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PARTIAL REPLACEMENT OF WOOD ASH AND QUARRY DUST WITH CEMENT AND SAND TO STUDY THE STRENGTH PARAMETERS OF CONCRETE

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ABSTRACT

Concrete is a globally accepted construction material in all types of Civil Engineering structures. Different types of mix-designs are used in order to obtain proper concrete to satisfy appropriate purposes. The increase in construction has brought heavy demand for ingredients of concrete such as cement and sand, and these materials are becoming costly and scarce. With ever-increasing environmental problems because of industrial waste products comes a great need to use these products in an appropriate manner to reduce health and environmental problems. Concrete being a versatile material the ingredients mainly the cement replacements have taken a step ahead for the better alternative by means of naturally available sources one such proposal is by the effective utilization of wood ash as fuel, of varying percentages as a partial replacement for ordinary Portland cement in concrete and Quarry dust (QD) is a waste material, the use of which in the production of concrete may prove advantageous as quarry dust is abundantly available as an industrial waste product. Workability and compressive strength in wood ash concrete is determined. The compressive strength of concrete obtained with wood ash increase with curing period and decreases with increasing wood ash content. Optimum percentage of replacement of sand with quarry dust is 45%.

Keywords: Partial Replacement, Pozzolan, Wood Ash, Quarry Dust, Cement, Sand, Strength Of Concrete.

I. INTRODUCTION

Cement and concrete production consumes enormous amounts of natural resources and aggregates, thereby causing substantial energy and environmental losses. This production also contributes significantly to the emission of carbon dioxide, a naturally occurring greenhouse gas. Recent technological developments have shown that these materials can be used as inorganic and organic resources to produce various value-added products. The concrete industry is constantly looking for supplementary cementations material with the objective of reducing the solid waste disposal problem. The quarry dust (QD) is the by-product obtained during the crushing and washing of stones from the crushing units. Wood ash is a by –product of wood in boilers at paper mills and other burning facilities, wood ash is composed of both organic and inorganic compounds. Substantial energy and cost savings can result when industrial by-products are used as partial replacements for the energy-intensive Portland cement. In addition to this, constant use of sand from the river bed deteriorates the river channeling and causes various problems like excessive seepage, deteriorating water level etc. Thus, an increased demand for the materials which is alternated for cement and sand in the concrete.

Several alternative aggregates are being investigated to overcome this challenge, and some examples include manufactured aggregates, waste from quarrying activities, crushed sandstone aggregates, materials recycled from construction and demolition waste, copper slag and fly ash particles. In the past, residues from quarrying activities have been used for different construction applications such as in the construction of roads and highways, and in the development of building products. However, their application for concreting purposes has been very limited. The beneficial effects of some of these materials on the properties of concrete have further enhanced these efforts. The physical and chemical properties of wood ash vary significantly depending upon various factors such as species of trees/wood, method and manner of combustion of fuel, efficiency of boiler, and other contemporary fuel used with wood. Wood ash is similar to fly ash since it is obtained from a practical combustion device. Fly ash is defined as a material collected from a practical combustion device after the fuel is burned. It is an industrial by product that possesses pozzolanic and hydraulic properties.

In this project, attempts has been made to study the feasibility of using locally available quarry dust as partial replacements for cement and sand when developing high quality concrete mixes. This study explores the strength behavior of concrete mixes with and without quarry dust. The various percentage of quarry dusts such as 10 percent to 45 percent were used to partially replace sand and cement in concrete mixes.Wood ash tested had significant variations in its chemical composition:SiO_2(4 to 60%),Al_2O_3(5 to 20%),Fe_2O_3(10 to 90%),CaO(2 to 37%),MgO(0.7 to 5%) and is known to have similar pozzolanic property i.e., similar reaction rate of pozzolan with calcium hydroxide in the presence of water or Ca^{+2}ions. Hence it can be accepted as a better alternative to fly ash as it is also a byproduct of combustion process in steel production approximately 65% of the wood ash is being land filled, around 25% is being used as soil substitute, and the remaining 10% is being used for different applications Wood ash has been better known as soil supplement, but its possible utilization in cement -based materials hasn't been explored Because of the availability of siliceous compounds and utilized in replacement of cement like the fly ash but proper determination of chemical composition is required to serve the purpose in a better manner. The presence of the compounds like MgO (0.7 to 5%), TiO_2 (0 to 1.5%), K_2O (0.4 to 14%), SO_3 (0.1 to 15%), LOI (0.1 to 33%), and alkali in wood ash reduces the effective utilization as a pozzolan material and hence bringing down the line for optimum usage of wood ash.

