OPTIMIZATION OF FIBER REINFORCED CONCRETE IN DRAINAGE COVER APPLICATIONS

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***ABSTRACT*: Many a times the drainage covers that cover potholes for sewage and other underground civil access points are made from cast concrete. These structures lack durability owing to non-flexibilty and do not sustain under cyclic load as in the vehicles on road moving over this drainage cover point . Considering that there are two load cycles per vehicle passing the durability study needs to be done for the structure. More over innovation needs to be done in this regards as to changes in material used for these drainage covers, FRC being a good option . This project will study the application of FRC technology to the drainage cover manufacturing , more over effect of specific gravity of mixture before it is cast (in form of slump test) on the structural durability and integrity of the product. The FRC will be developed, cast and tested in form of slabs that will be tested on the set up developed. Curing time will be same for all specimens as to 28 days. The durability of the specimens will be determined as to number of cycles the specimen with stands before failure, process variabiles being the specific gravity of mixture to be cast (tested by slump test) and percentage of fiber additive.**

Keywords : FRC, slump test, durability

I. INTRODUCTION

Compared to other building materials such as metals and polymers, concrete is significantly bleeding, plastic settlement, thermal and shrinkage strains and stress concentrations imposed by external restraints. To produced macro-cracks due to an applied load, distributed micro-cracks propagate coalesce. When loads are increased the conditions of growth of critical crack rises.

The micro and macro-fracturing processes can improve by using randomly distributed fiber materials. The formation of cracks smother by fiber. The resulting material with a random distribution of short, discontinuous fibers is termed fiber reinforced concrete (FRC) and is becoming a well-accepted mainstream construction material. Important progress has been made in the last thirty years towards perception of the short and long-term performances of fiber reinforced cementatious materials. Our ability to create safe reinforced concrete (R/C) structures has continued to grow with experience. The problem of infrastructure deterioration is not limited to the US alone. In countries like Japan and Korea, the annual outlay for infrastructure maintenance will soon surpass that of new construction. In Europe, it has been estimated that more than 50% of the European infrastructure needs improvements.

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Many a times the drainage covers that cover potholes for sewage and other underground civil access points are made from cast concrete. These structures lack durability owing to non- flexibilty and do not sustain under cyclic load as in the vehicles on road moving over these drainage cover point . Considering that there are two load cycles per vehicle passing the durability study needs to be done for the structure. More over innovation needs to be done in this regards as to changes in material used for these drainage covers, FRC being a good option . This project will study the application of FRC technology to the drainage cover manufacturing , more over effect of specific gravity of mixture before it is cast (in form of slump test) on the structural durability and integrity of the product. The FRC will be developed , cast and tested in form of (4" x 10"x 0.75") slabs that will be tested on the set up developed. Curing time will be same for all specimens as to 28 days.

1.1 OBJECTIVES

The goal of this research are as follow:

- To identify causes of failure of drainage cover with help of literature review.
- Determination of slump value and categorization of specimen before casting.
- .Design and development of FRC slab specimens with varying Fiber content (% by volume).
- Casting of Components with Plain Concrete, FRC with fiber addition & Concrete -FRC + U-boot.
- Testing of cast specimen on test-rig development to find the durability of the specimen of varied composition, with number of cycles withstand before failure

II. LITERATURE SURVEY

[1] Yuequan Bao and Dongyang Feng (2018) deals with the Experimental and numerical study on structural performance of reinforced concrete box sewer with localized extreme defect. An experimental and numerical investigation into the structural process of carrying out of reinforced concrete box sewers with typical corrosion-related extreme defects localized at the ceiling was conducted. Firstly, during the large-scale laboratory test, some key structural responses were captured and evaluated, including the crack width development process, ceiling deflection, and material strains of both complete and typical defective boxes. The failure modes and load-carrying mechanism throughout the specimen loading phases were analysed. In addition, the specimen failure process was simulated using a damage based finite element method, and a related parameter sensitivity analysis was performed.

[2] Piotr Berkowskia and Marta Kosior-Kazberukb (2016) deals with Material and structural destruction of concrete elements in the industrial environment. A concise review of selected models which are currently used to describe the service life of structural systems especially made of concrete is presented, taking into account influences and processes that cause material damage and decrease in structural durability of such elements. This is of importance for proper planning and execution of repair works for degraded structural elements to maintain their further functionality. Finally, some examples of real assessment of condition, causes of deterioration and methods of repair of concrete structural elements deteriorated by the influence of industrial environment aggressive agents are presented.

