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A Review Investigation on Slurry Infiltrated Fibre Concrete by Using Crimped Fibre

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ABSTRACT:

Due of its strengthening and durability, concrete, a composite material, is used more frequently in the building sector. Materials with ever better qualities, in particular strengthening, stiffness, toughness, ductility, and durability, are needed for the construction of longer span bridges, high rise buildings, offshore constructions, and additional super structures. It is necessary in the cause circumstances to simultaneously improve a number of attributes. These materials, which are sometimes referred to as "High Performance Materials" and "Advanced Materials," vary fundamentally from other traditional materials. Studying the characteristics of Slurry Infiltrated Fibre Reinforced Concrete (SIFCON) is the goal of the current project. Because of its higher tensile strengthening as well as heavier ductility. Cement, sand, and fly ash are kept at consistent amounts in this experiment. To reach the ideal percentage, the steel fibre is added in a variety of ratios, including 5 percent, 15 percent, 25 percent, and 35 percent.

High Performance Concrete is being utilised more frequently in R.C. constructions as a result of the rapid improvement of concrete technology. Concrete that satisfies specific performance and uniformity standards that are not necessarily routinely achievable by utilising ordinary materials and customary mixing, laying, and curing procedures is referred to as high performance concrete. High compressive strengthening and low permeability are two of HPC's main characteristics. HPFRC has recently attracted more attention as a material for concrete structural parts. This is due to the fact that these materials' majority of rheological, mechanical, and durability qualities are superior to those of traditional FRC.

Less than 1% by vol. of fibres are commonly utilised in fibre reinforced concretes (FRC), which have mostly been employed in non-structural applications such slabs on grade, floors, and architectural concrete. Larger fibre contents are frequently prohibitive from a cost perspective as well as from the standpoint of ensuring adequate workability and homogeneity, but it has been tried and succeeded in a few instances, and in these circumstances other qualities besides ductility can be increased as well. High fibre content products, including Slurry Infiltrated Fibre Concrete, have even been utilised in conjunction with significant main reinforcement (SIFCON).

KEYWORDS: SIFCON, Cement, Steel fibre, Tensile strength, Ductility, Stiffness

INTODUCTION

Over the past ten years, concrete technology has advanced significantly. Concrete is now a designed material with multiple new constituents working satisfactorily under various conditions, as opposed to being a material made of cement, aggregates, water, and admixtures. Today, concrete can be customised for certain needs and might contain a variety of components. Concrete is now specified based on performance criteria rather than elements and materials, which has given producers and consumers countless opportunity to customise concrete to meet their unique needs. The creation of high performance materials is one of the amazing advancements in civil engineering.

Development of higher performance engineering materials with high strength, toughness, energy absorption, and durability is urgently needed due to the advancement of modern civil engineering. One of the traditional engineering materials, fibre reinforced concrete (FRC), is utilised in a variety of structural applications to improve the structural resistance and performance under various loading scenarios. Additionally, it speeds up construction and might even do away with the requirement for traditional reinforcement. Even though concrete has extremely high compressive strength ratings, it nevertheless essentially remains a fragile material. The addition of sufficient fibres enhances tensile strength and offers ductility.

High performance materials are becoming more and more necessary for structural member design and construction since the 1980s. In comparison to traditional building materials, high performance ones offer significantly greater strength, ductility, durability, and resistance to the elements. These materials can also significantly extend the lifespan of structures in the built environment while also lowering their maintenance costs. High performance steel, fibre reinforced cement composites, FRP composites, high performance concrete, and other high performance building materials are among the most important. SIFCON, or slurry-infiltrated fibrous concrete, is a high performance material.

It gets more challenging to mix and arrange these materials as the fibre concentration and fibre aspect ratio (length/diameter) grow. The amount of fibre must be kept to less than 2% of the volume and the aspect ratio must be less than 100, according to practical experience. The enhancements to the engineering characteristics of concrete (flexural strength, flexural toughness index, impact resistance, and fatigue resistance) that can be obtained through the employment of steel fibres are constrained by this circumstance. Lankard started looking at ways to add more steel fibres to cement-based composites that are reinforced with steel fibres in 1978. Slurry Infiltrated Fibre Concrete (SIFCON), a novel cement composite that allows the use of steel fibres up to 20% by volume, was created as a result of this work.

