International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 12, Issue 10 [October. 2023] PP: 81-87

An Experimental Investigation of Plastic Fiber Reinforced Self-Compacting Concrete

Ritika Shrivastava[1], Mayur Singi[2]
[1]*PG Scholar, CED, BMCT Indore, M.P., India*
[2]*Assistant Professor, CED, BMCT Indore, M.P., India*

Abstract- *- Self-compacting concrete (SCC) is a mixture that can be easily placed into formwork without the need for vibrating compaction, owing to its self-weight and high flowability. Unlike traditional concrete, SCC ensures that coarse aggregates remain uniformly distributed, eliminating the requirement for external or internal vibration during the compaction process while maintaining its engineering properties. Key properties of the new SCC include filling capacity, passing capacity, and strength, which are crucial considerations. Solidified mechanical properties of SCC with plastic fiber reinforcement are comparable to conventionally vibrated concrete. However, the disposal of waste plastics presents environmental challenges. Plastic is a non-biodegradable material, persisting in water and soil without degradation, leading to water and soil contamination. Incinerating plastic releases harmful gases, contributing to air pollution and posing health risks when inhaled. As a result, several countries have banned the use of plastics to address this pressing environmental issue. To tackle this problem, this research focuses on producing reinforced self-compacting concrete with waste plastic fibers (WPFRSCC) as a sustainable construction material. This approach offers a dual advantage, enhancing the properties of SCC while simultaneously addressing the disposal of waste plastics.*

In the study, a mix proportion for M40 concrete is determined using the IS: 10262:2009 method. Experiments are conducted to examine the flow characteristics of SCC with varying percentages of waste plastic fibers (0%, 0.50%, 1.00%, and 1.50%), along with different proportions of superplasticizer (1%, 0.90%, 0.80%, and 0.70%). After obtaining satisfactory mixes, cube, cylinder, and beam specimens are cast using different percentages of waste plastic fibers. Subsequent strength tests are performed on these specimens to evaluate the hardened properties of SCC with waste plastic reinforcement.

The results demonstrate that waste plastic fiber reinforced SCC can be successfully developed without the need for consistency-modifying agents. Four distinct mixtures are formulated to meet the specific requirements of fresh SCC, considering different fiber percentages. From a strength perspective, it is found that an optimal combination is achieved with 1.0% of fiber content and 0.70% of superplasticizer.

Key Words: *M40 Grade Concrete, Plastic Fibre, Glenium B233, NVC, SCC, EFNARC (2005), WPFRSCC.*

Date of Submission: 03-10-2023 Date of acceptance: 15-10-2023

I. INTRODUCTION

In the construction field, concrete is the most commonly used material. With the rise of tall buildings and mega projects worldwide, there is an increasing demand for high-strength concrete. Concrete has evolved from a simple mix of cement, aggregate, and water to an engineered material with new constituents. Modern-day construction requires improved efficiency, better working conditions, and enhanced quality and appearance of structures. To meet these demands, concrete should possess properties such as higher flowability, increased strength, improved durability, self-compatibility, and better serviceability, satisfying various performance criteria. Self-compacting concrete has emerged as an innovation to address these requirements.

After being used, plastics become waste and can be repurposed as fibers in concrete to impart additional desirable characteristics. Waste plastic containers, utensils, etc., can be cut into fibers and incorporated into concrete to enhance its elasticity and other properties. Concrete reinforced with waste plastic fibers exhibits significantly improved characteristics compared to traditional concrete. The addition of waste plastic fibers can confer special properties to concrete, making it a suitable and effective material in the construction field.

Self-compacting concrete (SCC) was first introduced in Japan in the 1980s. SCC is a type of concrete composed of conventional concrete materials, which may or may not include a viscosity-modifying admixture. It is also known as self-setting or self-leveling concrete. The key characteristic of SCC is its ability to flow uniformly under gravity without segregation, completely filling the formwork and spaces between reinforcements without the need for mechanical compaction.

To achieve the desired flowability, a high slump is necessary, which can be attained by adding a superplasticizer. However, the concrete must still maintain its strength during handling, which can be achieved by incorporating a viscosity-modifying admixture (VMA). Another approach is to increase the fine aggregate content while reducing the coarse aggregate content. However, this may lead to a larger volume of concrete, resulting in increased costs and temperature rise during hydration. Although adding chemical admixtures can be expensive, the reduction in labor costs may offset the increased expenses. Alternatively, the use of mineral admixtures like granulated blast furnace slag and fly ash can enhance the slump and also reduce costs.