II. LITERATURE REVIEW

Nataraja et al. developed concrete using large-size quarry waste as coarse aggregates, Hoetal used quarry dust as partial replacement for cementing material in self-compacting concrete applications. On the other hand, Kumar et al. evaluated the flexural behavior of high-performance reinforced concrete beams produced by using crushed sandstone as coarse and fine aggregates, and deduced that there is a good prospect to utilize crushed sandstone sand as fine aggregates. Eren and Mara revaluated the fresh and hardened properties of concrete with the combined utilization of limestone crusher dust in different proportions and steel fibres of different aspect ratios and volume percentages, where the crusher dust was used as a replacement for the fine Aggregates (<5 mm).This has encouraged researchers in the area of concrete engineering and technology to investigate and identify supplementary by-product materials that can be used as substitutes for constituent materials in concrete production. C. Nuntachai, J. Chai, et al [1].The fly ashes that have been widely studied are those obtained from power plants where coal is used as a fuel. D. A. Adesanya et al [2]. This study sought a better alternative source of fly ash by investigating the properties of the wood ash from burning of wood as fuel. R. Siddique [3] .The ash particles solidify as glassy spheres, microscopic that are collected from the bakery's exhaust before they can "fly" away, hence the product's name – fly ash. The classification is based on sum of ($SiO_2+Al_2O_3+Fe_2O_3$) .where as in the wood ash there are certain compounds which reduce the pozzolanic property of wood ash.

III. MATERIALS

Cement: Ordinary Portland cement of 53 grade of cement was used. With a specific gravity of 3.14.the chemical composition is shown in the Table 1.

Table 1:-chemical composition of cement

Oxides	Percentage Content
Calcium Oxide(CaO)	**60%-67%**
Silicon dioxide(SiO_2)	**17%-25%**
Aluminum Trioxide(Al_2O_3)	**3%-8%**
Iron oxide (Fe_2O_3)	**0.5%-6%**
Magnesium Oxide(MgO)	**0.1%-4%**
Alkalies(K_2O,Na_2O)	**0.4%-1.3%**
Sulphur trioxide(SO_3)	**1.3%-3.0%**

Wood Ash: Wood ash from combustion process i.e. burning of wood as fuel having composition similar to that of fly ash. Burnt wood which turns into wood ash in the presence of oxygen has compounds like alkalis which tend to reduce the pozzolanic property by slowing down the reaction rate of pozzolano with calcium hydroxide.

Fine Aggregate: The sand was passing through 1.7mm sieve was used to find the compressive strength of the concrete blocks.

Coarse Aggregate: 20mm nominal size of coarse aggregate is used, which are locally available.

Quarry Dust: The quarry dust was procured from quarry plant in Mambakkam, Chennai. The cement used was 53 grade Ordinary Portland cement (OPC). Water used was simple tap water and the calculations of the mix design was as per IS 10262-2009.

The tests performed confronted to the following IS codes

Table: 2

Experiment	IS CODE
Sieve analysis	IS 2346 (Part 1):1963
Specific gravity test	IS 2386 (part 3):1963
Vicat apparatus	
Consistency test	IS 4031 (Part 4):1988
Initial setting time	IS 4051 (Part 5):1988
Final setting time	IS 4051 (Part 5):1988
Concrete testing	IS 516:1959
Absorption test	IS 2386 (part 3):1963
Concrete Mix Design	IS 10262:2009

IV. MIX DESIGN

Mix design can be defined as selecting suitable ingredients of concrete such as cement, coarse aggregate, fine aggregate and water To get required strength, mix design was done according to the code IS10262:2009 for M20gade of 1:1.5:3. Table 3 shows the mix design data.

