Analysis And Optimization of Fiber-Reinforced Voided Precast Concrete Slabs (U-Boots) For An Affordable Housing Solution

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Abstract- *Since 1980,the construction industry's productivity worldwide has been challenging due to substantial material costs and environmental damage. To address this problem, lean construction is one of the approaches for improving the situation—lean construction results from applying a new form of production management to construction. Essential features of lean construction include a clear set of objectives for the delivery processaimed at maximizing performance for the customer at the project level, concurrent design, construction, and the application of project control throughout the project's life cycle from design to delivery. Significant research remains to complete the translation to the construction of lean thinking in several construction areas.This paper identifies the effectiveness of u-boot technology in casting concrete in terms of cost-saving, time-saving and durability. To this extent, we chose Concrete (C), Fiber-reinforced concrete (CF), and CF with U-Boot (CFU), which were subjected to various studies (viz. Slump tests, Stress and Strain) to understand their sustainability behaviour. It was found that CFU featured the best among all. Thus, CFU can be an effective alternative to achieve maximum durability at affordable costs and in a minimum time.*

Keywords- Lean concrete (LC), Fiber-reinforced concrete (FRC), U-boot

I. INTRODUCTION

Lean construction (LC) is a method of production aimed at reducing costs, materials, time and effort. [1] Essentially, the methodology is to minimize the bad and maximize the good. Using lean construction principles, the desired outcome would be maximizing the value and output of a project while reducing wasteful aspects and time delay. This outcome is produced when standard construction approaches are merged with a clear and concise understanding of project materials and information and two sets of management archetypes, planning and control. [2] This may seem complex to understand, but the essence of this system is to use what is necessary without extra. This can only be done through strategic planning and action by a management group with the help and aid of all workers. It should be understood that lean construction is a philosophy with principles and ideologies but not a concrete plan of action with set tools and methods. [3] LC principles are the same throughout the many different schools of thought. The basic principles include creating a predictable atmosphere based on planning and data, reducing waste overflow from careful planning and increasing communication between the customer and the project at hand. Lean is a way of thought based on the notion that less is more. [4-6] In the following sections, hopefully, a clear understanding of the principles and practices of the lean mindset is clearly expressed. Identify various lean construction models for executing low-cost sanitation facility enclosures to meet cost, time, and durability tests.[7-8] Proposal of innovation in construction methods, materials in the form of U-boot technology of casting and modular rebar sets in various permutations for effective low cost, manufacture time and maximum durability.[9]

II. EXPERIMENTAL WORK

Fabrication of U- Boot and casting models

Design and fabrication of U-Boot was done using AutoCAD- 3D Max. The composition of plain concrete was as follows:Cement: CEM I 32.5 R 318 kg/m^3, Aggregate: 2/8 mm 703 kg /m^3, Superplasticizer 1.20 kg/m^3. Later, Plain concrete (C), concrete + FRC (CF), and CF with U- Boot (CFU) were cast over a metal grid.

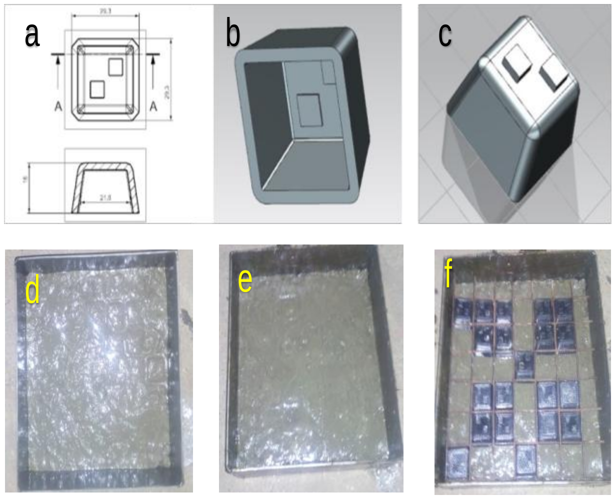

Figure 1. (a-c) Fabrication of U-Boot, and (d) casting of C, (e) CF and (f) CFU over a metal grid.

2.1 Metal Grid

It consists of agrid of beams and columnsand is typically constructed on a concretefoundation.Itsupports the building'sfloors, roof, walls, cladding,etc. Concrete has little tensile strength, andit generally needs to be reinforced. A rebar, orreinforcement steel (or reinforcing steel), is a steel bar or mesh of steelwires used to strengthen and hold the concrete in tension. To improve the quality of the bond with the concrete, the surface of the rebar is often patterned. The metal grid was designed in AutoCAD 3D-Max and is shown in Figure 2.