II. OBJECTIVE OF THE WORK

These objectives aim to:

- To conduct experiments to study the flowability of self-compacting concrete by incorporating waste plastic fibers in varying percentages. These experiments will evaluate the ability of the concrete to flow and consolidate on its own without segregation.
- To perform tests such as compressive strength, splitting tensile strength, flexural strength, and impact strength on Waste Plastic Fiber Reinforced Self-Compacting Concrete (WPFRSCC) with different proportions of waste plastic fibers. The aim is to assess the influence of waste plastic fibers on the mechanical properties of SCC.
- To compare the test results with a reference SCC mix that does not contain any fibers. This comparison will provide insights into the effects of waste plastic fibers on the performance of SCC.
- To conduct a comprehensive experimental program using available raw materials, GGBS, and waste plastic fibers. The program will encompass both fresh and hardened characteristics of SCC with various percentages of fibers.
- To examine the behavior of WPFRSCC at elevated temperatures and evaluate the impact of waste plastic fibers under such conditions. This assessment is important for understanding the concrete's performance in high-temperature environments.
- To analyze the results obtained from the experiments and draw meaningful conclusions. The data analysis will provide valuable insights into the benefits and limitations of using waste plastic fibers in SCC.

III. METHODOLOGY

In this detailed observational research on reinforced self-compacting concrete (SCC) with waste plastic fibers, the objectives mentioned in Chapter 1 are being pursued. The materials used for conventional concrete are also employed for manufacturing SCC, with the difference that SCC contains a lower amount of aggregate and a higher proportion of paste. SCC requires a high slump, which can be achieved by adding a larger quantity of super-plasticizer. However, this may lead to bleeding issues. To address this problem, two approaches are considered:

1) The use of mineral admixtures.
2) The use of viscosity-modifying agents.

In this research, ground granulated impact heater slag is employed as a mineral admixture to achieve the required functionality. The chemical admixture used is Glenium B233, which enhances the flow properties and reduces the water-cement ratio. To improve the strength and durability properties, waste plastic fibers with an aspect ratio of 50 are incorporated into the mix. This chapter presents the physical properties of the various materials used in the study, including cement, fine aggregate, coarse aggregate, GGBS, super-plasticizer, waste plastic fibers, and water. Various tests are conducted on these materials, and the results are presented in this section.

Mix design calculations for M40 SCC

The concrete mix for the Self-Compacting Concrete (SCC) is designed with the following material properties and proportions.

- Maximum size of coarse aggregate: 12.5mm
- Specific gravity of coarse aggregate: 2.80
- Specific gravity of fine aggregate: 2.55
- Specific gravity of cement: 3.05
- Specific gravity of GGBS: 2.92
- Bulk density of coarse aggregate: 1410kg/m3
- Bulk density of fine aggregate: 1570kg/m3
- Volume ratio of fine/coarse aggregate is 58/42
- Water to cement ratio (W/C): 0.35
- Water to fine aggregate ratio (W/F): 0.38
- Superplasticizer used is Glenium B233 with a specific gravity of 1.10

- Air content is 2.2%

These parameters are essential in determining the appropriate mix proportions to achieve the desired workability, strength, and durability of the SCC. The specific gravity and bulk density of the aggregates, cement, and GGBS play a crucial role in proportioning the mix, while the W/C and W/F ratios, as well as the air content, ensure the desired flow and consistency of the self-compacting concrete during placement. The superplasticizer, Glenium B233, helps to enhance the flow properties and reduce the water content in the mix, thereby improving the overall performance of the SCC.

These proportions have been determined to achieve the desired properties and workability of the SCC mixture. With these mix proportions, the SCC is expected to exhibit good flowability and strength characteristics.