Table 3

Sl.No	Materials	Quantity (Kg/m^3)	Sl.NO.	Material	Quantity(kg /m^3)
1	Cement	372	1	cement (Kg)	1.35
2	QD	X	2	Fine aggregate(Kg)	2.1
3	CA	1142.58	3	Coarse aggregate (Kg)	4.05
4	FA	761.72	4	Water(L)	0.784
5	Water	186			
6	Ratio	01:02:03			

The amount of cement and aggregates used in the mix is given in table no.3and the amount of quarry dust used to replace the fine aggregate is given in table no.3 the proportion is 0, 10, 15, 30, 45%. The mix design is as per IS CODES and the QD has been varied as per the weight of fine aggregate.

Mixing of Concrete: Mixing of concrete is done in several processes. Generally we use machine mix or hand mix. In this report hand mix is adopted, workability is measured by the slump and compaction factor values. Concrete is mixed and compacted by hand with 25 blows placed in three layers and the top layer is trimmed off with a trowel, and then remoulded after 24 hours and cured for required time, and then tested for compressive strength.

Table 4: Mixing of Concrete

Partial Replacement of FA with QD						
Sl.no	**% QD**	**cement (g)**	**QD (g)**	**FA (g)**	**CA (g)**	**Water (g)**
1	0	2000	0	4000	6000	1000
2	10	2000	400	3600	6000	1000
3	15	2000	600	3400	6000	1000
4	30	2000	1200	2800	6000	1000
5	45	2000	1800	2200	6000	1000

S.NO.	**Cement Content (kg)**	**Wood ash Content(kg)**
1	1.285	0.0675
2	1.215	0.135
3	1.14	0.2025

V. WORKABILITY

Slump Cone and Compaction Factor Tests: The slump cone test and compaction factor tests determines the workability of concrete, the slump cone values are determined for different percentages of wood ash content in concrete shown in table below. The table represents that the slump first decreased for up to 10% wood ash replacement, and then increases with increased content of wood ash. The compacting factor follows a similar trend to that of slump values. These results symbolizes that concrete containing wood ash beyond 10% replacement level becomes more workable as the content of wood ash increases means that less water is required to make the concrete workable. The low water can be achieved by the finer ash particles with filling role in concrete mix.

Table -5: Slump and Compacting Factor of Wood ash Concrete quarry dust concrete

S.NO.	% of wood ash replaced	Slump Value(cm)	Compaction Factor
1	5	85	0.97
2	10	45	0.96
3	15	100	0.98

QD %	QD amount	cement	FA	CA	W/C	slump height
30	0.9	2.1	6	9	0.58	110
30	0.9	2.1	6	9	0.55	95
30	0.9	2.1	6	9	0.5	80
30	0.9	2.1	6	9	0.48	76
30	0.9	2.1	6	9	0.45	55
30	0.9	2.1	6	9	0.4	50

In order to verify the mix design that was designed, the accuracy was calculated by doing a trial and error slump cone test. The amount of QD was made constant and the amount of water was varied. It was seen that at a w/c ratio of 0.48-0.5, we get a value of 75-100 cm. this is the same that we had designed the concrete for as per IS 10269, thus a satisfactory value of w/c ratio was taken into the final mix.

VI. PREPARATION OF SPECIMEN

The cubes are made of standard sizes 150*150*150mm with different proportions of wood ash i.e. 5, 10,15percentages replacement for cement. The mix ratio used was 1:2:4 (binder, sand and granite) with water to binder ratio maintained at 0.5.the wood ash content for the three different proportions are tabulated.

