iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** VI **Month of publication:** June 2017

DOI:

www.ijraset.com
IC Value: 45.98
Volume 5 Issue VI, June 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Partial Replacement of Natural Aggregates with Ferrochrome Slag

Nistala Anjani Sowmya Sree
M. Tech Student, Viswanatha Institute of Technology and Management, Visakhapatnam

I. INTRODUCTION

In a developing country like India, with fast decrease in the available natural resources which are used for the construction purpose we should search for alternative materials which satisfy the requirements of the materials in use. Construction of infrastructure also increases the demand for production of concrete, which in turn increases the demand and supply of aggregates. Lack of availability of good quality aggregates within reasonable distance brings out the need to identify the sources of new aggregate. The material used for testing need to have the potential to meet the aggregate demands for construction activities. The twin objectives of conservation of natural resources and pollution free environment may be achieved. Recycling the waste concrete was the first initiative step taken to produce a new aggregate concrete. Replacing part of the natural aggregates with alternatives has the benefits of reducing the extraction of aggregates, the amounts of disposed waste materials, and the associated environmental and social impacts.

The principal objective of this project is to evaluate the potential use of Ferrochrome Slag aggregate as alternative aggregates in concrete, a major construction product. 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 geosynthetic aggregates. Aggregates are the most mined material 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. Due to the relatively high hydraulic conductivity value as compared to most soils, aggregates are widely used in drainage applications such as foundation and French drains, septic drain fields, retaining wall drains, and road side edge drains. Aggregates are also used as base material under foundations, roads, and rail roads. In other words, aggregates are used as a stable foundation or road/rail base with predictable, uniform properties (e.g. to help prevent differential settling under the road or building), or as a low-cost extender that binds with more expensive cement or asphalt to form concrete.

Sources for these basic materials can be grouped into three main areas: Mining of mineral aggregate deposits, including sand, gravel, and stone; use of waste slag from the manufacture of iron and steel; and recycling of concrete, which is itself chiefly manufactured from mineral aggregates. In addition, there are some (minor) materials that are used as specialty lightweight aggregates: clay, pumice and vermiculite.

A. *Introduction to Ferrochrome slag*

Ferrochromium slag is a waste material obtained from the manufacture of ferrochromium (FeCr). FeCr metal is produced in electric-arc furnaces by a physical-chemical process from the oxide of chromium ore with coke as the reducing agent at a temperature of about 1700 °C. Both the molten FeCr metal and the slag flow out into ladles.

After gravity separation from the metal, the molten slag slowly cools in the air, forming a stable, dense, crystalline product having excellent mechanical properties. The physical properties of Ferrochrome slag offers advantages compared to other aggregates. It lacks clay and organic ingredients in its composition, has a rough and porous surface, good adhesion and good abrasion resistance. On the other hand, the water absorption rate is partially high because of the porous nature of the slag. The typical ferrochrome slag composition is 30 % SiO_2, 26 % Al_2O_3, 23 % MgO and 2 % CaO. The chrome content in the slag is about 8 % and the iron content 4 % respectively. Ferrochrome slag is acid. Its basicity is 0.8.

B. *Objectives of the Present Work*

The present investigation aims at conducting a feasibility study of producing concrete with available Ferrochrome slag aggregate as coarse aggregate in concrete. Different specimens viz., cubes, cylinders, beams will be cast and tested for obtaining properties like compressive strength, tensile strength and flexural strength. Accordingly, the specific objectives of the present work are listed

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

below.

1) To establish engineering properties of Ferrochrome slag aggregate and to assess suitability as coarse aggregate in concrete.
2) To study the strength characteristics of various M20 and M60 concrete mixes with different volumes with partial and full replacement of conventional aggregate by Ferrochrome slag aggregate.
3) To assess the Compressive, Split Tensile and flexure strengths of M20 and M60 Grades Ferrochrome slag aggregate concrete mixes and to compare with conventional aggregate concrete.
4) To assess the quality of Ferrochrome slag aggregate concrete mixes using to compare quality of FeAC with reference to CAC.

Thus, a detailed experimental program is carried out on various Ferrochrome slag aggregate concrete mixes (M20 and M60) produced with Ferrochrome slag aggregate.

C. *Properties of Ferrochrome slag aggregate*

The Physical and mechanical properties of Ferrochrome Slag aggregate (Fe SA) and natural coarse aggregate are presented below.

