IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684, p-ISSN: 2320-334X
PP 59-66
www.iosrjournals.org

Recent Trends in Replacement of Natural Sand With Different Alternatives

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ABSTRACT : *Cement, sand and aggregate are basic needs for any construction industry. Sand is a prime material used for preparation of mortar and concrete and which plays a major role in mix design. Now a day's erosion of rivers and considering environmental issues, there is a scarcity of river sand. The non-availability or shortage of river sand will affect the construction industry, hence there is a need to find the new alternative material to replace the river sand, such that excess river erosion and harm to environment is prevented. Many researchers are finding different materials to replace sand and one of the major materials is quarry stone dust. Using different proportion of these quarry dust along with sand the required concrete mix can be obtained. This paper presents a review of the different alternatives to natural sand in preparation of mortar and concrete. The paper emphasize on the physical and mechanical properties and strength aspect on mortar and concrete.*

Keywords- *Sand, Quarry Stone Dust, Alternative Material, Physical Properties, Mechanical Properties.*

I. INTRODUCTION

Cement, sand and aggregate are essential needs for any construction industry. Sand is a major material used for preparation of mortar and concrete and plays a most important role in mix design. In general consumption of natural sand is high, due to the large use of concrete and mortar. Hence the demand of natural sand is very high in developing countries to satisfy the rapid infrastructure growth. The developing country like India facing shortage of good quality natural sand and particularly in India, natural sand deposits are being used up and causing serious threat to environment as well as the society. Rapid extraction of sand from river bed causing so many problems like losing water retaining soil strata, deepening of the river beds and causing bank slides, loss of vegetation on the bank of rivers, disturbs the aquatic life as well as disturbs agriculture due to lowering the water table in the well etc are some of the examples. The heavy-exploitation of river sand for construction purposes in Sri Lanka has led to various harmful problems [1]. Options for various river sand alternatives, such as offshore sand, quarry dust and filtered sand have also been made (W.P.S. Dias et al 2008)[2]. Physical as well as chemical properties of fine aggregate affect the durability, workability and also strength of concrete, so fine aggregate is a most important constituent of concrete and cement mortar. Generally river sand or pit sand is used as fine aggregate in mortar and concrete. Together fine and coarse aggregate make about 75- 80 % of total volume of concrete and hence it is very important to fine suitable type and good quality aggregate nearby site (Hudson 1997). Recently natural sand is becoming a very costly material because of its demand in the construction industry due to this condition research began for cheap and easily available alternative material to natural sand. Some alternatives materials have already been used as a replacement of natural sand such as fly-ash, quarry dust or limestone and siliceous stone powder, filtered sand, copper slag are used in concrete and mortar mixtures as a partial or full replacement of natural sand (Chandana Sukesh et al 2013)[9]. Even though offshore sand is actually used in many countries such as the UK, Sri Lanka, Continental Europe, India and Singapore, most of the records regarding use of this alternative found mainly as a lesser extent of practice in the construction field [3].

Due to shortage of river sand as well as its high the Madras High Court restrictions on sand mining in rivers Cauvery and Tamirabharani. The facts like in India is almost same in others countries also. So therefore the need to find an alternative concrete and mortar aggregate material to river sand in construction works has assumed greater importance now a days. Researcher and Engineers have come out with their own ideas to decrease or fully replace the use of river sand and use recent innovations such as M-Sand (manufactured sand), robot silica or sand, stone crusher dust, filtered sand, treated and sieved silt removed from reservoirs as well as dams besides sand from other water bodies [4]. On the other hand, lack in required quality is the major limitation in some of the above materials. Now a day's sustainable infrastructural growth requires the alternative material that should satisfy technical requisites of fine aggregate as well as it should be available locally with large amount.