VII. EXPERIMENTAL PROCEDURE: SIEVE ANALYSIS

Table 6 : Seive Analysis

Sieve size	Cumulative grams retained	% passing	%retained , cumulative
3/8 inch	0	100	0
No 4	14.8	97.1	2.9
No 8	47.6	90.6	9.4
No 16	117.3	76.8	23.2
No 30	274.2	45.9	54.1
No 50	418.8	17.3	82.7
No 100	467.4	7.7	92.3
No 200	494.2	2.4	97.6
Pan	501	0	100

Vicat Apparatus: This standard covers the requirements of the Vicat apparatus used for determination of consistency of standard cement paste and initial and final setting times of cement. The Vicat frame consists essentially of a metal stand with a sliding rod. An adjustable indicator moves over a graduated scale. The needle or plunger is attached to the bottom end of rod to make up the test weight of 300 g.

Consistency: Initial Setting Time: Place the test block under the rod bearing the needle. Lower the needle gently in order to make contact with the surface of the cement paste and release quickly, allowing it to penetrate the test block. Repeat the procedure till the needle fails to pierce the test block to a point 5.0 ± 0.5mm measured from the bottom of the mould. The time period elapsing between the time, water is added to the cement and the time, the needle fails to pierce the test block by 5.0 ± 0.5mm measured from the bottom of the moulds, is the initial setting time.

Final Setting Time: Replace the above needle by the one with an annular attachment. The cement should be considered as finally set when, upon applying the needle gently to the surface of the test block, the needle makes an impression therein, while the attachment fails to do so. The period elapsing between the time, water is added to the cement and the time, the needle makes an impression on the surface of the test block, while the attachment fails to do so, is the final setting time. The results are as tabulated below.

Table 7:- Consistency of quarry dust Concrete

%QD	Cement (g)	QD (g)	Consistency	IST (min)	FST (min)
0	400	0	28.5	52	360
10	360	40	29	56	368
15	340	60	31	68	410
30	280	120	32.5	78	456
45	220	180	34	110	492

VIII. TESTING OF CONCRETE

The final strength of concrete was generated by using UTM after 28 days of curing. The test cubes were cured for 28 days and 2 duplicates each were made. The cubes after being taken Out of the curing tank was kept in open air for surface drying and then applied load by UTM.

Fig:-2:-Testing of concrete

Table 8: Testing of Quarry dust Concrete

%QD	Block I	Block II	Block III	Mean (N)
0	998	853	867	906
15	800	720	730	750
30	680	628	663	657
45	510	470	536	505.3

Compressive Strength: The results of Compressive strength of the concrete specimens mixed with various proportions are tabulate

Table 9: Testing of wood ash concrete

Sl.No.	% of wood ash Replaced	Curing Period(days)	Compressive strength(N/mm^2)
1	0	3	8.2
		7	12.9
		28	22.4
2	5	3	8.4
		7	13.2
		28	22.1
3	10	3	9.1
		7	14.5
		28	24.1
4	15	3	8
		7	12.3
		28	21.3