1) Specific Gravity: Specific Gravity of Fe SA is found to be (3.07) which is higher when compared to natural aggregate (2:76).This is due to the solid nature of waste material obtained from manufacture of Ferro chromium processed at a temperature of about 1700ºC.
2) Water absorption: Water Absorption of Fe SA is 0.604% and is slightly higher than that of natural aggregate (0.5%).
3) Elongation and Flakiness index: The Flakiness index is taken as the total weight of the material passing through the various thickness gauges expressed as a percentage of total weight of sample taken. Elongation index is the total weight of the material retained on various length gauges expressed as percentage of weight sample gauges. The percentage of Elongation index is 10.37 and Flakiness index is 15.18.
4) Resistance to crushing and impact value: The Crushing and impact values of Ferrochrome aggregate are relatively higher. As per IS 2386 part IV, the crushing and impact values for concrete wearing surfaces should not exceed 30% for its use. Hence the ferrochrome aggregate can be safely used for concrete roads and bridge wearing coats and other general RCC works. The percentage of crushing for ferrochrome aggregate is 13.7 and the aggregate impact value is 12.8 %.It was known that the values were well within the codal limits of 45% for concrete. Hence these aggregate can be used for structural concrete.

Table: Sieve Analysis for Conventional and Ferrochrome fine aggregates

Sieve size		Cumulative passing (%)	Cumulative passing (%)
		Conventional aggregate	Ferrochrome aggregate
0.15		5	0
0.3		18	16.25
0.6		46	44.25
1.18		80	71.25
2.36		100	97
4.75		100	100

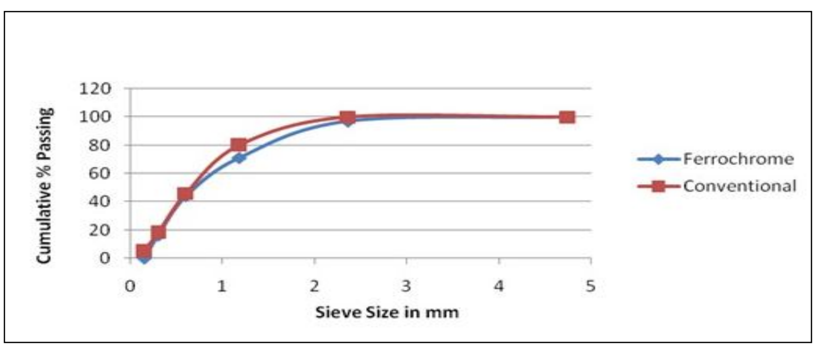


Fig . Grading Curves for Ferrochrome & Conventional fine aggregates

D. *Compressive Strength*

The results of compressive strength at 7, 28 days for two mixes M20 and M60 with various replacements are tabulated in table and

Volume 5 Issue VI, June 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

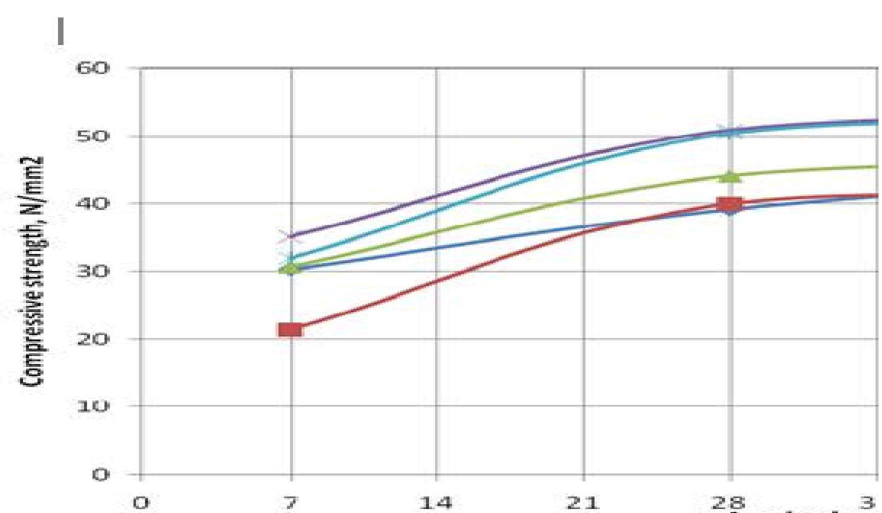
figures which include the average values of three cubes for each mix. It is observed from the table and figures that in FeAC mixes as the percentage of FeSA increases the compression strength increases upto 75 % replacement and further decreases for 100% replacement for M20. With the replacement of Ferrochrome slag aggregate in the range 25 % to 75 %, the 7 days compressive strength is about 21.33 N/mm^2 to 35.1 N/mm^2. For M20 grade the 7 days compressive strength is about 35.1 N/mm2 which is higher than CAC. The max % increase of 7 days compressive strength obtained for 75% replacement of FeAC is 13.68%. The 28 days cube compressive strength is about 50.89 N/mm^2 with the 75% replacement of FeAC. For M20 grade mix when compared with reference mix, the FeAC mix shown higher values. The increase of 28 days compressive strength when compared with CAC is about 22 %. This is due to superior properties of FeSA One notable observation is that in M20 grade of concrete the target mean compressive strength is reached easily. It can be noted that the % increase is marginal in the range of 12% as compared to strength at 28 days.