II. DIFFERENT ALTERNATIVES MATERIALS TO RIVER SAND

The world is resting over a landfill of waste hazardous materials which may substitutes for natural sand. Irrespective of position, location, scale, type of any structure, concrete is the base for the construction activity. In fact, concrete is the second largest consumable material after water, with nearly three tonnes used annually for each person on the earth. India consumes an estimated 450 million cubic meter of concrete annually and which approximately comes to 1 tonne per Indian. We still have a long way to go by global consumption levels but do we have enough sand to make concrete and mortar? Value of construction industry grew at staggering rate of 15 % annually even in the economic slowdown and has contributed to 7-8 % of the country's GDP (at current prices) for the past eight years. Thus, it is becoming increasingly discomforting for people like common people who talk about greening the industry to have no practical answer to this very critical question. In fact we have been sitting over a landfill of possible substitutes for sand. Industrial waste and by-products from almost all industry, which have been raising hazardous problems both for the environment, agricultural and human health can have major use in construction activity which may be useful for not only from the economy point of view but also to preserve the environment as well. Some of the researchers did the work to find the alternatives for natural sand and they concluded about different industrial waste and their ability to replace the much sought after natural river bed sand.

2.1 Copper Slag-

At present about 33 million tonnes of copper slag is generating annually worldwide among that India contributing 6 to 6.5 million tonnes. 50 % copper slag can be used as replacement of natural sand in to obtain mortar and concrete with required performance, strength and durability. (Khalifa S. Al-Jabri et al 2011). In India a study has been carried out by the Central Road Research Institute (CRRI) shown that copper slag may be used as a partial replacement for river sand as fine aggregate in concrete up to 50 % in pavement concrete without any loss of compressive and flexural strength and such concretes shown about 20 % higher strength than that of conventional cement concrete of the same grade [5].

2.2 Granulated Blast Furnace Slag

According to the report of the Working Group on Cement Industry for the 12th five year plan, around 10 million tonnes blast furnace slag is currently being generated in the country from iron and steel industry. The compressive strength of cement mortar increases as the replacement level of granulated blast furnace slag (GBFS) increases. He further concludes that from the test results it is clear that GBFS sand can be used as an alternative to natural sand from the point of view of strength. Use of GBFS up to 75 per cent can be recommended (M C Nataraja 2013)[6].

A mix of copper slag and ferrous slag can yield higher compressive strength of 46.18MPa (100 per cent replacement of sand) while corresponding strength for normal concrete was just 30.23MPa. Though she warns that with higher levels of replacements (100 per cent) there might be some bleeding issues and, therefore, she recommended that up to 80 per cent copper slag and ferrous slag can be used as replacement of sand (Meenakshi Sudarvizhi 2011)[7].

2.3 Washed Bottom Ash (WBA)

Currently India is producing in over 100 million tons of coal ash. From which total ash produced in any thermal power plant isapprox 15 –20 per cent of bottom ash and the rest is fly ash. Fly ash has found many users but bottom ash still continues to pollute the environment with unsafe disposal mechanism on offer.The mechanical properties of special concrete made with 30 per cent replacement of natural sand with washed bottom ash by weight has an optimum usage in concrete in order to get a required strength and good strength development pattern over the increment ages (MohdSyahrulHisyam 2010)[8].

2.4 Quarry Dust

About 20 to 25 per cent of the total production in each crusher unit is left out as the waste material-quarry dust. The ideal percentage of the replacement of sand with the quarry dust is 55 per cent to 75 per cent in case of compressive strength. He further says that if combined with fly ash (another industrial waste), 100 per cent replacement of sand can be achieved. The use of fly ash in concrete is desirable because of benefits such as useful disposal of a byproduct, increased workability, reduction of cement consumption, increased sulfate resistance, increased resistance to alkali-silica reaction and decreased permeability. However, the use of fly ash leads to a reduction in early strength of concrete. Therefore, the concurrent use of quarry dust and fly ash in concrete will lead to the benefits of using such materials being added and some of the undesirable effects being negated (Chandana Sukesh 2013)[9].

2.5 Foundry sand

India ranks fourth in terms of total foundry production (7.8 million tonnes) according to the 42nd Census of World Casting Production of 2007. Foundry sand which is very high in silica is regularly discarded by the metal industry. Currently, there is no mechanism for its disposal, but international studies say that up to 50 per cent foundry sand can be utilized for economical and sustainable development of concrete (Vipul D. Prajapati 2013)[10].

2.6 Construction and Demolition waste

There is no documented quantification of amount of construction and demolition (C&D) waste being generated in India. Municipal Corporation of Delhi says it is collecting 4,000 tonnes of C&D waste daily from the city which amounts to almost 1.5 million tonnes of waste annually in the city of Delhi alone. Even if we discount all the waste which is illegally dump around the city, 1.5 million of C&D waste if recycled can significantly substitute demand for natural sand by Delhi.

Recycled sand and aggregate from C&D waste is said to have 10-15 per cent lesser strength then normal concrete and can be safely used in non-structural applications like flooring and filling. Delhi already has a recycling unit in place and plans to open more to handle its disposal problem. Construction and demolition waste generated by the construction industry and which posed an environmental challenge can only be minimized by the reuse and recycling of the waste it generates (Akaninyene A. Umoh 2012) [11].

2.7 Spent Fire Bricks (SFB):

An experimental investigation on strength and durability was undertaken to use “Spent Fire Bricks” (SFB) (i.e. waste material from foundry bed and walls; and lining of chimney which is adopted in many industries) for partial replacement of fine aggregate in concrete (S. Keerthinarayana and R. Srinivasan 2010)[12].

2.8 Sheet Glass Powder (SGP)

Natural sand was partially replaced (10%, 20%, 30%, 40% and 50%) with SGP. Compressive strength, Tensile strength (cubes and cylinders) and Flexural strength up to 180 days of age were compared with those of concrete made with natural fine aggregates Attempts have been made for a long time to use waste glasses as an aggregate in concrete, but it seems that the concrete with waste glasses always cracks .Very limited work has been conducted for the use of ground glass as a concrete replacement. (M. Mageswari and Dr. B.Vidivelli 2010) [13].

III. PHYSICAL AND MECHANICAL PROPERTIES DIFFERENT ALTERNATIVES

3.1 Copper slag:

The slag is black glassy particle and granular materials in nature and has a similar particle size range like sand. The specific gravity of the slag is 3.91. The bulk density of granulated copper slag varies from 1.9 to 2.15 kg/m3 which is almost similar to bulk density of convectional fine aggregate. The hardness of the slag lies between 6 and 7 in Mohr scale. This is almost equal to the hardness of gypsum. The pH of aqueous solution of aqueous extract as per IS 11127 varies from 6.6 to 7.2. The free moisture content present in slag was found to be less than 0.5%.The presence of silica in slag is about 26% which is desirable because it is one of the constituents of the natural fine aggregate used in normal concreting operations. The fineness of copper slag was calculated as125 m^2 /kg. Table 1 shows the fineness tests on copper slag.

Table 1- Fineness test on copper slag [5].

Sieve size In (mm)	Weight retained(b)g	Cumulative weight retained (g)	Slag retained(n)g	Slag passing % of soil
4.75mm	4	0.4	0.4	99.6
2.36mm	17	1.7	2.1	97.9
1.18mm	225	22.5	24.6	75.4
600micron	433	43.3	67.9	32.1
300micron	281	28.1	96	4
150micron	37	3.7	99.7	0.3
75micron	3	0.3	100	0
Pan	0	0	100	0

The test results of concrete were obtained by adding copper slag to sand in various percentages ranging from 0%, 20%. 40%, 60%, 80% and 100%. All specimens were cured for 28 days before compression strength test, splitting tensile test and flexural strength. The highest compressive strength obtained was 35.11MPa (for 40% replacement) and the corresponding strength for control mix was 30MPa. This results of the research paper showed that the possibility of using copper slag as fine aggregate in concrete. The results showed the effect of copper slag on RCC concrete elements has a considerable amount of increase in the compressive, split tensile, flexural strength characteristics and energy absorption characteristics [5].

3.2 Granulated Blast Furnace Slag:

The granulated blast furnace slag (GBFS) is glassy particle and granular materials in nature and has a similar particle size range like sand. The specific gravity of the slag is 2.63. The bulk density of granulated slag varies from 1430 kg/m3 which were almost similar to bulk density of convectional fine aggregate. The water absorption of slag was found to be less than 2.56 %.The presence of silica in slag is about 26% which is desirable since it is one of the constituents of the natural fine aggregate used in normal concreting operations. The fineness of slag was 2.37.

Investigation was carried out on cement mortar mix 1:3 and GBFS at 0, 25, 50, 75 and 100% replacement to natural sand for constant w/c ratio of 0.5 is considered. The work is extended to 100% replacements of natural sand with GBFS for w/c ratios of 0.4 and 0.6. The flow characteristics of the various mixes and their compressive strengths at various ages are studied. From this study it is observed that GBFS could be utilized partially as alternative construction material for natural sand in mortar applications. Reduction in workability expressed as flow can be compensated by adding suitable percentage of super plasticizer [6].

The strength characteristics of conventional concrete and slag concrete such as compressive strength, tensile strength were found. Six series of concrete mixtures were prepared with different proportions of CS and FS ranging from 0% to 100%. The test results of concrete were obtained by adding of Copper Slag (CS) and Ferrous Slag (FS) to sand in various percentages ranging from 0%, 20%. 40%, 60%, 80% and 100%. All specimens were cured for 7, 28, 60 & 90 days before compression strength test and splitting tensile test. The results indicate that workability increases with increase in CS and FS percentage. The highest compressive strength obtained was 46MPa (for 100% replacement) and the corresponding strength for control mix was 30MPa. The integrated approach of working on safe disposal and utilization can lead to advantageous effects on the ecology and environmental also. It has been observed that upto 80% replacement, CS and FS can be effectively used as replacement for fine aggregate. Further research work is needed to explore the effect of CS+FS as fine aggregates on the durability properties of concrete [7].

3.3 Washed Bottom Ash (WBA):

The fineness modulus is the summation of the cumulative percentage retained on the sieve standard series of 150, 300 and 600 μm, 1.18, 2.36, 5.0 mm up to the larger sieve size used. The calculated fineness modulus of bottom ash was 3.65 which is more than 3.5 and is considered to be very coarse. For categorization given in BS 822:1992 based on percentage passing the 600µm sieve between 55% to100% would defined it as fine sand. While WBA has percentage passing 600 µm of 58.99%. Therefore, the WBA is considered as fine sand (Alexander & Mindess, 2005)[16].

Different concrete mixes with constant water to cement ratio of 0.55 were prepared with WBA in different proportions as well as one control mixed proportion. The mechanical properties of special concrete with 30% WBA replacement by weight of natural sand is found to be an optimum usage in concrete in order to get a favorable strength and good strength development pattern over the increment ages [8].

3.4 Quarry Dust:

The results (Table 2) show that there is an increase in the compressive strength of the concrete which the increment is about 55% to 75% depending on the replacement if the sand with the quarry dust, for the 100% replacement of the sand the compressive strength is depending on the quarry dust location from where the quarry dust was taken. The workability of the concrete is decreasing when the replacement percentage of the quarry dust is increasing gradually, so as to increase the workability small quantity of the fly-ash is replaced in place of cement to increase the workability. This show that the fly ash and quarry dust replacement showed the desirable results which can suggest the usage of the quarry dust as replacement of sand [9].

Table2- Physical properties for the quarry dust [9]

Property	Quarry Dust	Natural Sand	Test method
Specific gravity	2.54 -2.60	2.60	IS2386(Part III)- 1963
Bulk density (kg/m3)	1720- 1810	1460	IS2386(Part III)- 1963
Absorption (%)	1.20- 1.50	Nil	IS2386(Part III)- 1963
Moisture Content (%)	Nil	1.50	IS2386(Part III)- 1963
Fine particles less than 0.075 mm (%)	12-15	6	IS2386(Part III)- 1963
Sieve analysis	Zone-II	Zone-II	IS 383- 1970

3.5 Foundry Sand:

Foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon residual binder and dust.

The fine aggregate has been replaced by used foundry sand accordingly in the range of 0%, 10%, 30% & 50% by weight for M-20 grade concrete. Concrete mixtures were produced, tested and compared in terms of compressive and flexural strength with the conventional concrete. These tests were carried out to evaluate the mechanical properties for 7, 14 and 28 days. This research work is to investigate the behaviour of concrete while replacing used foundry sand in different proportion in concrete. This low cost concrete with good strength is used in rigid pavement for 3000 commercial vehicles per day and Dry Lean Concrete (DLC) 100mm thick for national highway to make it eco-friendly [10].

3.6 Construction and Demolition waste:

The fine aggregate was replaced with crushed waste sandcrete block (CWSB) in various percentages in the steps of 10 starting from 10% to a maximum of 100%, while 0% represents the control. The properties of the concrete were evaluated at 7, 14 and 28 days curing periods. Results showed (Table 3) that replacing 50% of CWSB aggregate after 28 days curing attained the designed compressive strength as the conventional concrete (i.e., the control). Thus it is concluded that CWSB can be used as a supplementary aggregate material in concrete [11].

Table 3- Physical Properties of the Construction and Demolition waste [11]

Sl. No.	Physical Properties	Values
01	Compacted Bulk density, [kg/m3]	1564
02	Porosity, [%]	11.22
03	Specific gravity	2.40
04	Water absorption (%)	28.74
05	Silt content (%)	5.22

3.7 Spent Fire Bricks (SFB):

An experimental investigation of strength and durability was undertaken to use “Spent Fire Bricks” (SFB) (*i.e*. waste material from foundry bed and walls; and lining of chimney which is adopted in many industries) for partial replacement of fine aggregate in concrete. The compressive strength of partial replacement of Crushed Spent Fire Bricks (CSFB) aggregate concrete is marginally higher than that of the river sand aggregate concrete at age of 7 days, 14 days, and 28 days, respectively. The split tensile strength of partial replacement of CSFB aggregate concrete is higher than that of the river sand aggregate at all ages. The modulus of elasticity of partial replacement of CSFB aggregate concrete is marginally higher than that of the river sand aggregate concrete. The partial replacement of GGBS can be used effectively as fine aggregate in place of conventional river sand concrete production [12].

Table 4- Physical Properties of the spent fire bricks [12]

Sl. No.	Physical Properties	Values
01	Bulk density, [kg/m3]	2,000
02	Porosity, [%]	25 to 30
03	Size tolerance, [%]	±2
04	Working temperature, [°C]	1,300 to 1,400
05	Crushing strength (cold), [N/mm2]	24.5 to 27

3.8 Sheet Glass Powder (SGP):

The SGP is suitable for use in concrete making. The fineness modulus, specific gravity, moisture content, uncompacted bulk density and compacted bulk density at 10% Sheet glass powder (SGP) were found to be 2.25,3.27,2.57%,1510kg/ m^3 and 1620kg/m^3.

The compressive strength of cubes and cylinders of the concrete for all mix increases as the % of SGP increases but decreases as the age of curing increases due to alkali silica reaction. The Tensile strength of cubes and cylinders of the concrete for all mix increases than that of conventional concrete age of curing and decreases as the SGP content increases. The Flexural strength of the beam of concrete for all mix increases with age of curing and decreases as the SGP content increases. 100% replacement of SGP in concrete showed better results than that of conventional concrete at 28 days and 45 days curing but later it started to decrease its strength because of its alkali silica reactions. The density of SGP concrete is more that of conventional concrete. SGP is available in significant quantities as a waste and can be utilized for making concrete. This will go a long way to reduce the quantity of waste in our environment. The optimum replacement level in fine aggregate with SGP is 10% [13].

IV. CONCLUSION

1. An improvement in the compressive strength, split tensile strength and flexural strength of concrete by addition of copper slag can be seen. The density of concrete increases with replacement of copper slag in concrete. There is increase in the flexural strength of the beam by 21% to 51% while replacement of copper

slag. By partial replacement of sand by copper slag, the strength increase is observed up to 40% replacement. Copper slag replacement at higher level leads to segregation and bleeding due to less water absorption capacity of copper slag. Author was also observed that the sand replaced copper slag beams showed an increase in energy absorption capacity.

2. It was also observed that the increase in compressive strength of cement mortar with the replacing the GGBS. This increase is not significant. But for 100% replacement the strength decreases a little bit compared to 100% natural sand. Author concluded that GGBS sand can be used as an alternative to natural sand from the point of view of strength and recommended to replace up to 75%.

3. It can be concluded that 30% of Washed Bottom Ash (WBA) can be replaced with sand in concrete is the optimum amount to get favorable strength, saving in environment and reducing the cost.

4. There is improvement in the compressive strength of the concrete by partial replacement of quarry dust with sand. Due to absorption of the water by the quarry dust, decreases the workability of concrete with increase in quarry dust quantity. The recommended percentage of the replacement of sand with the quarry dust is between 55% to 75% in case of compressive strength. The 100% replacement of sand can be achieved by addition of fly ash along with quarry dust. For mortar, stone powder is well suitable to choose it as an alternative of sand. The availability of the stone powder is depends on the locality and its price is mar vary. If the stone powder is available in the market, it can be used as an alternative to sand and it is observed that concrete made stone chip will have higher compressive strength compared with that of concrete made with brick chips. This may be due to inferior quality brick chip, poor workmanship, and improper proportions of mixing. Since brick chip is inexpensive and normally available, hence used for the low strength structures.

5. There is improvement in the compressive strength and flexural strength of the concrete by partial replacement of foundry sand with sand. It is observed that there is increase in compressive and flexural strength with increase in foundry sand replacing natural sand. The maximum compressive strength and flexural strength obtained at 50% replacement of natural fine aggregate with used foundry sand.

6. It is observed that increase in CWSB content in concrete, there is decrease in the density of concrete. Concrete containing up to 50% CWSB as fine aggregate compared suitably with normal concrete mix and hence 50% CWSB content is adopted as the optimum for design characteristic strength of $30N/mm^2$.

7. There is improvement in the compressive strength of the concrete by partial replacement of Crushed Spent Fire Bricks (CSFB) in concrete. The maximum strength is attained by 25% of CSFB replacement in concrete. There is no increase in strength observed with 30% and more of CSFB replacement in concrete. Test results shown that the compressive strength of partial replacement of CSFB aggregate concrete is a little bit higher than that of the river sand aggregate concrete at age of 7, 14 , and 28 days, respectively.

8. The sheet glass powder (SGP) is available in substantial quantity as a waste and it can be used for making concrete. This will help to reduce the quantity of waste in our environment. It is observed that the compressive strength of concrete for all mix increases as the percentage of SGP increases, but decreases with the age of curing increases because of alkali silica reaction. The Tensile strength of the concrete for all mix increases than that of conventional concrete of same age of curing and decreases with increase in SGP content. Similarly the Flexural strength of the beam of concrete for all mix increases with age of curing and decreases with increase in SGP content. SGP replacing by 100% showed improved results than that of conventional concrete at 28 days and 45 days but later it is observed decrease in strength due to alkali silica reactions. The density of SGP concrete is little bit higher that of conventional concrete. For the best results the optimum replacement level in fine aggregate with SGP is 10%.

This paper presented in view of alternatives available in place of natural sand in mortar and concrete. There are various materials available, which are recognized as waste product of industry or from Domestic. But from the above conclusion shows that many researchers have recognized these materials and spent their valuable time and shared their knowledge to make aware of these materials for the construction industry. They showed that no material in the world is waste, but one has to see it in different way to recognize, how best the waste can be handled. Few alternative materials discussed in this paper are from hard work of various research scholars. But those materials can be utilized effectively for concrete mix and building mortar and awareness should be spread to society. The utilization of these materials should be in such a way that the locally available such alternative materials should be selected so as to achieve economy and required design strength.

REFERENCES

[1] National sand study for Sri Lanka, vols. 1 and 2. Final Report, Phase 1, Delft Hydraulics, 1992.
[2] Dias WPS. The analysis of proposed change and stakeholder response– a case study, Civil Environ Eng Syst, 2000, Vol. 17,1–17.
[3] National practices and regulations in the extraction of marine sand and gravel, Ch. 3 in Sandpit Book. <http://sandpit.wldelft.nl/reportpage/reportpage.htm>.
[4] http://www.thehindu.com/todays-paper/tp-national/tp-tamilnadu/msand-thrown-up-as-an-alternative-to-river-sand/article3752772.ece
[5] Arivalagan.S, Experimental study on the flexural behavior of reinforced concrete beams as replacement of copper slag as fine aggregate, Journal of Civil Engineering and Urbanism, 2013, Vol. 3, 176-182.
[6] M C Nataraja, P G Dileep Kumar, A S Manu and M C Sanjay, Use of granulated blast furnace slag as fine aggregate in cement mortar, Int. J. Struct. & Civil Engg. Res., 2013, Vol. 2, 60-68.
[7] Meenakshi Sudarvizhi and S. Ilangovan , Performance of copper slag and ferrous slag as partial replacement of sand in concrete International Journal of Civil & Structural Engineering, 2011, Vol. 1, 918-27.
[8] Mohd Syahru, Hisyam bin Mohd Sani, Fadhluhartini bt Muftah and Zulkifli Muda , The properties of special concrete using washed bottom ash (wba) as partial sand replacement, International Journal of Sustainable Construction Engineering & Technology, 2010, Vol. 1, No 2, 65-78.
[9] Chandana Sukesh, Katakam Bala Krishna, P.Sri Lakshmi Sai Teja and S.Kanakambara Rao, Partial replacement of sand with quarry dust in concrete, International Journal of Innovative Technology and Exploring Engineering (IJITEE), 2013, Vol. 2, 254-58.
[10] Vipul D. Prajapati, Nilay Joshi and Prof. Jayeshkumar Pitroda, Techno- economical study of rigid pavement by using the used foundry sand, International Journal of Engineering Trends and Technology (IJETT),2013,Vol. 4, 1620-28.
[11] Akaninyene A. Umoh, Recycling demolition waste sandcrete blocks as aggregate in concrete, ARPN Journal of Engineering and Applied Sciences, 2012, Vol. 7, 1111-18.
[12] S. Keerthinarayana and R. Srinivasan, Study on strength and durability of concrete by partial replacement of fine aggregate using crushed spent fire bricks, Bul. Inst. Polit. Iaşi, 2010.
[13] M. Mageswari, and Dr. B.Vidivelli, The use of sheet glass powder as fine aggregate replacement in concrete, The Open Civil Engineering Journal, 2010, Vol. 4, 65-71
[14] Lohani T.K., Padhi M., Dash K.P. and Jena S., Optimum utilization of quarry dust as partial replacement of sand in concrete, Int. Journal of Applied Sciences and Engineering Research, 2012, Vol. 1, 391-404.
[15] W.P.S. Dias , G.A.P.S.N. Seneviratne and S.M.A. Nanayakkara, Offshore sand for reinforced concrete, Construction and Building Materials, 2008, Vol. 22, 1377–1384.
[16] Alexander M. & Mindess S. (2005). Aggregates in concrete. Taylor & Francis. Specification for Aggregates for natural source for concrete. British Standard BS882: 1992.
[17] H. M. A. Mahzuz, A. A. M. Ahmed and M. A. Yusuf, Use of stone powder in concrete and mortar as an alternative of sand, African Journal of Environmental Science and Technology, 2011, Vol. 5, 381-388.