Conduct of Extreme High routine Steel strength armored actual on Real Beams

[1]Name of 1st Mr Kartik Patel
[1]Designation of 1st Assistant Professor
[1]Name of Department of 1st Faculty of Engineering
[1]Name of organization of 1st Gokul Global University, Sidhpur, Patan, Gujarat – India

Abstract.

The primary objective of this study is to assess the efficacy of Ultra-High Performance Fiber-Reinforced Concrete (UHPFRC) layers in enhancing the performance of Reinforced Concrete (RC) beams. Significantly, the utilization of fine sand as an alternative to traditional coarse aggregates plays a role in enhancing this enhanced consistency. To effectively address the demanding criteria of modern architectural endeavors, such as earthquake-resistant concrete structures, skyscrapers, and bridges with large spans, it is crucial to substantially augment the mechanical and durability characteristics of concrete structures.

Key words: steel fibers, jacketing, Ultra-High Performance Fiber Reinforced Concrete (UHPFRC), Ductility, load carrying capacity.

INTRODUCTION

Recent developments in concrete technology, such as the introduction of High-Performance Concrete (HPC), have been crucial in addressing the limitations associated with conventional concrete. The High-Performance Concrete (HPC) employed in this context is a type of concrete that incorporates steel fibers for reinforcement and exhibits enhanced homogeneity. Significantly, the utilization of fine sand as an alternative to traditional coarse aggregates plays a role in enhancing this enhanced consistency. To effectively address the demanding criteria of modern architectural endeavors, such as earthquake-resistant concrete structures, skyscrapers, and bridges with large spans, it is crucial to substantially augment the mechanical and durability characteristics of concrete structures. Ultra-High Performance Concrete (UHPC) and Ultra-High Performance Fiber-Reinforced Concrete (UHPFRC) have made substantial progress in addressing the aforementioned requirements of the present era. Ultra-High Performance Concrete (UHPC) demonstrates extraordinary properties, such as very low permeability, which effectively inhibits the ingress of deleterious substances such as water and chlorides. Furthermore, Ultra-High Performance Concrete (UHPC) has remarkable compressive strength, tensile strength, as well as distinctive characteristics of tensile strain hardening and softening.

High performance concrete exhibits several performance properties, including resistance to freeze-thaw cycles, scaling, abrasion, chloride penetration, as well as notable compressive strength, elastic modulus, little shrinkage, and creep. It is produced by combining various binder components, including cement, silica fume, quartz powder, and fine aggregates such as river sand and quartz sand. Additionally, steel fiber and a super plasticizer are incorporated into the mixture. The technology originated in Europe and was initially employed in specialized contexts that demanded remarkable durability and resistance to corrosion, such as the construction of earthquake-resistant buildings or marine structures. In recent times, UHPC has been increasingly utilized in certain contexts that demand exceptional strength, such as bridge spans and building facades. The material's remarkable strength, wear resistance, reduced weight, and favorable life cycle costs have emerged as pivotal factors influencing its selection in these applications.

EXPERIMENTAL PROGRAMME

Materials utilised in this work

In the present investigation, OPC 53 grade cement was utilized, together with M sand that met the requirement of passing through an IS sieve with a size of 4.75mm. This study utilized locally available

20mm crushed stone aggregate as the fine aggregate. Reinforcement was carried out using bars made of Fe500-grade steel. Silica fume and quartz powder were utilized as binding agents in this study. The incorporation of steel fibres enhances the flexural characteristics. The superplasticizer known as conplast SP 430 is employed.

Material properties

The various materials utilized in this study and the evaluation of their material qualities were conducted in compliance with the specifications outlined by the IS (Indian Standards) organization. The materials utilized in this investigation consist of regular Portland cement, with a specific gravity of 3.14, M sand serving as a fine aggregate, exhibiting a specific gravity of 2.65, and crushed granite, characterized by a particle size of 20 mm, functioning as a coarse aggregate with a specific gravity of 2.85. The flexural reinforcement of each beam under consideration comprises two steel bars, positioned on both the tension and compression sides, with a diameter of 8 mm each. Shear reinforcement is achieved through the utilization of 6 mm steel bars positioned at intervals of 120 mm. The study employed deformed steel fibers of the hooked end type, characterized by an aspect ratio of 80. Tab presents the characteristics of steel fiber.

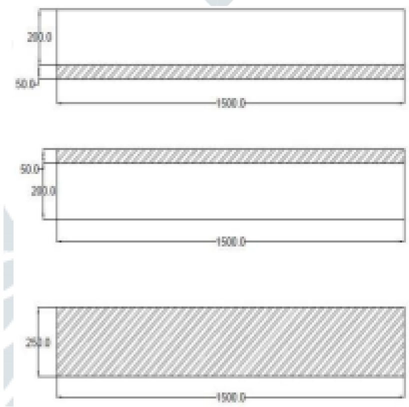
Parameters Proportion Shape Hoked End (Deformed) Type HE 0.75/60 Diameter(mm) 0.75 Length(mm) 60 Aspect Ratio, l/d 80 Unit Weight (kg/m) 7850 Elastic Modulus, E(MPa) 205000 Tensile Strength (N/mm2) 1100 Coating None

For average strength concrete, the cement to fine aggregate to coarse aggregate mass proportions were 1:1.56:2.72 and the water to cement ratio was 0.45.