Table shows the results of compressive strength test on 150mm cubes at different ages. The 28 days compressive strength was 39.21N/mm^2 for concrete with conventional aggregate and 50.89 N/mm^2 for concrete with Ferrochrome slag aggregate with 75% replacement (coarse aggregate) the compressive strength of FeAC is observed to vary from nearly 22% higher than that of the conventional concrete. The 7days strength have shown similar trend. It is also observed that pattern of the strength development with age for FeAC and CAC in similar.

Similar results were observed in M60 grade concrete. The compressive strength increased up to 50% in M60, signifying the fact that the percentage increase in compressive strength, with the addition of Ferrochrome slag aggregate gradually reduces as the grade of concrete increases.

Table Variation of compression strength with age for FeAC

S.No.	% replacement of aggregate	At 7 days	At 28 days
M60	0	45.21	54.82
	25 %	45.33	58.86
	50%	48.89	61.00
	75%	43.56	51.38
	100%	41.22	48.66
M20	0	30.30	39.21
	25 %	21.33	40.00
	50%	30.67	44.12
	75%	35.1	50.89
	100%	31.91	50.38



Variation of Compressive Strength with age for different percentages ofFerrochrome slag aggregate (M20)

Volume 5 Issue VI, June 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

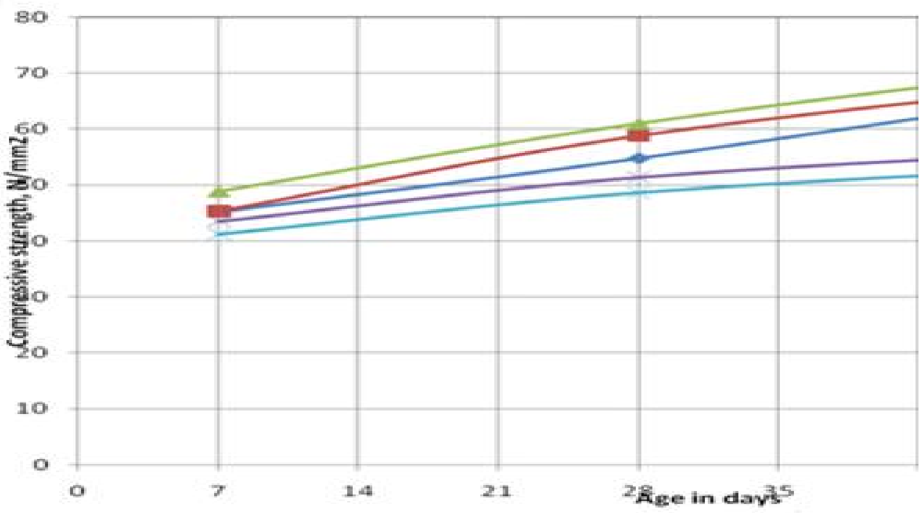


Fig 4.3 Variation of Compressive Strength with age for different percentages of Ferrochrome slag aggregate (M60)

II. SUMMARY AND CONCLUSIONS

A. General

Based on the results of laboratory investigations carried out on Ferrochrome Slag aggregate as coarse aggregate in CAC specific conclusions have been drawn for using slag in concrete making.

B. Conclusions

The following conclusions are drawn from the extensive experimental investigation carried out.