The mix proportions for the self-compacting concrete (SCC) in terms of the cement, Ground Granulated Blast Furnace Slag (GGBS), fine aggregate, and coarse aggregate are as follows:

Cement: GGBS: Fine aggregate: Coarse aggregate

1: 0.705: 3.34: 2.62

These proportions represent the relative quantities of each material in the SCC mixture. They have been carefully selected to achieve the desired performance and characteristics of the self-compacting concrete**.**

IV. RESULTSAND DISCUSSION

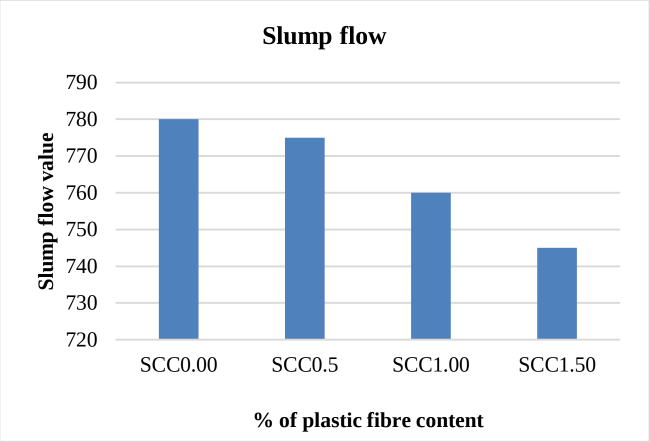

Figure 1 Graph b/w % plastic fiber and Slump flow value

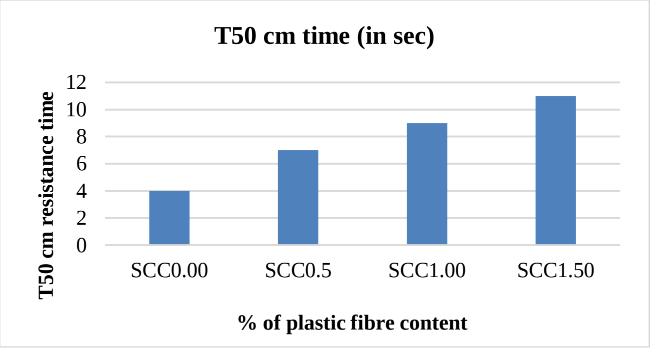

Fig. 2 Graph b/w % of plastic fiber and T50cm time values

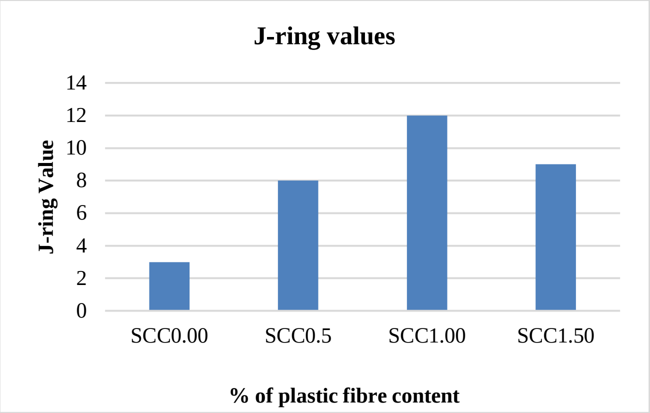

Fig. 3 Graph b/w % plastic fiber and J-ring values

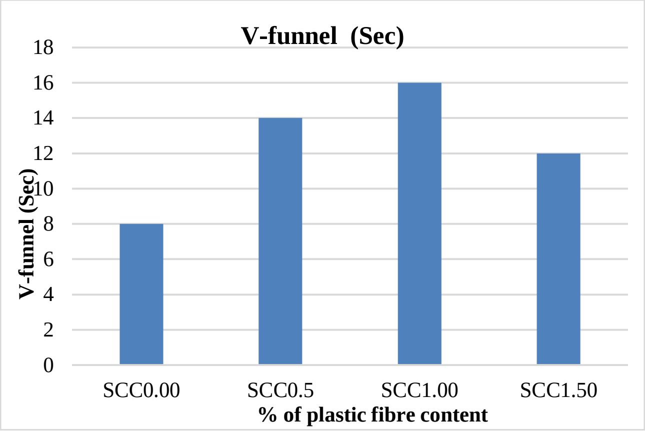

Fig. 3 Graph b/w % plastic fiber and V-funnel values

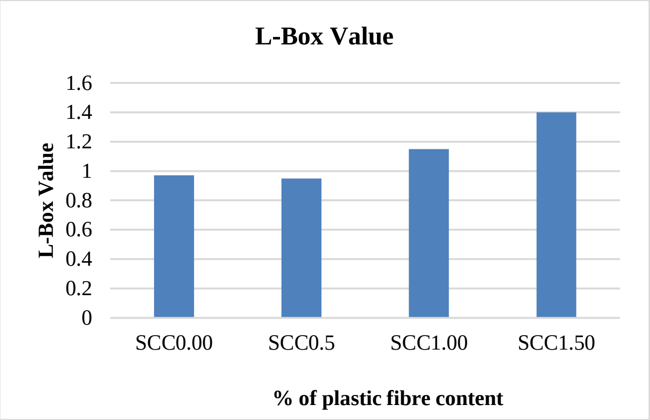

Fig. 3 Graph b/w % plastic fiber and L-Box Value values