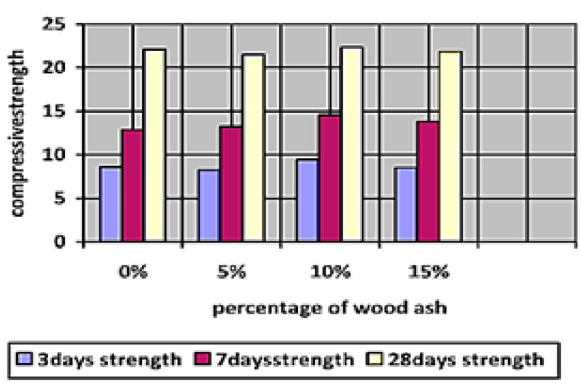


Fig 3: Testing of wood ash concrete

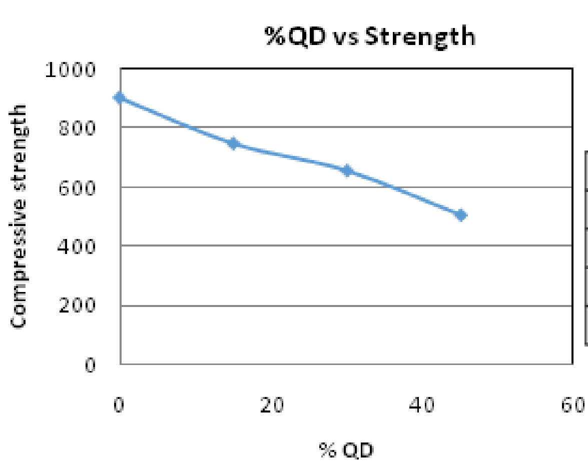
IX. ABSORPTION TEST

Table 10: Quarry dust Concrete Absorption test values

Sl .no	% QD replaced	Initial wt. (W1)	Final wt. (W2)	% absorption
0	0	8.62	8.635	0.17
10	10	8.175	8.19	0.183
15	15	8.18	8.245	0.79
30	30	8.185	8.425	2.93
45	45	8.255	8.57	3.81

X. RESULTS AND DISCUSSION

Based on grain size analysis and Blain air permeability test, it has been found that quarry dust has very fine particle of size seen in Table 5. The fineness of the quarry dust depends up on the type of crusher that is used in the quarry plant. . The fineness of the material leads to decrease in voids of the concrete which enables to achieve more compaction, which in turn increases the compressive strength of the concrete. It can be observed from fig 3 and Table 8 that as the percent of quarry dust increases the strength of concrete decreases. This is attributed to the decrease amount of fine aggregate i.e. sand, but replacing with QD which has less strength that natural sand**.**



% QD	block I	block II	Block III	Mean
0	998	853	867	906
15	800	720	730	750
30	680	628	663	657
45	510	470	536	505.3

Fig: 4: Quarry dust % vs strength

Test results of the specimen in UTM. Inlet contains the various replacement of QD with FA and their as found mean compressive strength.

It was observed that the cubes so casted gave readings inferior to that of its parent cubes which had no QD

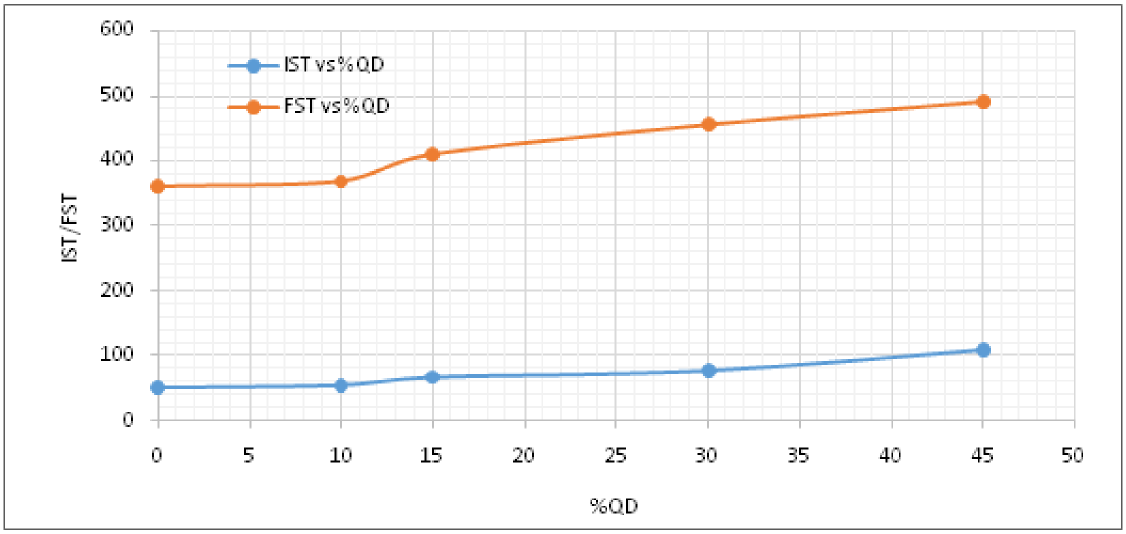


Fig 5: % Quarry dust (vs) Initial setting time and Final setting time

replacement. The Vicat apparatus readings gave higher initial and final setting time than the conventional mix. The proportion of quarry dust that was used was 0, 10,15,30,45 % with fine aggregate replaced. The increase in the value of setting time is due to the decrease in the amount of binder in the mix. Since the amount of cement decreases, the binding capacity of the total mix decreases. The final setting time also increases as a result of the same consequence. The value of the same is tabulated in table 7.