ABOUT SIFCON

In the beginning, steel fibres were largely employed to replace secondary reinforcement or to manage cracks in less important portions of the building. Today, precast concrete products, shotcrete, and industrial floor slabs all use steel fibres as their primary and exclusive form of reinforcement. They are also taken into consideration for structural purposes in the shear reinforcement of pre stressed elements, the reinforcement of slabs on piles, the complete replacement of the standard reinforcing cage for tunnel segments, and concrete cellars.

One of the most recently created building materials, slurry infiltrated fibre concrete (SIFCON), can be regarded as a unique variety of high performance fibre reinforced concrete (HPFRC) with a greater fibre content. Dr.Lankard had contributed to the material's development and some of its early applications in the paving and metal fabrication industries. High strength and ductility were qualities that SIFCON possessed.

SIFCON is appropriately compared to preplaced aggregate concrete and can be thought of as pre-placed fibre concrete. In FRC, the fibres are combined with the other materials, whereas the first stage in the creation of SIFCON is the placing of steel fibres in a form or mould. Hand placement of fibres is also possible, as are commercial fibre dispersing systems. During the fibre installation procedure, a slight external vibration is applied. Following the installation of the fibres, a fine-grained cement-based slurry is poured onto the densely packed fibre bed, and external vibration is then used to further infiltrate the slurry. To produce the proper slurry viscosity while retaining a low water cement ratio, high range water reduction admixtures are used. SIFCON is cured using the same process as other types of concrete when the slurry infiltration is finished.

The fibre network created in the mould must be adequately ingested by the matrix fineness. In the absence of this, huge pores could emerge, significantly reducing the mechanical characteristics. To improve the flowing characteristics of SIFCON, additives such high range admixtures like super plasticizer are used.

ADVANTAGES

- SIFCON is often quite ductile and works especially well for structures that need more ductility.
- SIFCON have exceptional toughness, impact and abrasion resistance, energy absorption capability, and durability.
- SIFCON has greater ductility and has higher modulus of elasticity (E) values when compared to plain concrete.
- Due to its fibre alignment, SIFCON can overcome the balling issue with steel fibres as fibre volume increases in SFRC.
- SIFCON will have far less deflection than conventional

SIFCON should only be used as an effective alternative construction material in applications where concrete or conventional SFRC cannot perform as may be expected or required by the user or in circumstances where such special properties as high strength and ductility are required because SIFCON's ductility, crack resistance, penetration, and impact resistance are found to be very high when compared to other materials. The following applications are most suited for SIFCON:

- Pavement rehabilitation and precast concrete products
- Overlays, bridge decks and protective revetments
- Seismic and explosive-resistant structures
- Security concrete applications (safety vaults, strong rooms etc)
- Refractory applications (soak-pit covers, furnace lintels, saddle piers)
- Military applications such as anti-missile hangers, under-ground shelters
- Sea-protective works
- Primary nuclear containment shielding
- Aerospace launching platforms
- Repair, rehabilitation and strengthening of structures
- Rapid air-field repair work
- Concrete mega-structures like offshore and long-span structures, solar towers etc

