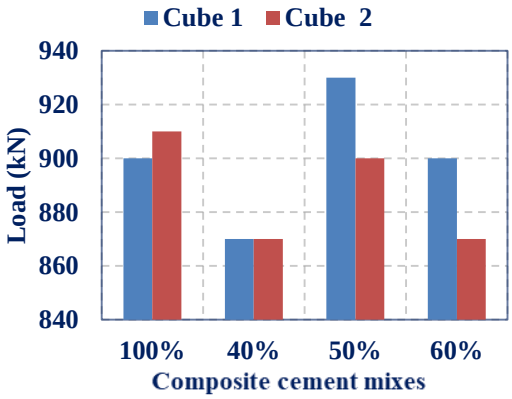

Fig. 11: Compressive strength test for 7 days

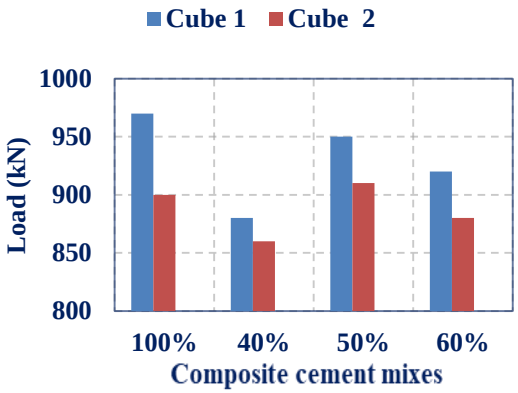

Fig. 12: Compressive strength test for 28 days

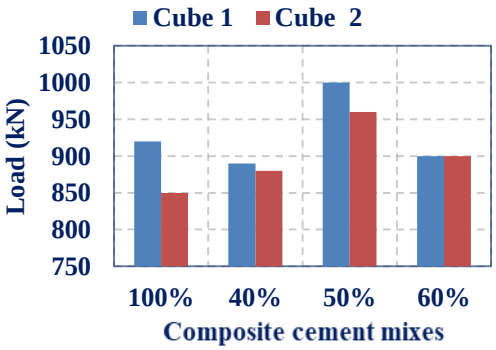

Fig. 13: Compressive strength test for 56 days

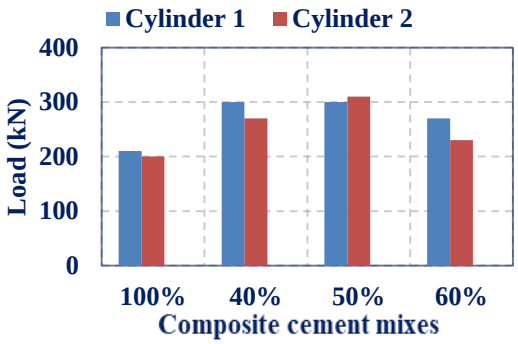

Fig. 14: Split tensile strength test for 7 days

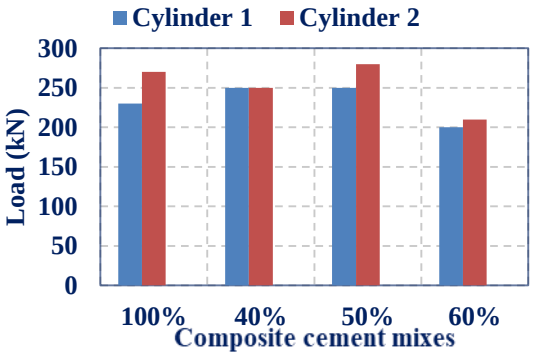

Fig. 15: Split tensile strength test for 28 days

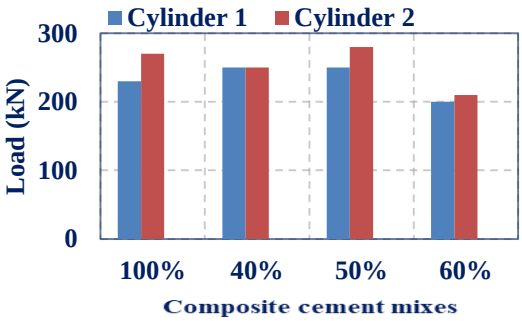

Fig. 16: Split tensile strength test for 56 days

VIII. CONCLUSIONS

After the observation and performing the test results states that the initial increase in the raise of the strength for the 28 day of the test results and gradually decreases. There is compressive strength shows certain development when it mixes with the 50% ordinary Portland cement, 25% fly ash, 25% ground granulated blast furnace slag. There is a negligible change in the strength when compared to the without the glass fibers.

ACKNOWLEDGEMENT

The constant support and encouragement of Koneru Lakshmaih Educational Foundation is gratefully acknowledged. This work wouldn't have been completed without the University Support and we're forever thankful. Our special thanks to Head of the Department, Civil Engineering for providing us with adequate facilities, ways and means by which we can complete this project work. We thank teaching, non-teaching members and friends of Civil Engineering Department for supported or partially supported.

REFERANCES

1. P. N.Shakor and S. S. Pimplikar, "Glass Fibre Reinforced Concrete Use in Construction," *Int. J. Technol. Eng. Syst.*, Vol. 2, Issue 2, 2011.
2. Jatale, K. Tiwari, and S. Khandelwal, "Effects on compressive strength when cement is partially replaced by fly-ash," *OSR J. Mech. Civ. Eng.*, Vol. 5, Issue 4, pp. 34–43, 2013.
3. S. K. Chaturvedi and A. K. Sahu, "Performance of Multi Blend Cement Containing Fly Ash , Granulated Blast Furnace Slag and Limestone," *Int. J. Geomate*, Vol. 12, Issue 29, pp. 38–45, 2017.