1) The Specific gravity and bulk density of Ferrochrome Slag aggregate are found to be higher than conventional coarse aggregate.
2) The water absorption is relatively lesser for Ferrochrome slag aggregate in comparison to conventional coarse aggregate.
3) Ferrochrome Slag Aggregate concrete exhibited relatively less workability thus posing problems in terms of mobility and place ability control.
4) The percentage increase in compressive strength, split tensile strength and flexure strengths with the addition of Ferrochrome slag aggregate gradually reduces as the grade of concrete increases.
5) When compared to plain concrete strength variation in the both grades of concrete is very marginal.
6) All the mixes attained the target mean strength. Cube Strength of FeAC is about 38.00 to 51.00N/mm^2 respectively with the replacement of Ferrochrome Slag Aggregate in the range of 25 to 100% for M20 grade and for M60 grade the increase in cube strength is about 48.00 to 68.00N/mm^2 respectively in the range of replacement 25 to 100%.
7) Concrete with 100% replacement of conventional coarse aggregate with Ferrochrome Slag aggregate had less compressive strength than conventional aggregate concrete at 28 days with same W/C ratio (0.52) for both grades and quantity of cement is 330 kg/m^3
8) Concrete made with 25% replacement of conventional coarse aggregate with Ferrochrome slag aggregate achieved the same mechanical properties as that of the CAC employing the same W/C ratio 0.52 and quantity of cement are 330 kg/m3 for M20 and M60 grades.
9) Concrete made with 50% and 75% replacement of CAC with FeAC achieved the compressive strength of 44.12 N/mm2 and 50.89 N/mm2 respectively at 28 days for M20. Whereas, M60 grade concrete made with 25% and 50% replacement of CAC with FeAC at 28days achieved compressive strength of 58.86N/mm2 and 61.00N/mm2 respectively.
10) Split tensile strength of FeAC mixes is about 2.3 to 3.0N/mm^2 with the replacement of FeAC in the range of 25 to 100% for M20 and for M60 is about 3.2 to 3.8N/mm^2 with the replacement of FeAC in the range of 25 to 100%.
11) Modulus of Rupture of FeAC is about 5.3 to 6.8N/mm^2 with the replacement of FeAC in the range of 25 to 100% for M20 and for M60 is about 7.0 to 7.5N/mm^2 with the replacement of FeAC in the range of 25 to 100%.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

12) The FeAC mix resulted in reduction of Compressive, Split and Modulus of Rupture when compared with the CAC concrete mix when the replacement percentage is 100% for M20 and 75% to 100% for M60
13) Compressive, Split Tensile and Modulus of Rupture strengths of ferrochrome slag aggregate concrete have shown increase in strength up to 75% replacement of conventional aggregate by ferrochrome slag for M20 grade and up to 50% for M60 grade.
14) NDT results revealed that the strength of conventional and ferrochrome aggregate concrete is more or less equivalent as noticed for destructive tests and quality of concrete in terms of homogeneity is good.
15) The test results obtained from non-destructive testing are in accordance with the conventional test results.

The experimental study has helped to investigate the various properties of Ferrochrome slag aggregate as global replacement of conventional aggregate with ferrochrome slag aggregate in the production of structural concrete.

In view of the other advantages such as conservation of natural resources, the ferrochrome slag aggregate material from landfills and elimination of disposal problems, the Ferro chrome slag aggregate and Ferrochrome slag aggregate concrete can be considered as a potential and suitable alternative material with a bright future.