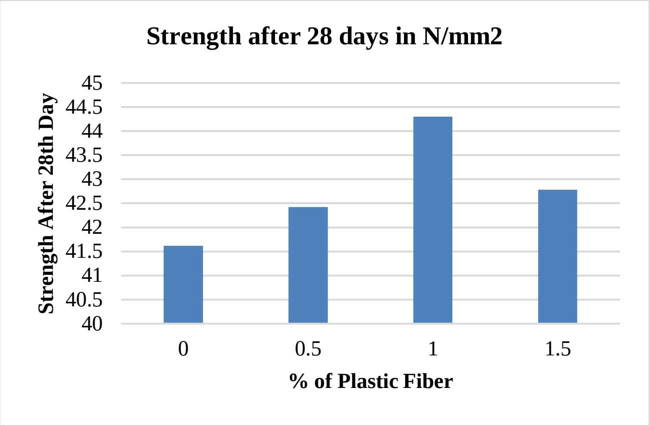

Fig. 3 Graph b/w % plastic fiber and Compressive Strength

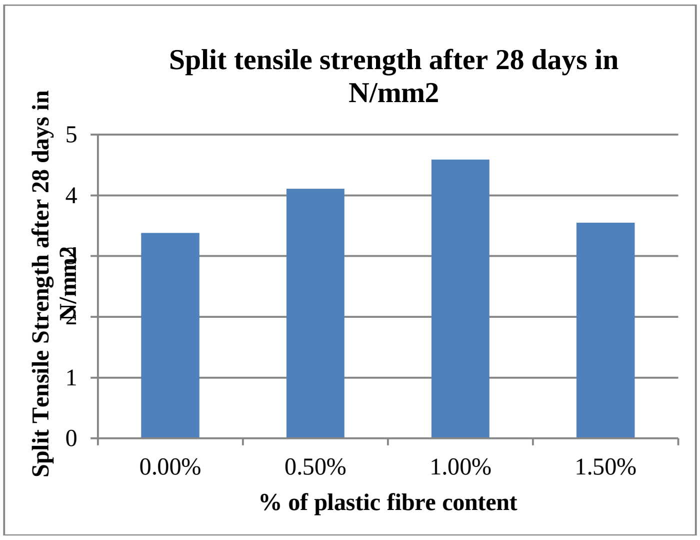

Fig. 3 Graph b/w % plastic fiber and Split Tensile Strength

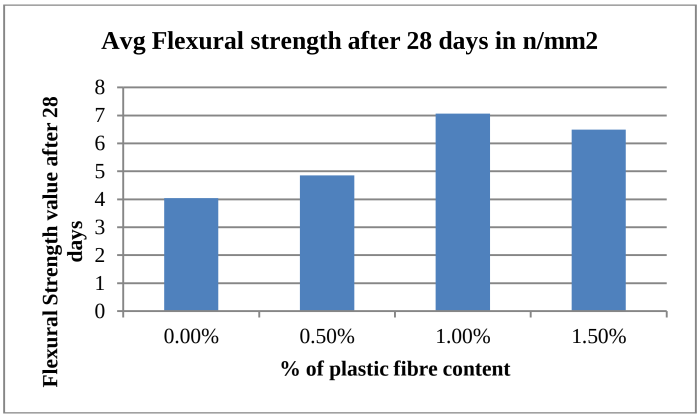

Fig. 3 Graph b/w % plastic fiber and Avg Strength

V. CONCLUSIONS

Based on the results of the experiments and analysis conducted, the following conclusions were drawn:

1. The addition of waste plastic fibers to WPFRSCC affected its flowability, passing capacity, and segregation resistance in the fresh state. Super plasticizer dosage was increased from 0.7% to 1.0% as the fiber content increased from 0.0% to 1.5%. Beyond 1.5% fiber content, achieving self-compacting concrete with an aspect ratio of 50 became difficult.
2. The slump-flow values of WPFRSCC met the criteria for class SF3 according to EFNARC 2005 guidelines. It can be used in highly congested structures with complex shapes and provides better surface finish than SF2 for regular vertical applications.