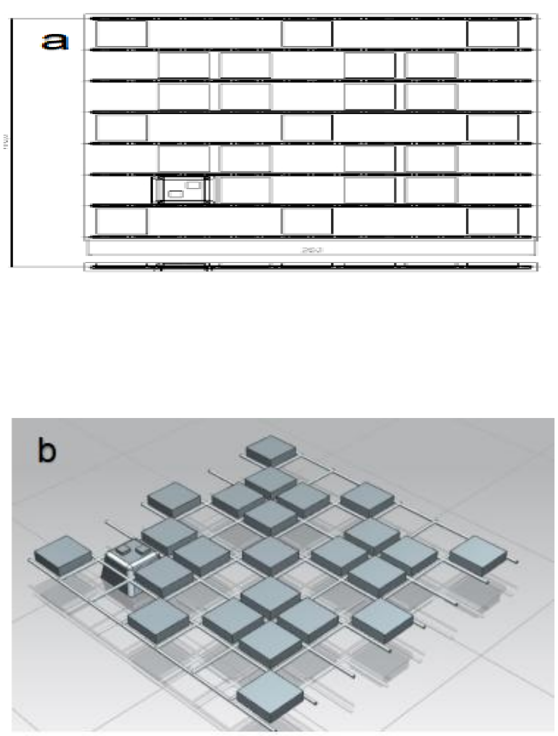

Figure 2. (a) Design and (b) 3D model of metal grid.

2.2 Fiber-reinforced concrete (FRC)

Fibre-reinforced concrete (FRC) contains fibrous material, increasing its structural integrity. It contains short discrete fibres that are uniformly distributed and randomly oriented. This study used 20 Nos of Nylon 6 filaments- boots (10% volume) to fabricate FRC.

III. RESULTS

3.1 Determination of Optimum slump value

A slump test was conducted on the CFU system to determineits workability.Slump valuesof 6 and 7 were considered. The workability is optimum at minimum deflection. As seen from the graphical plot (Figure 3 (a). Furthermore, at a slump value of 7, more cycles were observed, as seen in Figure 3 (b). This suggests that a slump value of 7 should be considered for optimum workability and durability.

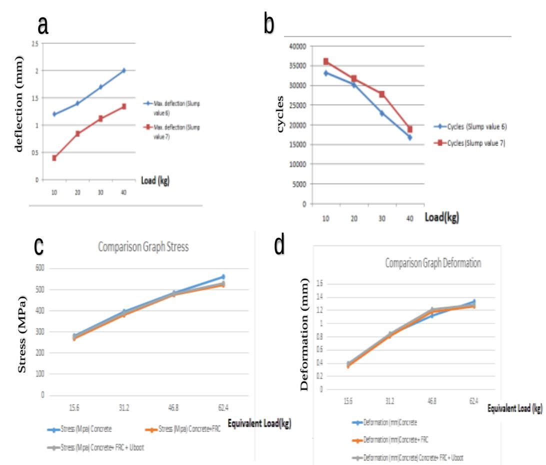

Figure 3. (a-b) Slump test for CFU and (c-d) comparative stress and deformation tests for C, CF and CFU.

3.2 Stress analysis

Three systems (viz. C, CF, and CFU) were subjected to incremental load, and the corresponding stress was measured. The values were graphically plotted in Figure 3 (c), and it was observed that among the three systems, the CFUsystem illustrated the least stress value, which consisted of U-Boot. The significance of the U-boot can be understood here.

3.3 Load bearing ability

Three systems (viz. C, CF and CFU) were subjected to incremental load, and the corresponding deformation was recorded and plotted in Figure 3 (d). The least deformationwas recorded for the CFU system. This was because of the lower load exhibited by the U-boot compared to concrete and CF.

IV. CONCLUSIONS

A slump value of 7 shows lower deflection and more cycles, suggesting better workability.

The graphs show that the CF system showed the least stress. However, when U-Boot was added, the stress was even reduced. This suggests that the U-boot system is low in weight, and there is no significant change in the stress value compared to the CF. Hence, it is recommended for optimal strength and lowest weight. Also, the CFU system features the highest durability and least deformation. Overall, the U-boot system designed herein could be a better alternative to achieve optimum performance and durability at affordable costs.

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