C. Limitations

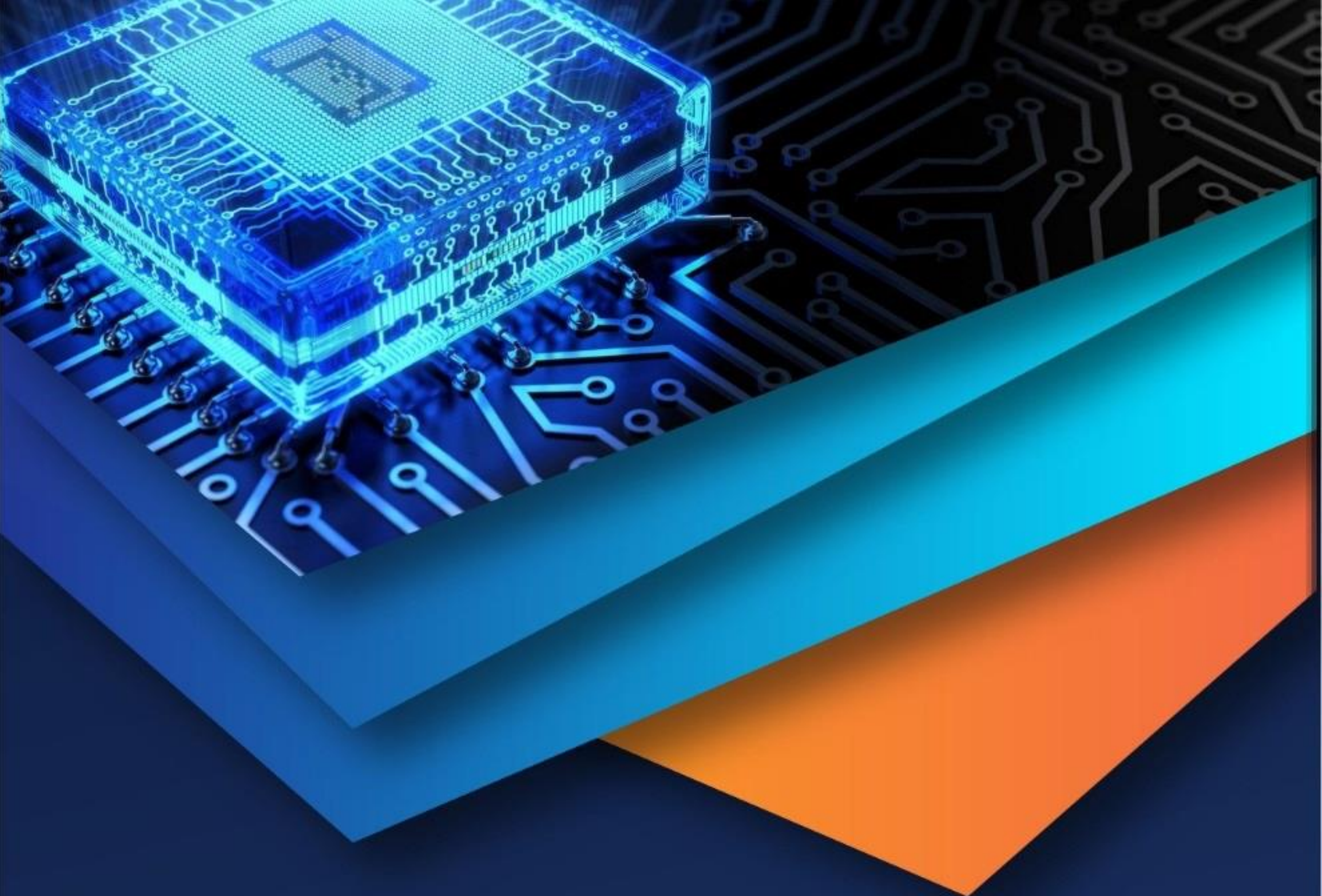
1) The conclusions made are with respect to M20 and M60 Concrete mixes. The behavior may vary with other grades of concrete.
2) The study did not deal with chemical leaching of slag when used for underground concreting.

D. Suggestions for future work

1) In the present investigation, Ferrochrome slag aggregate has been used in producing concrete. Investigation may be carried out to conduct feasibility of using different types of aggregate produced at other industries such as HZL, Si Mn and Ferro Alloys.
2) Experimentation may be carried out to investigate the possibility of using dosage of mineral admixtures.
3) Investigations may be planned to study the flexural strength of FeAC mixes.

REFERENCES

[1] Abdullah A. Siam (2007) "Properties of Concrete Mixes with Waste Glass" A Thesis Submitted in Partial Fulfillment of the Requirement for the Degree of Master of Science in Civil Engineering
[2] Akhtaruzzaman AA, Hasnat (1983) "Properties of concrete using crushed brick as aggregates", Concr Int 1983, PP : 58–63.
[3] Altan Yılmaz & Mustafa Karasahin (2009) "Mechanical Properties of Ferrochromium slag in granular layers of flexible pavement". Materials and Structures 43, PP :309–317
[4] Bairagi N.K, Kishore Ravandie & V.K.Poreek, "Behaviour of concrete with different proportions of natural and recycled aggregates", Resources, conservation and recycling 9(1993) 109-126, Elsevier Journal, July 1992.
[5] Brito J.de., Pereira A.S, Correia J.R., (2005) "Mechanical behaviour of non-structural concrete made with recycled ceramic aggregates", Cement & Concrete composites, pp 429-433.
[6] Cabral, Schalch, Dal Molin, Ribeiro, Rasiah Sri Ravindrarajah (2009) "Performance of red ceramic recycled aggregate concrete", 55, 2009,PP : 448-460.
[7] Cachim PB (2009) "Mechanical properties of brick aggregate concrete", Constr Build Mater 23(3):1292–7.
[8] Debieb F, Kenai S (2008) "The use of coarse and fine crushed bricks as aggregate in concrete", Constr Build Mater 2008. 22(5):886–93.
[9] Dina M. Sadek (2012) "Physico-mechanical properties of solid cement bricks containing recycled aggregates", Journal of Advanced Research 3, PP: 253–260.
[10] Emili Bhattacharjee, Debjani Nag, Partha P. Sarkar and Lipika Haldar (2011) "An Experimental Investigation of Properties of Crushed over Burnt Brick Aggregate Concrete", International Journal of Engineering Research and Technology, Volume 4, Number 1 (2011), PP. 21-30.



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL
IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY