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Study of Mechanical Properties of Concrete Using Construction and Demolition Waste in Concrete

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***Abstract*: Recycling of construction and demolition rubble is not new concepts as several countries have been using crushed waste aggregates. It is estimated that the total waste generated in India is 960 million tones. The construction waste in India is estimated as 24 million tones, out of Brick and masonry waste is 3.60-4.40 million tones. These wastes create impacts on environment in the form of construction wastes debris. Impacts on environments can be minimized by finding various ways to reuse these products.**

The present experimental investigation work describes possibility of using crushed masonry as aggregates. Herein experimental work clay bricks aggregate and cement bricks aggregates used as coarse aggregates at constant water cement ratio 0.45. In this project effort have been made to gain mechanical properties of concrete by inclusion of steel fiber. The steel fiber is added at systematically by 1%, 1.5% and 2% of cement content.

The comparative study is presented with respective to workability, compressive strength of M35 grade concrete. Recycled aggregates doing lesser workability compare with conventional concrete. Cement brick aggregates concrete obtained more strength compare with clay brick aggregates but both are gain lesser strength compare with conventional aggregates. It is found that, steel fibers taken more advantages to improve in strength of compare with conventional concrete.

***Keywords*: Concrete waste, Concrete waste reuse, Construction waste, New concrete.**

1. Introduction

Concrete plays a vital part in our daily lives and in a functioning society. Concrete posses important property like durability, strength, high mould ability, structural stability, versatility, fire-resistance, Excellent thermal mass, Albedo effect and relatively low cost make it the backbone of buildings and infrastructure worldwide. It is estimated that the total solid waste generated in India is about 960 million tons of which the construction waste alone is 14.5 million tones. Construction and Demolition waste in India is estimated as 24 million tones out of which Bricks & masonry waste is 3.60 – 4.40 million tones. Impacts to the environment can be minimized by finding a way to reuse the products/materials when they reach their lifetime, which ensures only minimal impacts to environment, or alternatively, by extending their lifetime, thus improving their durability and reducing resource consumption.

Alternative materials such as CDW as well as other industries by-products are increasingly being tested and used as environmental sustainable natural aggregates substitutes. Rapid advances in Construction materials technology have enabled civil and structural engineers to achieve impressive gains in the safety, economy, and functionality of structure built to serve the common needs of society.

This study present an initial understanding of the current strengths and weaknesses of the practices intended to support construction industry in developing effect policies. It has been established that materials and components recovered from demolished buildings are being reused for new construction works as well as renovation projects, especially by low-income communities in developing countries.

Fiber use in concrete will increasingly continue to be the preferred selection for many works like repair and rehabilitation projects involving constructions of tunnel, dams, bridges, Industrial floors, airport pavements, overlays, and high rise buildings, TV towers, parking garages, offshore structures, historic monuments and other structures. . The concept of using fibers as reinforcement is not new they have been used since ancient times to reinforce brittle materials. Horse hair was used to reinforce plaster, straws were used to reinforce sun baked bricks and asbestos fibers are being used to reinforce Portland cement. The applications of fibers in concrete are increasing rapidly. The fibers can be successfully used to improve the post cracking response of the concrete, i.e., to improve its energy absorption capacity and apparent ductility, and to provide crack resistance and crack control. The low tensile strength and brittle character of concrete have been bypassed by the use of fibers. Fiber may be an improved means of providing foundations for machinery where shock and vibratory loads are evident. Steel fiber reinforced concrete is a composite material consisting of a concrete matrix containing a random dispersion of steel fibers.

2. Materials

For preparation of concrete cube, clay brick aggregates concrete and cement brick aggregates concrete, materials used were cement, fine aggregates, coarse aggregates (20mm), coarse aggregates (10mm), Clay brick aggregates, Cement brick aggregates, hooked end steel fibers, and water. Tests performed on materials used are discussed below with compression of IS codes.

A. Cement

The cement used in this experimental work was 53 Grade Ordinary Portland cement (OPC), and is used within one month of its arrival in the laboratory. IS: 12269-1987- Specification for 53 grades ordinary Portland cement [45] was referred to test all properties of cement. The properties of cement are listed in Table 1.

Table 1
Properties of Cement

S. No.	Tests Performed	Results
1	Standard consistency.	34%
2	Fineness	1.8%
3	Specific gravity	3.10
4	Setting time, a) Initial setting time b) Final setting time	87 minute 255 minute
5	Compressive strength at the age of a) 7 days b) 28 days	42.38 N/mm^2 56.57 N/mm^2
6	Soundness test (Le- chatelier's)	1.0 mm

B. Fine aggregate

Fine aggregates (sand) passing through 4.75 mm sieve confirming to IS: 383-1970 [49] was used. Natural sand from Godavari River at Paithan, District Aurangabad was used for experimental work. The quality and grading of fine aggregates, shown in Table 2. The sieve analysis was conducted to determine the particle size distribution in a sample of aggregate, which will call gradation. Sieve analysis of fine aggregates has been shown in Table 3.

Table 2
Physical Properties of Fine Aggregates

Sr. No.	Property	Results
1	Particle size	4.75 mm down
2	Particle shape	Round
3	Fineness modulus	2.89
4	Specific gravity	2.65
5	Bulk density	1785 kg/m^3
6	Silt content	1.4%
7	Bulking of sand	4.18 %

Table 3
Sieve Analysis of Fine Aggregates

IS Sieve size	Weight Retained gm	Cumulative Weight Retained gm	Cumulative Percentage Retained
4.75 mm	22	16	1.6
2.36 mm	109	131	13.1
1.18 mm	110	241	24.1
600 micron	365	606	60.6
300 micron	295	901	90.1
150 micron	92	993	99.3
Lower than 150 micron	7	-	-
Total	1000	-	289.4
Fineness Modulus (FM) = 289.4/100 = 2.89			

C. Coarse aggregates

Coarse aggregates are originated from basalt rocks. Different size of coarse aggregates was used in this experimental work. Aggregates size 20 mm down confirming to IS: 383-1970 [49] was used. Physical properties are shown in Table 4 and sieve analysis of coarse aggregates for size 20mm down shown in Table 5.

Table 4
Physical properties of coarse aggregates

Sr. No.	Property	Results
1	Particle Size	20 mm down
2	Particle Shape	Angular
3	Fineness Modulus of 20 mm	6.97
5	Specific gravity	2.81
6	Bulk density of 20 mm aggregate	1550 kg/m^3
7	Water absorption	1.3 %

Table 5
Sieve Analysis of Coarse Aggregates (Size 20 mm down)

S. No.	IS Sieve Size	Weight Retained Kg	Cumulative Weight Retained kg	Cumulative Percentage Retained
1	40 mm	0	0	0
2	20 mm	0.150	0.150	2.2
3	10 mm	4.630	4.180	94.8
4	4.75 mm	0.220	5.000	100
5	2.36 mm	-	-	100
6	1.18 mm	-	-	100
7	600 micron	-	-	100
8	300 micron	-	-	100
9	150 micron	-	-	100
Total		5.000	-	697
Fineness Modulus (FM) = 697/100 = 6.97				

D. Brick aggregates

Table 6
Physical Properties of Brick Coarse Aggregates

Sr. No.	Property	Results
1	Particle Size	20 mm down
2	Particle Shape	Angular
3	Fineness Modulus of 20 mm	6.84
4	Specific gravity	2.73
5	Bulk density of 20 mm aggregate	1800kg/m^3
6	Water absorption	7.25 %

Table 7
Sieve Analysis of Coarse Aggregates (Size 20 mm down)

Sr. No.	IS Sieve Size	Weight Retained Kg	Cumulative Weight Retained kg	Cumulative Percentage Retained
1	40 mm	0	0	0
2	20 mm	0.100	0.100	2.0
3	10 mm	4.030	4.130	82.60
4	4.75 mm	0.870	5.000	100
5	2.36 mm	-	-	100
6	1.18 mm	-	-	100
7	600 micron	-	-	100
8	300 micron	-	-	100
Total		5.000		684
Fineness Modulus (FM) = 684/100 = 6.84				

Brick aggregates are originated from burning of clay material at high temperature. In this experimental work clay brick aggregates were used collected from demolished construction work. Physical properties are shown in Table 6 and sieve analysis of brick aggregates for size 20mm down is shown in Table 7 for aggregates size 20mm down.

E. Cement aggregates (size 20 mm down)

Cement brick is combination of fine particles and cement. The use of cement brick is increased from last decades due to easy manufacturing process. In this experimental work cement brick aggregates were used collected from demolishing construction work. Table 8 indicates the physical properties and sieve analysis of brick aggregates for size 20mm down is shown in Table 9 for aggregates size 20mm down.

Table 8
Physical properties of cement coarse aggregates

Sr. No.	Property	Results
1	Particle Size	20 mm down
2	Particle Shape	Angular
3	Fineness Modulus of 20 mm	6.97
4	Specific gravity	2.85
5	Bulk density of 20 mm aggregate	1725 kg/m^3
7	Water absorption	5.20 %

Table 9
Sieve Analysis of Coarse Aggregates (Size 20 mm down)

Sr. No.	IS Sieve Size	Weight Retained Kg	Cumulative Weight Retained kg	Cumulative Percentage Retained
1	40 mm	0	0	0
2	20 mm	0.100	0.100	2.0
3	10 mm	4.030	4.130	82.60
4	4.75 mm	0.870	5.000	100
5	2.36 mm	-	-	100
6	1.18 mm	-	-	100
7	600 micron	-	-	100
8	300 micron	-	-	100
9	150 micron	-	-	100
Total		5.000		684
Fineness Modulus (FM) = 684/100 = 6.84				

F. Fibers

For the present experimental work DuraflexTM high tensile steel fibers with hooked ends are made from prime quality high carbon steel wire were used. They had hooked ends and were collated into clips of about10 individual fibers using water soluble adhesive as shown in Figure 1. The collation reduces the tendency for balling of fibers during the mixing process. The adhesive dissolved in the mixing water in about one minute, facilitating the distribution of individual fibers. These fibers are manufactured by the M/s Kasturi metal, Amravati, company with the trade name of DuraflexTM and type HKL80/60 BN.

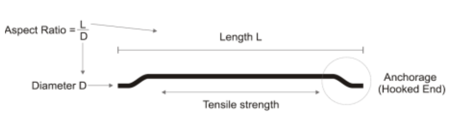

Fig. 1. Hooked End Steel Fibers

Table 10
Physical Properties of Fiber

Sr. No.	Description	Value
1	Type of fiber	Hooked end steel fiber
2	Length of fiber (*l*)	60 mm
3	Thickness (diameter) of fiber (d)	0.75 mm
4	Aspect ratio (*l*/d)	80
5	Tensile Strength	>1100 N/mm^2
6	Specific gravity	7.8
7	Modulus of Elasticity	200 Gpa

Photo-1: Hooked end Steel Fiber

Photo-2: Fine Aggregates

Photo-3: Crushed Brick Aggregates

Photo-4: Cement Aggregates

3. Methodology

For the experimental work, following type of nine specimens for each mix designation were prepared. Out of nine cubes three are tested for 7 days compressive strength and remaining for 28 days for M35 grade concrete. Schedule of specimen preparation has been shown in Table 11.

Table 11
Schedule of Preparation of Specimens with fiber content w/c Ratio=0.45

Sr. No.	Mix Designation	% of Brick aggregates replacement	% of Cement aggregates replace-	Fiber Content (V_f) %	Compression Test	Total Specimen
1	Conventional Concrete	0	0	0	9	9
2	$M35B_{40}F_0$	40	0	0	9	9
3	$M35B_{40}F_1$	40	0	1	9	9
4	$M35B_{40}F_{1.5}$	40	0	1.5	9	9
5	$M35B_{40}F_2$	40	0	2	9	9
6	$M35C_{40}F_0$	0	40	0	9	9
7	$M35C_{40}F_1$	0	40	1	9	9
8	$M35C_{40}F_{1.5}$	0	40	1.5	9	9
9	$M35C_{40}F_2$	0	40	2	9	9
	Total Cubes					45

4. Mix design

The demolished concrete material is collected from 18 years old residential demolished building located in Aurangabad. The Demolished waste is crushed in concrete lab by hammer after crushing the material sizes are taken from sieve analysis. Mix proportion of concrete was decided by mix design. Mix design of concrete for grade M35 was done by using IS10262-2009[46]. The mix proportion of concrete for grade M 35 have 1: 2.05: 2.80: 0.45 (C: FA: CA 20mm: w/c). This thesis based on the partial replacement of normal aggregates by cement aggregates and brick aggregates. The natural aggregates are replaced by systematically 10%, 20%, 30% and 40%. The considerable strength reduction is observed for the 40% replacement, hence in this these the total coarse aggregates are used as 60:40 (NA: BA/CA) for new mix design.

Hooked end steel fiber are used as 1%, 1.5%, 2% of cement quantity and detail of steel fiber requirement for 432.00 kg cement is given in following Table 13.

Table 13
Steel fiber Quantity in Kg

Fiber dose in Percent	Quantity of fiber in Kg
1	4.32
1.5	6.48
2	8.64

5. Results

Compressive strength for different mix designations concrete has been calculated by equation and the results have mentioned in Table 14. Graph of failure compressive load with respect to fiber content and compressive strength with respect to fiber content has plotted as shown in Figure 2 to Figure .3 respectively for 7 days compressive strength.

6.

Table 14
Compressive load (Pc), Compressive Strength (fcu) and Percentage increase in Compressive Strength at 7 Days tests

Sr. No.	Mix Designation	Compressive load kN	Comp. Strength (f_{cu}) MPa	Variations in Comp. strength over Conventional Concrete	% increase in Comp. Strength over CC
1	2	3	4	5	6
1	Conventional Concrete	640.25	28.46	NA	NA
2	$M35B_{40}F_0$	470.0	20..9	-7.53	-26.45
3	$M35B_{40}F_1$	510.15	22.6	-5.78	-20.32
4	$M35B_{40}F_{1.5}$	620.37	27.55	-0.88	-3.11
5	$M35B_{40}F_2$	650.90	28.9	0.47	1.66
6	$M35C_{40}F_0$	495.22	22.0	-6.45	-22.65
7	$M35C_{40}F_1$	630.15	28.0	-0.45	-1.58
8	$M35C_{40}F_{1.5}$	695.10	30.8	2.44	8.57
9	$M35C_{40}F_2$	751.22	33.39	4.93	17.33

Table 12
Mix proportion and quantity of brick aggregates and cement aggregates material in Kg for 1 CuM concrete

Cement (kg)	Fine aggregates (kg)	Aggregates (kg)					
		Normal aggregates		Brick aggregates		Cement aggregates	
		20mm	10mm	20mm	10mm	20mm	10mm
432.00	464.10	267.84	182.02	207.36	142.08	198.72	134.40

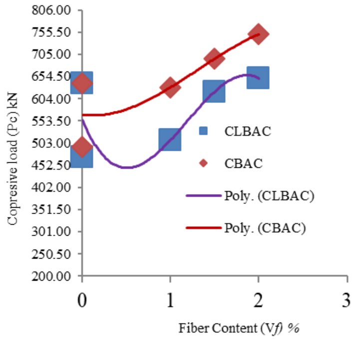

Fig. 2. Variation of 7 days Compressive Failure Load (P_u) with respect to Fiber Content (V_f%) of CLBAC abd CBAC

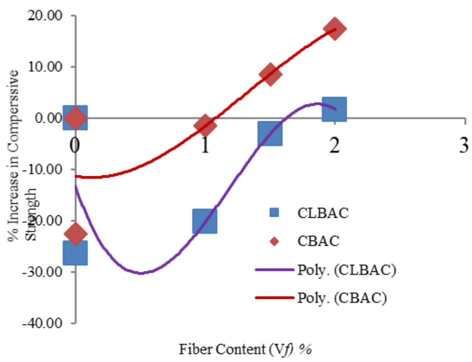

Fig. 3. Variation of Percentage in 7 days Compressive Strength (f_{cu}) with respect to Fiber Content (V_f%) of CLBAC abd CBAC

Photo-5: Compression testing machine after placing specimen

Photo-6: Failure of Specimen

Compressive strength for different mix designations for 28 days compressive strength shown in table.

Table 15
Compressive load (Pc), Compressive Strength (fcu) and Percentage increase in Compressive Strength at 28 Days tests

Sr. No.	Mix Designation	Compressive load kN	Comp. Strength (f_{cu}) MPa	Variations in Comp. strength over Conventional Concrete	% increase in Comp. Strength over CC
1	2	3	4	5	6
1	Conventional Concrete	910.50	40.47	NA	NA
2	$M35B_{40}F_0$	709.85	31.55	-8.92	-22.04
3	$M35B_{40}F_1$	777.86	34.57	-5.90	-14.57
4	$M35B_{40}F_{1.5}$	927.55	41.22	0.76	1.87
5	$M35B_{40}F_2$	945.60	42.03	1.56	3.86
6	$M35C_{40}F_0$	715.20	31.79	-8.68	-21.45
7	$M35C_{40}F_1$	904.50	40.20	-0.27	-0.66
8	$M35C_{40}F_{1.5}$	1010.50	44.91	4.44	10.98
9	$M35C_{40}F_2$	1070.00	47.56	7.09	17.52

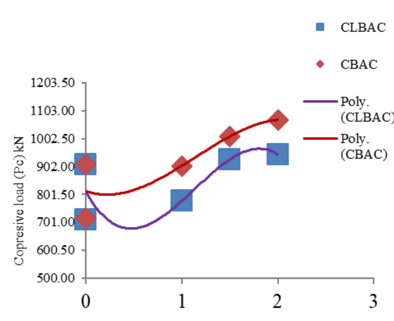

Fig. 4. Variation of 28 days Compressive Failure Load (P_u) with respect to Fiber Content (V_f%) of CLBAC and CBAC

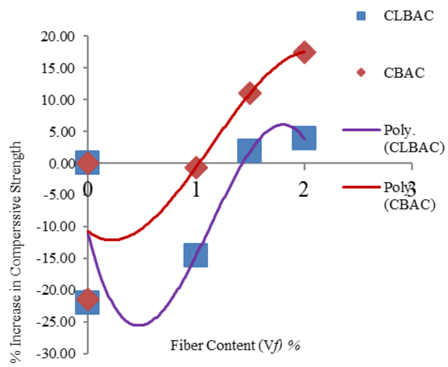

Fig. 5. Variation of Percentage in 28 days Compressive Strength (f_{cu}) over Conventional Concrete with respect to Fiber Content (V_f%) of CLBAC and CBAC

The above results are discussed with respect to the results obtained the compressive Strength of the cubes under the 7, 28 days curing.

7. Conclusion

An experimental study of suitability of clay brick and cement brick aggregate with steel fiber has been carried out in the laboratory. On the basis of results obtained from experimental work, observation made during casting and testing of conventional concrete, clay brick and cement brick aggregate concrete, the following conclusion are drawn:

1) Workability of concrete decreases as rapidly as steel fibers content increases, without changing any water cement ratio, water content and cement content.
2) Brick aggregates concrete is more workable as compare to the cement brick aggregates.
3) There was a systematically decrease in compressive strength, flexural strength and split tensile strength with incorruption of 40% of brick aggregates and cement brick aggregates. However, the incorruptions up to 40% of recycled masonry aggregates to partially replace in conventional concrete, caused a decrease in all strength parameter.
4) Maximum loss in compressive strength of brick aggregates concrete and cement aggregates concrete is 22.04% and 21.45% for 0% fiber content and maximum compressive strength for 2% for content is 3.86% and 17.52% as compared conventional concrete.
5) Cement aggregates concrete is more suitable for concrete as compare to brick aggregates concrete in all strength parameter.
6) The optimum fiber content is 2% compare with 1% and 1.5% and 2% fiber content. The results revels that higher fiber content has brought in increased compressive strengths, flexural strengths, split tensile strength and crack control effect.

References

[1] Roshan S. Shetty "Construction and Demolition waste – An Overview of Construction Industry in India" International Journal of Chemical, Environmental & Biological Sciences (IJCEBS), Volume 1, Issue 4 (2013).
[2] Ministry of Environment and Forests New Delhi "Report of the Committee to Evolve Road Map on Management of Wastes in India," March 2010.
[3] G. Kaszonyi "The Strength, Deformation and Thermo mechanic Properties' of Crushed Brick Aggregate Light Weight Concrete" Department of Building Materials Technical University, H-1521 Budapest.
[4] S. Ahmad and A. F. M. Saiful Amin "Effect of Curing Conditions on Compressive Strength Brick Aggregate Concrete" Journal of Civil Engineering. The Institutions of Engineers, Bangladesh. vol. 26, no. 1 1998.
[5] Jafar Bolouri Bazaz, Mahmood Khayati and Navid Akrami "Performance of concrete produced with crushed bricks as the coarse and fine aggregate" IAEG, 2006.
[6] Mohammad Abdur Rashid, Tanvir Hossain, and M. Ariful Islam "Properties of higher strength concrete made with crushed brick as coarse aggregate" Journal of Civil Engineering (IEB), 37(1) (2009) 43-52.
[7] F. Bektas, K. Wang, H. Ceylan "Effects of crushed clay brick aggregate on mortar durability" Civil, Construction and Environmental Engineering, Iowa State University, Ames, IA 50011, United States.
[8] Fadia S. Kallak, Assistant Lecturer Civil Eng. Dept.-University of Tikrit "Use of Crushed Bricks as Coarse Aggregate in Concrete" Tikrit Journal of Eng. Sciences, vol. 16, no. 3, September 2009, 64-69.
[9] M. R. Alam, M. A. K. Azad and M. A. Kadir "Fracture toughness of plain concrete specimens made with industry-burnt brick aggregates" Journal of Civil Engineering (IEB), 38 (1) (2010) 81-94.
[10] Osama M. Ghazi, "Properties of Hardened Concrete Using Crushed Clay Brick as Aggregates," Journal of Engineering, Number 4, Volume 17, August 2011, Jian Yang, Qiang Du, Yiwang Bao "Concrete with recycled concrete aggregate and crushed clay bricks," 2010.
[11] Tanvir Hossain, Md. Abdus Salam, Mohiuddin Abdul Kader "Pervious concrete using brick chips as coarse aggregate: An experimental study" Journal of Civil Engineering (IEB), 40 (2) (2012) 125-137.
[12] Mohd. Sarfaraz Banda, Md. Shamim Hossain, Md. Ruhul Amin "A Study on Cube and Cylinder Strength of Brick Aggregate Concrete" IOSR Journal of Mechanical and Civil Engineering, Volume 9, Issue 3 (Sep. - Oct. 2013), pp. 65-72.
[13] Essam A. Kishar, Doaa A. Ahmed, Maha R. Mohammed, Rehab Noury "Effect of calcium chloride on the hydration characteristics of ground clay bricks cement pastes," 2013.
[14] Nyiutsa Samson Apebo, Aondowase John Shiwua,Ameh Polycarp Agbo, Josephat Chukwugozie Ezeokonkwo, Paul Terkumbur Adeke "Effect of Water-Cement Ratio on the Compressive Strength of gravel - crushed over burnt bricks concrete." Civil and Environmental Research, Vol. 3, No. 4, 2013.
[15] Tariq Ali, Nouman Iqbal, Md Zeeshan, Md. Zulfiqar Ali Khan "Evaluation of the Compressive strength of Concrete for partial replacement of Over Burnt Brick Ballast Aggregate" International Journal of Science and Modern Engineering, Volume 2, Issue 1, December 2013.
[16] Norlia Mohamad Ibrahim, Shamshinar Salehuddin, Roshazita Che Amat, Nur Liza Rahim and Tengku Nuraiti Tengku Izhar "Performance of Lightweight Foamed Concrete with Waste Clay Brick as Coarse Aggregate" APCBEE Procedia 5 (2013) 497 – 501.
[17] Dallas E, Schwerin, Tara L., Cavalline, and David C. Weggel "Use of Recycled Brick Masonry Aggregate and Recycled Brick Masonry Aggregate Concrete in Sustainable Construction" KICEM Journal of Construction Engineering and Project Management.
[18] Othman Hameed Zinkaah "Influence of steel fibers on the behavior of light weight concrete made from crushed clay bricks" American Journal of Civil Engineering 2014; 2(4): 109-116.
[19] George Rowland Otoko "Recycling of Products of Brick Plants in Nigeria" European International Journal of Science and Technology, Vol. 3, No. 1, January, 2014.
[20] Gopinandan Dey and Joyanta Pal "Use of Brick Aggregate in Standard Concrete and Its Performance in Elevated Temperature" IACSIT

International Journal of Engineering and Technology, Vol. 5, No. 4, August 2013.
[21] Riaz Bhanbhro, Irfanullah Memon, Aziz Ansari, Ahsan Shah, Bashir Ahmed Memon "Properties Evaluation of Concrete Using Local Used Bricks as Coarse Aggregate" Engineering, 2014, 6, 211.
[22] Romualdas Mačiulaitis , Marija Vaičiene & Ramune Žurauskiene "The effect of concrete composition and aggregatesproperties on performance of concrete (2009)", Journal of Civil Engineering and Management, 15:3, 317-324.
[23] George Rowland Otoko "Use of Crushed Clay Bricks as Aggregate in Concrete." International Journal of Engineering and Technology Research Vol. 2, No. 4, April 2014, pp. 1-9.
[24] Ali A. Aliabdo, Abd-Elmoaty M. Abd-Elmoaty, Hani H. Hassan, "Utilization of crushed clay brick in concrete industry" review under responsibility of Faculty of Engineering, Alexandria University.
[25] Apebo, N. S., Agunwamba, J. C., Ezeokonkwo, J. C. "The suitability of crushed over burnt bricks as coarse aggregates for concrete," International Journal of Engineering Science and Innovative Technology, Volume 3, Issue 1, January 2014.
[26] Faisal Fouad Wafa "Properties and Applications of Fiber Reinforced Concrete" JKAU: Eng. Sci., Vol. 2.
[27] M. Beddar and L. Belgaraâ, T. Ayadat "Optimizing of Steel Fiber Reinforced Concrete Mix Design". IJE Transactions B: Applications Vol. 17, No. 1, April 2004.
[28] P. Srinivasa Rao, Sravana, Z. Abdul Rahim and T. Seshadri Sekhar "Durability Studies on Steel Fibre Reinforced Metakaolin Blended Concrete."
[29] Yung-Chih Wang and Ming-Gin Lee "Ultra-High Strength Steel Fiberreinforced Concrete for Strengthening of RC Frames" Journal of Marine Science and Technology, Vol. 15, No. 3, pp. 210-218, 2007.
[30] Anant Parghi, C. D. Modhera, D. L. Shah, "Micro Mechanical Crack and Deformations Study of Sfrc Deep Beams"33rd Conference on Our World in Concrete & Structures: 25 - 27 August 2008, Singapore.
[31] "Flexural Fatigue Characteristics of Steel Fiber Reinforced Recycled Aggregate Concrete" Facta Universitatis Series: Architecture and Civil Engineering, Vol. 7, No.1, 2009, pp. 19 - 33,
[32] Pant Avinash S., Parekar Suresh R. "Steel Fiber Reinforced Concrete Beams Under Bending, Shear and Torsion Without Web Reinforcement" International Journal of Recent Trends in Engineering, Vol. 1, No. 6, May 2009
[33] Shende. A. M., Pande. A. M. "Comparative study on Steel fibre reinforced Cum control concrete under flexural and deflection" International Journal of Applied Engineering Research, Dindigul Volume 1, No. 4, 2011.
[34] G. Murali, C. M. Vivek Vardhan, P. Sruthee, P. Charmily, "Influence of Steel Fibre On Concrete" International Journal of Engineering Research and Applications, Vol. 2, Issue 3, May-June 2012, pp. 075-078.
[35] Sreeja. M. D. "Behaviour of Steel Fibre Reinforced Concrete Beam under Cyclic Loading" IOSR Journal of Mechanical and Civil Engineering, Volume 6, Issue 3 (May. - Jun. 2013), pp. 1-4.
[36] B. Setti, M. Taazount, S. Hammoudi, F. Setti, M. Achit-Henni "Compressive, flexural and abrasive performances of steel fiber reinforced concrete elements" International Journal of Mechanical Engineering and Applications. Vol. 1, No. 3, 2013, pp. 69-77.