LITERATURE REVIEW

In literature survey of last 15 years different research has been carried out to develop the high performance fiber Reinforced in different country under different climatic conditions, assumptions, and materials, etc. The technique of infiltrated layers of steel fibers with Portland cement based materials was first proposed by Haynes (1968).Lankard (1979) modified the method used by Haynes and proved that if percentage of steel fibres in cement matrix could be increased, one could get a material with very high strength properties which he christened as SIFCON. He presented the basic properties of SIFCON such as load-deflection curve, ultimate compressive and flexural strengths, impact and abrasion resistance. SundarsanaRao and Ramana tested the SIFCON slab elements under flexure and compared the results with FRC and PCC slabs and concluded that SIFCON slabs exhibit superior performance in flexure when compared to FRC and PCC slabs. He investigated the response of SIFCON two way slabs under impact loading and concluded that the SIFCON slabs with 12% fibre volume fraction exhibit excellent performance in strength and energy-absorption characteristics. He presented the behavior of SIFCON two way slabs in punching shear and show that the SIFCON slabs with 12% fibre volume fraction exhibits excellent performance in punching shear among other slabs. However, literature review reveals that a very little work has been carried out on SIFCON to determine the durability characteristics. Mr. Bryan Thane Wood from of North Carolina State University, Raleigh worked on "Use of Slurry Infiltrated Fiber Concrete (SIFCON) in Hinge Regions for Earthquake Resistant Structures" In this paper the researcher demonstrated that reinforced SIFCON hinges can exhibit superior performance as compared to reinforced concrete hinges. Many problems encountered with reinforced concrete hinges do not occur when using SIFCON hinges. There are three primary advantages of using reinforced SIFCON flexural hinges in place of reinforced concrete hinges. 1. Greater shear strength and toughness prevent shear sliding on through-depth flexural cracks in reinforced SIFCON. In contrast, reinforced concrete hinges develop a through-depth flexural crack. As loading progresses, sliding occurs on this plane, quickly degrading structural integrity. However, the SIFCON hinges tested in this program rarely developed any through-depth cracks. If a through-depth flexural crack developed, it never opened enough to degrade the shear capacity of the section. 2. Although SIFCON enables the reinforcing to undergo cyclic yielding withoutbuckling, minimal confining steel may be required. Reinforced concrete hinges require longitudinal and transverse confining steel to not only confine the flexural. Mr.HalitYazici and others from Turkey has developed the practical technique of Development of “Autoclaved SIFCON with high volume Class C fly ash binder phase”. In his work Cement was replaced with up to 60% FA (fly ash) in SIFCON compositions and three different steel fiber volumes (2%, 6% and 10%) were used. Test results were presented in comparison with the control mix (0% FA and 0% fiber). Mechanical properties were positively affected almost at every FA replacement. Moreover, by increasing the fibre volume, flexural strength and toughness were remarkably increased. This behaviour was more pronounced at 10% fibre volume. At this fibre volume ratio, flexural strength of 55 MPa could be achieved with 60% FA replacement. Mr. D. Elavarasi& others from India has developed and worked on “Behavior of fly Ash based slurry Infiltrated Fibrous”. In this work the author has explained the use of high content of Fly ash with replacement to cement in making of SIFCON so as to overcome the problems such as greater heat of hydration, higher shrinkage & high production cost. The author studied the effect of fly ash and fiber content on mechanical properties of SIFCON. In this course of work the author replaced cement with 10, 20, 30 % of fly ash. Fibre content in SIFCON varied with 6, 8, and 10%. .Mr.Bhushan L. Karihaloo from Cardiff University, U.K and others worked on "Effect of Casting Direction on the Mechanical Properties of CARDIFRC”. In this study tests were performed to investigate the effect of fiber orientation ISSN(Online) : 2319-8753 ISSN (Print) : 2347-6710 International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization) Vol. 5, Issue 5, May 2016 Copyright to IJIRSET DOI:10.15680/IJIRSET.2016.0505278 8570 and any unintentional grading over the specimen size of CARDIFRC® on its mechanical properties. CARDIFRC® is an UHPC reinforced with steel fibres of two differentlengths and a compressive strength of about 200 MPa. Tests were performed to investigate the effect of fibre orientation and the unintentional grading over the specimen size of CARDIFRC.

FINITE ELEMENT MODELLING AND METHODOLOGY

The analysis of stress and deformation of the loading of simple geometric structures can usually be accomplished by closed-form techniques. As the structures become more complex, the analyst is forced to use approximations of closed-form solutions, experimentation, or numerical methods. There are a great many numerical techniques used in engineering applications for which digital computers are very useful. In the field of structural analysis, the numerical techniques generally employ a method which discretizes the continuum of the structural system into a finite collection of points (or nodes)/ elements called finite elements. The most popular technique used currently is the finite element method (FEM). Other methods some of which FEM is based upon include trial functions via variation methods and weighted residuals the finite difference method (FDM), structural analogues, and the boundary element method (BEM).

The Finite Difference Method

In the field of structural analysis, one of the earliest procedures for the numerical solutions of the governing differential equations of stressed continuous solid bodies was the finite difference method. In the finite difference approximation of differential equations the derivatives in the equations are replaced by difference quotients of the values of the dependent variables at discrete mesh points of the domain. After the equations are replaced by difference quotients of the values of the dependent variables at discrete mesh points of the domain. After imposing the appropriate boundary conditions on the structure, the discrete equations are solved obtaining the values of the variables at mesh points. The technique has many disadvantages, including inaccuracies of the derivatives of the approximated solution, difficulties in imposing boundary conditions along curved boundaries, difficulties in accurately representing complex geometric domains, and the inability to utilize non- uniform and non-rectangular meshes.

The Boundary Element method

The boundary element method developed more recently than FEM, transforms the governing differential equations and boundary conditions into integral equations, which are converted to contain surface integrals. Because only surface integrals remain, surface elements are used to perform the required integrations. This is the main advantage of BEM over FEM, which require three-dimensional elements throughout the volumetric domain. Boundary elements for a general three-dimensional solid are quadrilateral or triangular surface elements covering the surface area of the component. For two- dimensional and axis symmetric problems, only line elements tracing the outline of the component are necessary.

Although BEM offers some modelling advantages over FEM, the latter can analyse more types of engineering applications and is much more firmly entrenched in today's computer-aided-design (CAD) environment. Development of engineering applications of BEM is proceeding however, and more will be seen of the method in the future.

Basic steps in the Finite Element Method

The following are the steps adopted for analyzing a structural engineering problem by the finite element method.

1. Discretization of the domain

The continuum is divided into a number of finite elements by imaginary lines or surfaces. The interconnected elements may have different sizes and shapes. The choice of the simple elements or higher order element straight or curved, it's shape, refinement are to be decided before the mathematics formulation starts.

2. Identification of variables

The elements are assumed to be connected at their intersecting points referred to as nodal points. At each node, generalized displacements are the unknown degrees of freedom. They are dependent on the problem at hand. For example in a plane stress problem the unknowns are two linear translations at each nodal point.

3. Choice of approximating functions

Once the variables and local coordinate system have been chosen. The next step is the choice of displacement function. In fact it is the displacement function that is the starting point of the mathematical analysis. This function represents the variation of the displacements within the element. The function can be approximated in a number of ways. The displacement function may be approximated in the form of a linear function or a higher order function. The shape of element or the geometry may also be approximated. The co ordinates of corner nodes define the element shape accurately if the element is actually made of straight line or plates.

4. Formation of the element stiffness matrix

After the continuum is discredited with desired element shapes, the element stiffness matrix is formulated. This can be done in a number of ways. Basically it is a minimization procedure whatever may be the approach adopted. For certain elements, the form involves a great deal of sophistication. With the exception of a few simple elements, the element stiffness matrix for majority of elements is not available in explicit form. As such they require numerical integration for their evaluation.

The geometry of the element is defined in reference to a global frame. In many problems such as those of rectangular plates, the global and local axis systems are coincident and for them no further calculation is needed at the element level beyond computation of element stiffness matrix in local coordinates. Coordinates transformation must be done for all elements where in is needed.

5. Formulation of the overall stiffness matrix

After the element stiffness matrices in the global coordinates are formed, they are assembled to form the overall stiffness matrix. The assembly is done through the nodes, which are common to adjacent elements. At the nodes, the continuity of the displacement function and possibly their derivatives are established. The overall stiffness matrix is symmetric and banded.

6. Calculation of stress or stress-resultants

In the previous step, nodal displacements are calculated and these values are utilized for the calculation of stresses or stress-resultants. This may be done for all elements of the continuum or it may be limited only to some predetermined elements.

Results may be obtained by graphical means. It may be desirable to plot the contour of the deformed shape of the continuum. The contour of the principal stresses may be one of the sought after items for certain category of problems.

Advantages

The main advantage of finite element analysis can be put in one sentence. The physical problems which were so far intractable and complex for any closed bound solution can now be analyzed by this method. The advantages in relation to the complexity of the problem are stated below.

- Finite element method is fast, reliable and accurate.

- It can analyse any structure with complex loading and boundary conditions i.e. the method can be efficiently applied to cater irregular geometry and can handle any type of loading.
- It can analyse structures with different material properties i.e. material anisotropy and non homogeneity can be catered without much difficulty.
- This method is easily amenable to computer programming.
- It can analyse structures having variable thickness.

Disadvantages

One should not form the idea that the F.E.M is the most efficient for the analysis of any type of structural engineering or physical problem. There are many types of problems where some other method of analysis may prove efficient than the F.E.M.

Main disadvantages of this method are the cost involved in the solution of the problem. (Simpler computer methods such as finite strip or other same analytic methods for the vibration and stability analysis of simpler structure will lead to more economic solution, but these methods will work within their own limitations and will not be as versatile as the F.E.M)

- It is difficult to model all problems accurately and the results obtained are approximate.
- The result depends upon the number of elements used in the analysis.
- Data preparation is tedious and time consuming.

Limitations of finite element method

- In whatever sophisticated manner the problem might be formulated and solved, it has been done so within the frame work of its assumptions using proper engineering judgment. However, one has to be exercised in interpreting the results.
- Not that all conceivable existing complicated problems have been solved by the finite element method. There are still some which has remained intractable till today.
- Due to the requirement of large computer memory and time, computer programs based on the FEM can be run only in high speed digital computers. For some problems, there may be considerable amount of input data. Errors may creep up in their preparation and results thus obtained may also appear to be acceptable which indicates deceptive state of affairs. It is always desirable to make a visual check of the input data as described in the next section.

SUMMARY:

The need for conducting a feasible study for modelling SIFCON slabs with locally available low tensile strength steel wire fibres using FEA is identified. The need to understand the behaviour of SIFCON slab elements in flexure using FEA is identified. The aims and specific objectives are decided accordingly for the present modelling.

Once the aim and objectives are decided, the state of the art of the technology related to the present work is reviewed. From this review the aim and objectives of the present investigation have been validated.

References:

1. A. Bajpai, and R. Chandak, “EXPERIMENTAL STUDIES ON SLURRY INFILTRATED FIBROUS CONCRETE (SIFCON).”
2. A. Beglarigale, Ç. Yalçınkaya, H. Yiğiter, and H. Yazıcı, “Flexural performance of SIFCON composites subjected to high temperature,” Construction and Building Materials, vol. 104, 2016, pp. 99-108, doi: 10.1016/j.conbuildmat.2015.12.034.
3. A. E. Naaman, H. W. Reinhardt, and C. Fritz, “Reinforced concrete beams with a SIFCON matrix,” Structural Journal, vol. 89, no. 1, 1993, pp. 79-88, doi: 10.14359/1298.
4. A. Kumar, and N. Gupta, "STUDY OF MECHANICAL PROPERTIES AND DURABILITY OF SIFCON."
5. A. P. Shelorkar, and P. D. Jadhao, “Effects of Steel Slag on Durability Properties of Slurry Infiltrated Fibrous Concrete,” doi: 10.35940/ijeat.D6501.088619.
6. A. Prakash, S. Srinivasan, and A. R. M. Rao, “Numerical investigation on steel fibre reinforced cementitious composite panels subjected to high velocity impact loading,” Materials & Design, vol. 83, 2015, pp. 164-175, doi: 10.1016/j.matdes.2015.06.001.
7. A. Rattan, D. Himmi Gupta, and S. Sharma, “Effect of Alccofine on Compressive Strength of SIFCON,” 2016.
8. A. S. Ali, and Z. Riyadh, “Experimental and Numerical Study on the Effects of Size and type of Steel Fibers on the (SIFCON) Concrete Specimens,” International Journal of Applied Engineering Research, vol. 13, no. 2, 2018, pp. 1344-1353.

9. Abd-Alrazaak, W.Kh., (2006) "Membrane Action in Orthotropically Reinforced Concrete Rectangular Slabs Restrained along Two Parallel Edges", M.Sc. Thesis, University of Technology, Baghdad.
10. Abdel Rahman, H.H. and Hinton, E. (1986). "Nonlinear Finite Element Analysis of Reinforced Concrete Stiffened and Cellular Slabs". Computers & Structures, Vol. 23, No. 3, PP. 333-350
11. Abdollahi.B, Bakshi.M "SIFCON strengthening of concrete in comparison with conventional GFRP confinement method" vol.36,765-778,2012.
12. Adeghe, L.N. and Collins, M.P. (1986). "A Finite Element Model for Studying Reinforced Concrete Detailing Problems". Publication No. 86-12, Department of Civil Engineering, University of Toronto
13. Adrin E Long, (1975), "A Two-phase approach to the prediction of the punching strength of slabs", ACI Journal, PP 37-45.
14. Ahmed H. Alwathaf, Aidy Ali, Mohd S. Jaafar and Mohd A. Algorafi, (2011), "Stress-strain modelling of reinforced concrete membrane structures", International Journal of the Physical Sciences Vol. 6(30), PP. 6820 - 6828, 23.
15. Ahmed H. Alwathaf, Aidy Ali, Mohd S. Jaafar and Mohd A. Algorafi, Stress- strain modelling of reinforced concrete membrane structures, International Journal of the Physical Sciences Vol. 6(30), pp. 6820 - 6828, 23 November, 2011
16. AlavaroVasauez and Vistasp M. Karbhari, (2003) "Fibre reinforced polymer composite strengthening of concrete slabs with cutouts", ACI Structural Journal Vol. 100, No.5, PP 665-673.
17. Al-Hassani, H.M.,(1978) "Behavior of Axially Restrained Concrete Slabs", Ph.D. Thesis, University Collage, London, England, PP.241.
18. Ali R. Khaloo and Majid Afshari, (2005)"Flexural behavior of small steel fibre reinforced concrete slabs", Cement and concrete Composites, 141-149.
19. Ali R. Khaloo, Majid Afshari, (2005), "Flexural behaviour of small steel fibre reinforced concrete slabs", Cement and Concrete Composites, Vol. 27, PP 141-149. Al-Shimmery, N.S., (2005) "Membrane Action in R.C. Rectangular Slabs
20. An Yan, Keru Wu, Xiong Zhang, (2002), "A quantitative study on the surface crack pattern of concrete with high content of steel fibre", Cement and Concrete Research Vol. 32, PP 1371-1375.
21. Aravindhan A, Veeraragavan S, Satheesh V S, "Experimental Investigation of Cold Formed Steel Long and Short Composite Columns Infilled with M-Sand", International Journal of Science Technology & Engineering, Vol 3, Issue 9, March 2017, PP 329-333, ISSN 2349 784X.
22. Arnesen, A., Sorensen, S. I. and Bergan, P.G. (1980), "Nonlinear Analysis of Reinforced Concrete". Computers & Structures, Vol. 12, PP. 571-579.
23. Aron Zaslavsky, (1967), "*Yield line analysis of rectangular slabs with central openings"* ACI JournalTitle No. 64-74, PP 838-844.
24. Arun Aniyan Thomas "Strength and behaviour of SIFCON with different types of fibres" vol.5(12),25- 30, 2014.
25. ASCE Task Committee on Finite Element Analysis of Reinforced Concrete Structures. (1982), "State-of-the-Art Report on Finite Element Analysis of Reinforced Concrete", ASCE Special Publications.
26. Ayesha Kani.M, Ravindra. B.J "Investigation on strength and durability of slurry infiltrated fibrous concrete" vol.4, 2016.
27. Balaguru P and Kendzulak.J, (1987), "Mechanical properties of Slurry Infiltrated Fibre Concrete (SIFCON)", Fibre Reinforced Concrete Properties and Applications SP, 105, American Concrete Institute, Detroit, Michigan, PP 247-268.
28. Balaguru P and Surendra .P. Shah, (1992), "Fibre Reinforced Cement Composites", Mcgraw-Hill, Inc.
29. Balaguru. P and Kendzulak.J, (1986), "Flexural behavior of Slurry Infiltrated Fibre Concrete (SIFCON) made using condensed silica fume, fly ash, silica fume, slag, and natural pozzolonas in concrete", SP-60, American Concrete Institute, Detroit, Michigan, PP 1215-1230.
30. Barzegar, F. and Maddipudi, S., (1994) "Generating Reinforcement in FE Modelling of Concrete Structures" , ASCE Journal of the Structural Division, vol. 120, PP. 1656– 1662.
31. D. Elavarasi, and K. S. R. Mohan, "On low-velocity impact response of SIFCON slabs under drop hammer impact loading," Construction and Building Materials, vol. 160, 2018, pp. 127-135, doi: 10.1016/j.conbuildmat.2017.11.013.\
32. Dhinesh N P, Satheesh V S, "Flexural Behaviour of Hollow Square Beam", International Journal of Scientific Engineering and Applied Science, Vol 3, Issue 3, March 2017, PP 236-242, ISSN 2395 3470
33. Dr. P. Thamilselvi, Behaviour of exterior beam column joints using SIFCON, International Journal of Engineering Research and Technology(IJERT), Volume-1, 2012, Issue 5.
34. Elnono, M. E., Salem, H. M., Farahat, A. M., and Elzanaty, A. H. (2009). "Use of slurry infiltrated fibre concrete in reinforced concrete corner connections subjected to opening moments." Journal of Advanced Concrete Technology, Vol. 7, No. 1, pp. 51- 59.