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[3] Zoran bonic and Gordan toplicic curcic (2015) deals with Damage of Concrete and Reinforcement of Reinforced-Concrete Drainage cover Caused by Environmental Effects. The course of their service period, the concrete structures are exposed to a variety of impacts. An integration of exposure to aggressive effects, poorly constructed structural details, negligence of the durability issues, construction errors and underestimation of the importance of maintenance can lead to a great intense of damage of reinforced concrete which is used for construction of these structures. The reinforced concrete damage issues can be separated into parts, the concrete damage and reinforcement damage. The paper provides some of the aggressive effects which can have impact on the reinforced concrete.

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[4] Gina Crevello , Nancy Hudson and Paul Noyce (2015) deals with Corrosion condition evaluations of historic concrete icons Corrosion condition assessments of historic concrete structures can provide the owner with invaluable information regarding the current condition of the structure, the factors contributing to the corrosion damage, and can also project when the structure may reveal further material loss. This information is vital to be proactive in the repair process which is essential to minimize loss to the structure. When dealing with a highly significant concrete structure the investigative team is many times faced with restrictive parameters limiting the amount of data which can be collected. This paper discusses challenges in to maintain 'historic concrete' and provides four case studies of predictive corrosion condition assessments which were carried out to help in the decision-making process.

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[5] Yan He, Xiong Zhang, R.D. Hooton, and Xiaowei Zhang (2017) deals with Effects of interface roughness and interface adhesion on new-to-old

Concrete bonding. Mechanical properties of new-to-old concrete bond were tested. The impact of interface roughness on new-to-old concrete bond was studied. The effects of interface adhesion agents on new-to-old concrete bond were also studied. Results show that the concrete interfacial fractal dimension is in good relevancy with new-to-old concrete mechanical properties, including splitting tensile strength, flexural strength and bonding strength. If concrete interfacial fractal dimension is higher than new-to-old concrete can obtain higher mechanical strengths. The interface adhesion agents much improve the mechanical strength of new-to-old concrete and result in higher bonding strengths. Distinct kinds of adhesion agents may have different effectiveness and they may contribute to a different degree of increase in mechanical strength. While the interfacial roughness affects the concrete bonding.

III. RESEARCH METHODOLOGY

3.1. Material selection for reinforcement in FRC

3.2 Slump test for various grades of FRC prepared

3.3 System design of testing mechanism as for the component selection, geometry and profile selection, charge system selection, mounting & orientation.

3.4 Mechanical design of components under given system of forces to determine functional dimensions of the components to be used using various formulae and empirical relations

3.5 Manufacturing, assembly of the device and test-rig for experimental analysis and validation.

3.6 Testing and trial to derive performance characteristic of equipment under various load conditions.

3.7 Statistical analysis &/or Mathematical modeling for validation.
3.8 CAE of critical component and Result discussion and thesis preparation.

IV. SYSTEM DEVELOPMENT:

a) System Design:
(Here we define the principle of working, functional Components, discuss their shapes and geometry though graphical / pictorial representation and define the list of components (Bill of materials) --- categorizing the Standard parts and bought out parts)--accordingly we decide as to which parts are to be designed / drawn / manufactured.

b) Mechanical Design :
This section is where we carry out theoretical design and analysis of the critical components we fear will fail under the given system of forces. The design work is carried out in two stages as elaborated sample below:

Part -1: Mathematical Design of the part using standard text book formulae

Title : Design and Analysis of slabs with different Pour value of concrete , and fiber content layout for minimum weight and minimum cost configurations
Materials Template : What we need that we save the data below as standard template and recall it for each new design of different concrete mixes of different pour value

Part -2 The experimental results will be determined using Universal testing machine and the maximum stress produced (σ Mpa) and maximum deformations (δ mm) will be determined and thus all three results of (Theoretical / Analytical / Experimental) will be compared.

Part-3 Statistical tools and Software used: Minitab

I) Types of Analysis: Design of Experiment using Taguchi Analysis between three subject factors

a) Pour Value of concrete

b) Fiber content

c) Additive addition

For Concrete mix designs M20....

Result parameters under study will be Strength, Weight and Cost

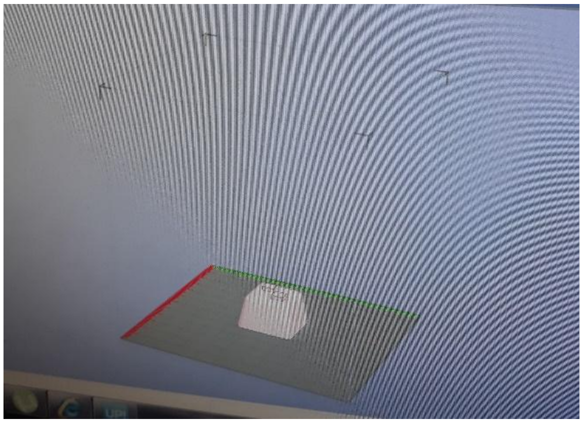
II) One way anova to study the effect of different subject factors on output parameters a& thereby determining the optimum parameters for

a) Maximum Strength.

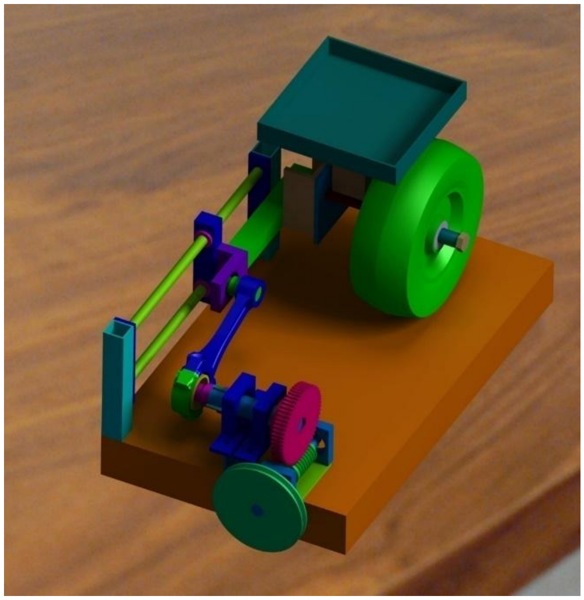
b) Minimum Weight.

c) Minimum Cost.

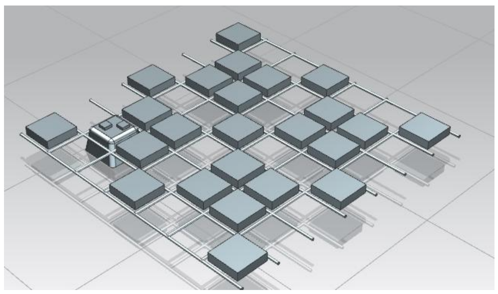
V. Results and Discussions



a)Draw structure in minitab software



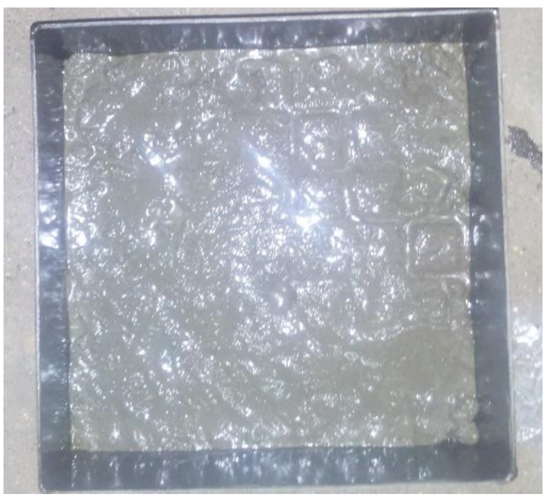
The machine above is the schematic of the system used to measure the load cycles the concrete withstand before failure.



Layout of u-boot

U-boots arranged in grid.

Casting of FRC + Concrete Block



Plain Concrete Block Casted

Casting of U-boot Block

Testing of Weight Of Casted Blocks

weight of model

MODEL	**Plain Concrete**	**Concrete + FRC**	**Concrete+ FRC +U-boot**
WEIGHT	**4.86 kg**	**4.44 kg**	**4.02 kg**

Test and Trial on Specimens Of Plain Concrete
Slump test is conducted to know the workability of the Concrete, slump value varies between 5-7 for M20 grade concrete.

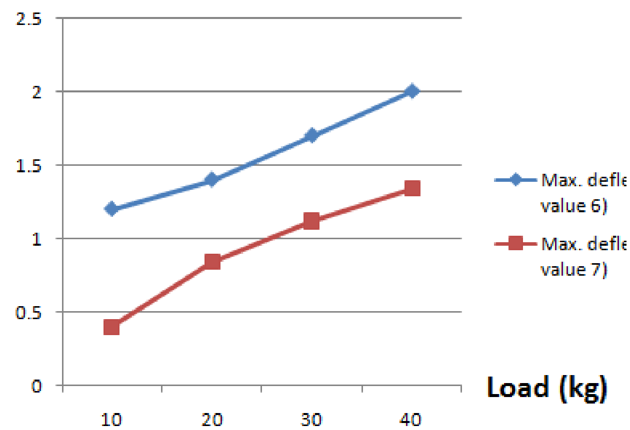
a) Slump Value = 7

Load(P)	Effective Load (Pe)	Stress max	Cycles :	Maximum deflection
10	15.6	280.3490163	36000	0.4
20	31.2	396.473381	31680	0.84
30	46.8	485.5787401	27750	1.12
40	62.4	560.6980326	18900	1.34

a) Slump Value =6

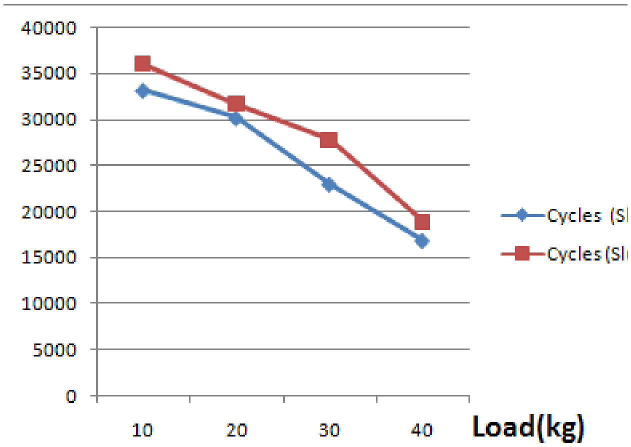
Load(P)	Effective Load (Pe)	Stress max	Cycles :	Maximum deflection
10	15.6	280.3490163	33200	1.2
20	31.2	396.473381	30180	1.4
30	46.8	485.5787401	22960	1.7
40	62.4	560.6980326	16800	2

Graph of Maximum deflection Vs Load

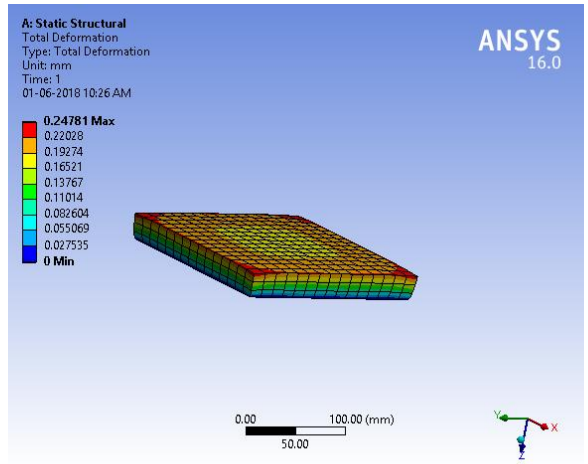


Graph indicates that the specimen with slump value 7 show less deflection as compared to specimen of slump value 6 .

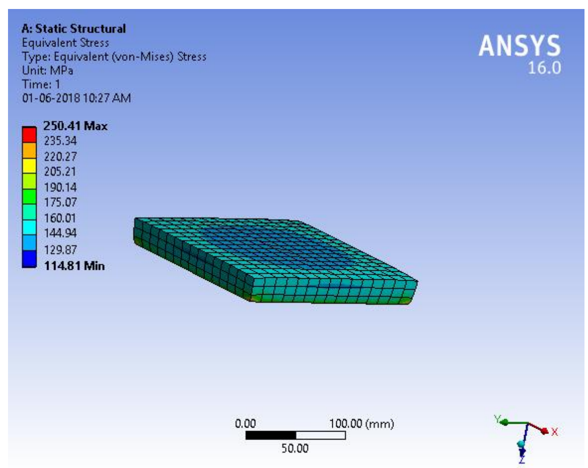
Graph of cycles Vs Load



Graph indicates that the specimen with slump value 7 show more cycles as compared to specimen of slump value 6 indicating that the slump value 7 specimen is more durable than the slump value 6 specimen



The total deformation observed was 0.24 mm which is in close agreement with the experimental results and thus the experiment is validated.



The maximum equivalent stress was found to be 250.42 which is also near to the theoretical fatigue stress calculated using the number of cycle s withstand.

VI. Conclusion:

- Concrete block casted with slump value of 7 shows lower deformation as compared to the concrete block casted with slump value of 6
- Concrete block casted with slump value of 7 shows more cycles with standing as compared to the concrete block casted with slump value of 6
- The maximum deformation observed in the concrete block using Ansys workbench is in close agreement to the experimental values hence the experiment is validated.
- The maximum stress observed in the concrete block using Ansys workbench is in close agreement to the theoretical values calculated based on number of cycles withstand hence the experiment is validated.

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