3. All the WPFRSCC mixes met the criteria for class VS2 as per EFNARC 2005 guidelines based on T500 values being greater than 2. They exhibited favorable viscosity and fluidity characteristics, making them suitable for walls, piles, and tall structures.
4. All the WPFRSCC mixes met the criteria for class VF2 according to EFNARC 2005 guidelines as the V-funnel values were between 9 to 25. They displayed suitable consistency and flow capacity characteristics, making them suitable for walls and piles in tall and slender structures.
5. All the WPFRSCC mixes produced in this study belonged to PA1 class SCC according to EFNARC 2005 guidelines, with L-Box ratio values greater than 0.8 with three bars in the L-box. They are suitable for reinforcement with spacing between 80-100mm, meeting the specific requirements for SCC in the fresh state.
6. Compressive strength measurements of WPFRSCC at 28 days increased with increasing fiber content up to 1.0% fibers. The maximum compressive strength achieved for 1.0% fiber content was 44.30 N/mm2 for M40 grade. At 1.5% fiber content, the strength decreased to 42.78 N/mm2.
7. Split tensile strength measurements of WPFRSCC at 28 days increased with increasing fiber content up to 1.0% fibers. The maximum split tensile strength achieved for 1.0% fiber content was 4.59 N/mm2 for M40 grade. At 1.5% fiber content, the tensile strength decreased to 4.24 N/mm2.
8. Flexural strength measurements of WPFRSCC at 28 days increased with increasing fiber content up to 1.0% fibers. The maximum flexural strength achieved for 1.0% fiber content was 5.06 N/mm2 for M40 grade. At 1.5% fiber content, the strength decreased to 4.49 N/mm2.
9. From the hardened properties test results, it was concluded that the maximum compressive strength, split tensile strength, and flexural strength could be achieved with 1.0% addition of waste plastic fibers with an aspect ratio of 50. Hence, 1.0% waste plastic fiber can be considered optimal from a strength perspective for WPFRSCC.
10. The cost analysis of SCC per cubic meter for various blends was compared with that of equivalent grade of NVC per cubic meter. The cost of SCC (100% OPC) was found to be 2.90% more than that of NVC.
11. The cost comparison considered only the basic cost of cement, including material, transportation charges, and labor charges. The costs of steel and fabrication charges were excluded from the analysis.

REFERENCE

[1]. Hajime Okamura "Self-compacting high-performance concrete", Concrete International, 19(1997) 55-54.
[2]. Yahia A, M.Tanimura, A. Shimabukuro, Y Shimoyoma, "Effect of rheological parameters on self compactability of concrete containing various mineral admixtures in: A, skerendal, o. Peterson (Eds.)", proceedings of first RILEM International Symposium on SCC, Stockholm, September, (1999)523-535.
[3]. Kazumasa Ozawa, "Development of high-performance concrete based on the durability of concrete structures", EASEC-2, (1989455-450.
[4]. Mustafa Sahmaranet et al., "Transport and mechanical properties of self-consolidating concrete with high volume fly ash" Science Direct Cement and Concrete Composites 31(2009)99-106.
[5]. D.W.S.Ho, A.M.M Sheinn, C.C Ng and C.T Tam, "The use of quarry dust for SCC applications" Cement And Concrete Research, 32(2002)505-511.
[6]. Prajapathi Krishna palatal, "Development and properties of self-compacting concrete mixed with fly ash" Research Journal of Engineering Sciences, 1 (3) Sep (2012)11-14.
[7]. P. Ramanathan et al., "Performance of self-compacting concrete containing different mineral admixtures" KSCE Journal of Civil Engineering, 17(2) (2013)456-472.
[8]. K Turk et.al, 9th International Congress on Advances in Civil Engineering, 27-30 September (2010)1-3.
[9]. MD NOR ATAN, HANIZAM AWANG, "The compressive and flexure strengths of self-compacting concrete using Raw Rice Husk Ash". Journal of Engineering Science and Technology. 6 (6) (2011)720-732.
[10]. Okamura, "Self-compacting high-performance concrete", Concrete Institute 19(7) 50- 54.
[11]. Jagadish Vengala and R. V Ranganath, "Mixture proportioning procedure for Self- compacting concrete", The Indian concrete Journal, August (2004)13-21.
[12]. Nan su, Kung-Chung Hsu, His-Wen Chai, "A simple mix design method for Self- compacting concrete", Cement and concrete Research, 31, (2001)1799-1807.
[13]. K. H. Khayat "Workability testing and performance of self-consolidating concrete." ACI Materials Journal June (1999) 346-353
[14]. Hajime Okamura, Masahiro Ouchi, "Effect of super plasticizer on self-compatibility of fresh concrete", Journal of Transportation Research Board, (1997)37-40.
[15]. Anant Patel, Prashant Bhuva, Elizabath Georgr, Darshana Bhatt, "Development of self- compacting concrete using different range of cement content," National Conference on Recent Trends in Engineering and Technology, (2011)1-5
[16]. Sabeer Alavi, C. I. Baskar, Dr. R. R. Venketasubramini, "Strength and durability characteristics of GGBS based SCC", International Journal of Emerging Trends in Engineering and Development, 2(2013).
[17]. Soo-Duck Hwang et al., "Performance based specifications of self-consolidating concrete used in structural applications" ACI material journal,103(2006)121-129
[18]. Salmet Widodo, "Fresh and hardened properties of polypropylene fibre added self- consolidating concrete". International journal of civil and structural engineering, 3 (1)(2012)85-93.
[19]. Buquen Miao, et al., "Influences of fibre content on proportions self-compacting steel fibre reinforced concrete". Journal of The Chinese Institute of Engineers, 26 (4) (2003)523-530
[20]. O.Gencel et al., "Mechanical properties of self-compacting concrete reinforced with polypropylene fibres".Materials Research Innovations, 15 (3) (2011)216-225.
[21]. Kandaswamy and Murugesan, "Fibre reinforced self-compacting concrete using domestic waste plastic fibres". Journal of Engineering and applied sciences, 7 (2012) 405-410.

[22]. Kishore S.Sable, Madhuri K Rathi, “Effect of different types of steel fibre and aspect ratio on mechanical properties of SCC”. International Journal of Engineering and Innovative Technology (IJEIT), 2 (1) July (2012)184-188.

[23]. B Krishna Rao et al., “steel reinforced self-compacting concrete incorporating high volumes of class F fly ash”. International Journal of engineering and science and technology, 2 (9) (2010) 4936-4943.

[24]. HemanthB.Dhonde, Y.L.Mo, Thomas T.C Hsu and John Vogel, “Fresh and hardened properties of self-consolidating concrete fibre reinforced concrete”. ACI Material journal, 104(5) September 1, (2007)491-500.

[25]. R.N.Nibudey et al.,“Strength prediction of plastic fibre reinforced concrete (M40)”, International Journal of Engineering Research and Application (IJERA), 3 (1) Jan-feb (2013)1818-1825.

[26]. A Alavi Nia M Hedayalian and MohmoudNili.“ An experimental and numerical study on how steel and polypropylene fibers affect the impact resistance in fiber- reinforced concrete” International Journal of Impact Engineering,46 (2012)62-73.

[27]. Tara Rahmani et al., “An experimental and numerical study on how steel and polypropylenefibers affect the impact resistance in fiber-reinforced concrete” Construction and building materials, 37 (2012)360-369.

[28]. K Ramesh, Dr. K. Arunachalam, S. RoobanChakravarthy, “Experimental Investigation on Impact Resistance of flyash concrete and flyash fiberreinforced concrete”International journal of Engineering Research and Applications (IJERA) 3(2)(2013)990-999.

[29]. Salamet Widodo, “Fresh and hardened properties of polypropylene fiber added Self – consolidating concrete” International Journal of civil and structural Engineering 3(1), (2012)85-93.

[30]. D. Marutha Chelan et al., “Studies of durability aspects of Fibre reinforced concrete” International journal of engineering science and technology, vol. 4 No.2 Feb (2012)620-628.