The absorption test results shows that the absorption of concrete increases as the amount of quarry dust present in it increases. The absorption capacity was calculated after keeping the cubes in the water for 24 hours. This might be because the quarry dust do not play any role in binding capacity and due to their very small size. This might also be because of the irregular shape of the QD due to which the voids in the cube increases thus causing the increase in absorption. This is one detrimental effect of using QD which might cause corrosion of reinforcements in Fig 6.

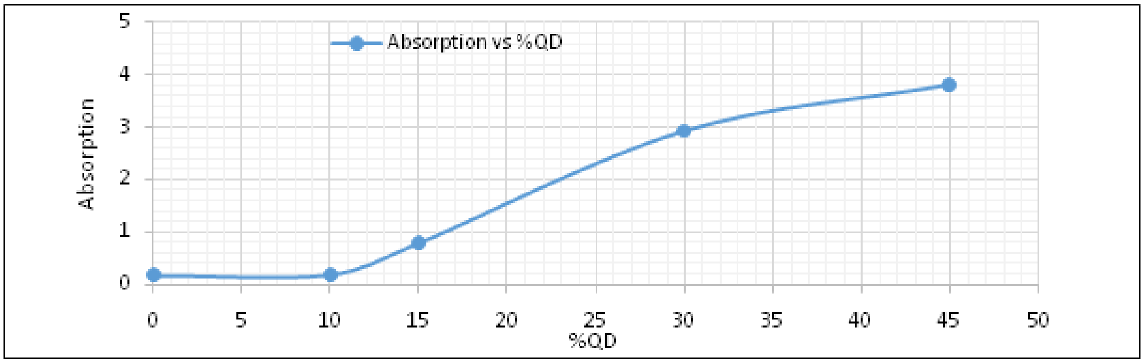


Fig 6: (Absorption vs Quarry Dust %)

RCC structures. It might also cause cracks as due to freezing and thawing action. Thus proper compaction has to be implemented if such concrete is used where such replacements are made.

As already mentioned that the size of the aggregate plays a very important role, the slump cone is a good evident to that. As the amount of quarry dust increases in the concrete, the amount of water required also increases. This is because, owing to the size of quarry dust and rough surface of the same, the quarry dust absorbs a lot of water. Thus it is another detrimental effect of the same.

Finally a quantity estimation was done in order to see the economic aspect of the using of QD as a replacement of fine aggregate. The cost of each aggregate was found and the total cost for the making one block was calculated and to have a clear picture, the price was scaled up to 1000 blocks. It was well noticed that the investment made in using quarry dust was less than, when simple fine aggregate is used. It is observed that the price of a M20 block is more than M40 block while made with quarry dust. Since the concrete cubes show decrease in strength, M40 concrete made with quarry dust shows property of M20 grade concrete. Thus the same can be used to construct structures which demands M20 grade concrete. This will reduce the cost of the structure subsequently.

Table 11: (Cost Estimation)

Cost Estimation				M40	M40 (QD)	M20
Material	Price	Unit	Price/Unit			
Cement	312	50	6.24	8.112	8.112	6.0528
Coarse Aggregate	75	50	1.3	5.018	5.018	6.24
Fine Aggregate	80	50	1.6	4.112	2.272	3.7584
Quarry Dust	5000	10000	0.5	0	0.575	0
water			0.2	0.2	0.2	0.2
Cost/ casting cube				17.442	16.177	16.2512
Cost/ cu m				5168.0646	4793.245	4815.231
Difference				374.8195	21.98546	

XI. CONCLUSION

- Based on the experimental results discussed herein, it has been concluded that when cement and sand is partially replaced with quarry dust, the following effects take place as percent of quarry dust increases