4. N. Shanmuganathan, A. B. S, K. Sheikibrahim, and A. S. Mohammed, "Ground Granulated Blast Furnace Slag (Ggbs or Ggbfs) and Fly Ash (Fa) in Concrete – A Study Report," Vol. 5, Issue 3, pp. 13–17, 2018.
5. Shi, N. Xie, K. Fortune, and J. Gong, "Durability of steel reinforced concrete in chloride environments: An overview," *Constr. Build. Mater.*, Vol. 30, pp. 125–1382012.
6. K. Hwang, T. Noguchi, and F. Tomosawa, "Prediction model of compressive strength development of fly-ash concrete," *Cem. Concr. Res.*, Vol. 34, Issue 12, pp. 2269–2276, 2004.
7. M. Syarif, V. Sampebulu, and M. W. Tjaronge, "Case Studies in Construction Materials Characteristic of compressive and tensile strength using the organic cement compare with portland cement," *Case Stud. Constr. Mater.*, Vol. 9, p. e00172, 2018.

AUTHORS PROFILE

V. Phani Teja is doing his Master of Technology in structural engineering at koneru lakshmaiah education foundation (Deemed to be university), vaddeswaram Guntur district, Andhra Pradesh, India.

Mr. K. J. Brahma Chari, M.Tech in Structural Engineering, Working as Assistant Professor and Research scholar, Department of Civil Engineering, K L Deemed to be University, Vaddeswaram, Guntur, Andhra Pradesh, India. I'm published 4 Scopus indexed papers in various reputed journals. Also, Professional member of Indian Society for Technical Education (ISTE), International Society for Research and Development (ISRD), International Association of Engineers (IAENG) and ASTM International.

V. Ranga Rao is working as Professor, Department of Civil Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, AP, India. He has completed Ph.D. in Structural Engineering from Andhra University in 1999. His research interests include Dykes, Check dams, Roads & Rehabilitation and Retrofitting of RC structures. He has published 28 research papers in international journals and conferences and guiding 1 number of Ph.D. scholars, guided 15 number of masters and 10 number of bachelor's dissertation work.