[37] Fatih Altun, Bekir Aktas "Investigation of reinforced concrete beams behavior of steel fiber added lightweight concrete" Construction and Building Materials, 38, 2013, 575–581.
[38] Šarūnas Kelpša, Mindaugas Augonis, Mindaugas Daukšys, Algirdas Augonis "Analysis of Crack Width Calculation of Steel Fibre and Ordinary Reinforced Concrete Flexural Members" 2014. No. 1(6) Journal of Sustainable Architecture and Civil Engineering,
[39] Ankit Agrawal, Tarit Jain, Sarang Agarwal, "Compressive S trength T esting of Steel Fiber Reinforced Concrete in Different Curing Regimes" International Journal of Engineering Research & Technology, Vol. 3, Issue 10, October 2014.
[40] Abdul Ghaffar, Amit S. Chavhan, R. S. Tatwawadi "Steel Fibre Reinforced Concrete" International Journal of Engineering Trends and Technology, Volume 9, Number 15, March 2014.
[41] Patil Shweta, Rupali Kavilkar "Study of Flexural Strength in Steel Fibre Reinforced Concrete" International Journal of Recent Development in Engineering and Technology, Volume 2, Issue 5, May 2014.
[42] Seong-Cheol Lee, Jeong-Hwan Oh, and Jae-Yeol Cho "Fiber Orientation Factor on Rectangular Cross-Section in Concrete Members" IACSIT International Journal of Engineering and Technology, Vol. 7, No. 6, December 2015.
[43] IS 10262: 1987 "Concrete Mix Proportioning - Guidelines" Bureau of Indian Standards, Manak Bhavan,Bahadur Shah Zafar Marg, New Delhi 110002
[44] IS 10262: 2009 "Concrete Mix Proportioning - Guidelines" Bureau of Indian Standards Manak Bhavan. Bahadur Shah Zafar Marg, New Delhi 110002.
[45] ACI 211.1-91, "Standard practice for selecting proportion for normal, heavyweight, and mass concrete" ACI Committee 211, Farmington Hills, MI, USA, 1991.
[46] IS: 1199- 1959 "Methods of Sampling and Analysis of Concrete" Bureau of Indian Standards, Manak Bhavan, 9 Bahadur Shah Zafar Maro New Delhi 110002
[47] IS:383-1970 "Specification for Coarse and Fine Aggregates FromNatural Sources for Concrete" Bureau of Indian Standards Manak Bhavan, 9 Bahadur Shah Zafar Marc, New Delhi 110002
[48] IS: 516 – 1959 "Methods of Tests for Strength of Concrete" Bureau of Indi.an Standards Manak bhavan, 9 Bahadur Shah Zafar Marc3 New Delhi 110002
[49] IS:4031(PART1):1996 "Method of Physical Tests for Hydraulic Cement" Bureau of Indian Standards Manak Bhavan, 9 Bahadur Shah Zafar Marg New Delhi 110002.
[50] IS: 4031 (Part 3) – 1988 "Methods of Physical Tests for Hydraulic Cement" Bureau of Indian Standards Manak Bhavan, 9 Bahadur Shah Zafar Marg New Delhi 110002.
[51] IS: 4031 (Part 5) – 1988 "Methods of Physical Tests for Hydraulic Cement" Bureau of Indian Standards Manak Bhavan, 9 Bahadur Shah Zafar Marg New Delhi 110002.
[52] IS: 516 – 1959 "Methods of Tests for Strength of Concrete" Bureau of Indi.an Standards Manak bhavan, 9 Bahadur Shah Zafar Marc3 New Delhi 110002.
[53] IS: 4031:1968 "Method of Physical Tests for Hydraulic Cement" Bureau of Indian Standards Manak Bhavan, 9 Bahadur Shah Zafar Marg New Delhi 110002
[54] BS: 8110 (Part-2)–1985.