  1. Increase in setting time
  2. Increase in water requirement
  3. Increase in absorption
  4. Decrease in strength

- Based on the limited work done, it can be concluded that 45 percent of quarry dust can be safely use to replace the sand in concrete and can be used for low strength prospects such as roof concreting, floor concreting and footing.
- It can also be concluded that partial replacement of quarry dust with sand reduces the overall cost of the structure.
- It can be finally concluded that quarry dust can be used in construction of structures, but proper measures has to be taken while preparing a mix.
- It is not recommended to use quarry dust in pace of in moisten conditions where high strength concrete is required and in cold areas, where, the concrete is supposed to gain its strength faster than conventional concrete.

- From above results and discussions of wood ash concrete for different proportions, the following conclusions can be drawn:

  1. Concrete becomes more workable as the wood ash content increases. This means that wood ash concrete has lower water demand.
  2. The compressive strength generally increases with curing period and decreases with increasing wood ash content. Wood ash concrete has higher strength than the control at early ages.

Further studies such as long term strength, durability and volume change are required to establish the effectiveness of replacement.

REFERENCES

1. M. Rame Gowda; M. C. Narasimhan; and Karisiddappa, “Development and Study of the Strength of Self-Compacting Mortar Mixes Using Local Materials” (2011) American Society of Civil Engineers.
2. Ho, D.W. S., Sheinn, A. M. M., Ng, C. C., and Tam, C. T. (2002). “The use of quarry dust for SCC applications.” Cem. Concr. Res., 32, 505–511.
3. Kumar, P., Mehta, and Monteiro, P. J. M. (1997). Concrete—Microstructure, Properties and materials, Indian Ed., Indian Concrete Institute, Chennai, India, 23–285.
4. James, J., and Rao, M. S. P. (1986). “Reaction products of lime and silica from rice husk ash.” Cem. Concr. Res., 16(1), 67–73.
5. Nataraja M.C., Nagaraj T.S. and Reddy. A. 2001. Proportioning Concrete Mix with Quarry Wastes Cement. Concrete and Aggregate Journal, ASTM. 23(2): 81-87.
6. Kumar, S., and Barai, S. V. (2009). “Determining double-K fracture parameters of Concrete for compact tension and wedge splitting tests using weight function.” Eng. Fracture Mech., 76, 935-948.
7. C.Nuntachai,J.Chai,and K.Kraiwood,”Utilization of bagasse ash as a Pozzolanic Material”.
8. D.A.Adesanya, and A.A.Raheem, “A study of the Workability and Compressive Strength Characteristics of Corn Cob ash blended cement Concrete.
9. R.R.Siddique,”Performance characteristics of high volume Class Fly ash Concrete”.
10. S.Jerath, and N.Hanson, “Effect of fly ash content and aggregate gradation on durability of concrete pavement.
11. Dr. V. Bhaskar Desai, A. Sathyam and S. Rameshreddy, “Some Studies on Mode-Ii Fracture of Artificial Light Weight Silica Fume Pelletized Aggregate Concrete” International Journal of Civil Engineering & Technology (IJCIET), Volume 5, Issue 2, 2014, pp. 33 - 51, ISSN Print: 0976 – 6308, ISSN Online: 0976 – 6316.
12. Rushabh A. Shah and Jayeshkumar R. Pitroda, “Assessment of Sorptivity and Water Absorption of Mortar with Partial Replacement of Cement by Fly Ash (Class-F)”, International Journal of Civil Engineering & Technology (IJCIET), Volume 4, Issue 5, 2013, pp. 15 - 21, ISSN Print: 0976 – 6308, ISSN Online: 0976 – 6316.
13. Madan Mohan Reddy. K, Sivaramulu Naidu. D and Sanjeeva Rayudu. E, “Studies on Recycled Aggregate Concrete by using Local Quarry Dust and Recycled Aggregates”, International Journal of Civil Engineering & Technology (IJCIET), Volume 3, Issue 2, 2012, pp. 322 - 326, ISSN Print: 0976 – 6308, ISSN Online: 0976 – 6316.