35. F. Olutoge, O. M. Ofuyatan, O. Olowofoyeku, G. Bamigboye, and A. Busari, “STRENGTH PROPERTIES OF SLURRY INFILTRATED FIBROUS CONCRETE (SIFCON) PRODUCED WITH DISCRETE BAMBOO AND STEEL FIBRES,” ARPN Journal of Engineering and Applied Sciences, vol. 11, no. 23, 2016, pp. 13448-13453.
36. Farnam, Y., Moosavi, M., Shekarchi, M., Babanajad, S. K., and Bagherzadeh, A. (2010). “Behavior of Slurry Infiltrated Fibre Concrete (SIFCON) under triaxial compression.” Cement and Concrete Research, Vol. 40, Issue 11, pp. 1571-1581
37. Farnam.Y, Moosavi.M “Behaviour of slurry infiltrated fibre concrete (SIFCON) under triaxial compression” vol.40,(11),1571-1581,2010.
38. Flexure, Asian Journal of Civil Engineering (Building and Housing), Volume-10, 2009, 427-449
39. G. D. Abdel-Hameed, H. M. Salem, T. M. Bahaa, and A. M. Farahat, “SHEAR BEHAVIOR OF SLURRY INFILTRATED FIBER CONCRETE BEAMS.”
40. G. Murali, A. Santhi, and G. M. Ganesh, “Effect of crimped and hooked end steel fibres on the impact resistance of concrete,” Journal of Applied Science and Engineering, vol. 17, no. 3, 2014, pp. 259-266, doi: 10.6180/jase.2014.17.3.06.
41. G. Ruano, F. Isla, R. I. Pedraza, D. Sfer, and B. Luccioni, “Shear retrofitting of reinforced concrete beams with steel fiber reinforced concrete,” Construction and Building Materials, vol. 54, 2014, pp. 646-658, doi: 10.1016/j.conbuildmat.2013.12.092.
42. G. S. Kumar, and K. Rajasekhar, “Performance analysis of Levenberg-Marquardt and Steepest Descent algorithms based ANN to predict compressive strength of SIFCON using manufactured sand,” Engineering science and technology, an international journal, vol. 20, no. 4, 2017, pp. 1396-1405, doi: 10.1016/j.jestch.2017.07.005.
43. Ghada D. Abdel-Hameed, Hamed M. Salem “Shear behaviour of slurry infiltrated fibre concrete beams” vol.5(2),2009.
44. H. Draganić, G. Gazić, and D. Varevac, “Experimental investigation of design and retrofit methods for blast load mitigation–A state-of-the-art review,” Engineering Structures, vol. 190, 2019, pp. 189-209, doi: 10.1016/j.engstruct.2019.03.088.
45. H. S. Rao, K. Gnaneswar, and N. Ramana, “Behaviour of simply supported steel reinforced SIFCON two way slabs in punching shear,” 2008.
46. H. Sharma, V. Singh, and M. Kumar, "Structural optimization and performance of SIFCON plates."
47. H. Sundharsana Rao, K. Ganeswar and N V Ramana, Behaviour of restrained SIFCON two way slabs part 1:
48. H. Sundharsana Rao, K. Ganeswar and N V Ramana, Behaviour of simply supported steel reinforced SIFCON two way slabs in punching shear, Indian Journal of Engineering and Material Sciences, Volume-15, 2008, 326-333.
49. H. Sundharsana Rao, Performance of steel reinforced SIFCON two-way slabs in Flexure, 35th conference on Our world in concrete and structures, 2010.
50. H. Yazıcı, S. Aydın, H. Yiğiter, M. Y. Yardımcı, and G. Alptuna, “Improvement on SIFCON performance by fiber orientation and high-volume mineral admixtures,” Journal of Materials in Civil Engineering, vol. 22, no. 11, 2010, pp. 1093-1101, doi: 10.1061/(ASCE)MT.1943-5533.0000114