Cement 1 475 River sand 0.90 427 Quartz sand 0.60 285 Quartz powder 0.20 95 Silica fume 0.25 118 W/C ratio 0.45 0.45 Steel fiber 2% by Volume 40 Super plasticizer 0.10 47

Specimens

The investigation focused on determining the compressive strength of concrete by utilizing cubes with dimensions of 150x150x150 mm. The investigation involved the examination of various beam specimens, including a conventional reinforced concrete beam (referred to as the control beam or CB). Additionally, three other specimens were studied: specimen I, which consisted of a beam with a 50 mm thick layer of ultra-highperformance fiber-reinforced concrete (UHPFRC) with steel fibers on the tensile side (referred to as UTS); specimen II, which had a 50 mm thick UHPFRC layer with steel fibers on the compressive side (referred to as UCS); and specimen III, which featured a 50 mm thick UHPFRC layer with steel fibers on three sides (referred to as UST3).The dimensions of the reinforced concrete (RC) beam specimens, measuring 1.5 meters in length, 0.15 meters in width, and 0.2 meters in height, are depicted in Fig. Detailing of each test specimens are shown in Fig.



Detailing of beams with UHPFRC in the tension side, (b) the compression side, And (c) three side jacket

Testing of specimen

The beams were subjected to a two-point loading configuration, where the load was applied at the center of the beam and the ends were supported in a simply supported manner. The monotonic load was applied using a hydraulic jack, while reliable data gathering was facilitated by the use of a proving ring. The beam was subjected to a gradually increasing load. Linear variable differential transducers (LVDTs) were positioned at the center bottom and along the diagonal of the slab bottom.

The Linear Variable Differential Transformer (LVDT) is employed for the purpose of quantifying the displacement of the test specimens. The recorded displacement is visually presented on the digital indicator and afterwards linked to the Data Acquisition System (DAQ).The beams were subjected to significant levels of stress, resulting in their eventual failure. The magnitudes of the loads at which cracking initially occurred and complete collapse ensued were documented. The mid-span deflections were measured for each incremental load. In order to determine the maximum load and resulting deflection of a beam under gradual load application, it is necessary to set the reading to zero. The experimental configuration for the UHPFRC strengthened beam on the tensile side is depicted in Fig.

Experimental test set up for UHPFRC strengthened beam at tensile side

RESULTS AND DISCUSSIONS

The experimentation involved the evaluation and documentation of the deflection of both the control beam (CB) and the steel fiber reinforced beam under various load conditions. The cracking load and ultimate load carrying capacity of each specimen are determined. The deflection associated with each loading condition has been measured, and the ultimate deflection for each system has been established. The findings of the analysis conducted on reinforced specimens are examined with respect to their capacity to bear maximum loads, their behavior under load-induced deformation, and the types of failure observed.

LOAD DEFLECTION GRAPH

Upon analysis of diverse specimens utilizing a loading frame apparatus, varied test outcomes are generated. The load associated with the initial occurrence of a crack is measured during the testing process. The failure load and the related deflection for each specimen are derived from the recorded results

Summary of test results for beam testing

Beam	Ultimate load (kN)	Deflection at mid span (mm)	Deflection at L/3 (mm)	Load at first crack	Ultim ate load gain factor
CB	48.4	22.03	18.19	29.1	1
UCS	69.2	21.81	15.82	34.5	1.40
UTS	50.8	28.7	22.62	34.2	1.05
UTS3	88.5	9.74	8.84	47.4	1.83

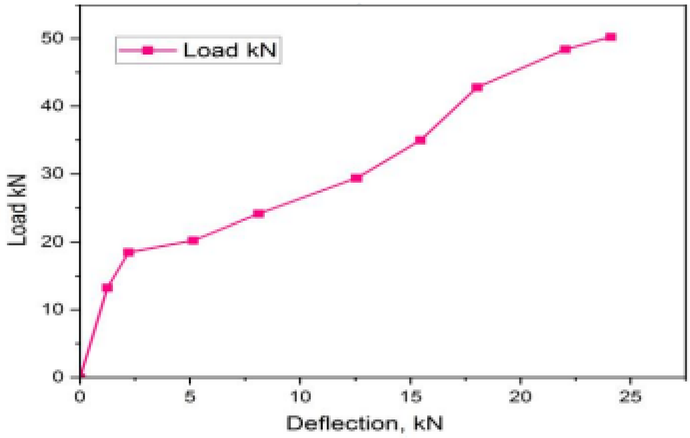


Fig. exhibits the Load Vs deflection graph for the Control Beam. The relationship between loading and deflection is directly proportional. The control beam exhibits flexural failure when subjected to its maximum load carrying capacity. The applied load on the structure is 48.4 KN, resulting in a maximum central deflection of 22.03 mm. additionally; the deflection at a distance of one-third the length of the structure is measured to be 18.19 mm.

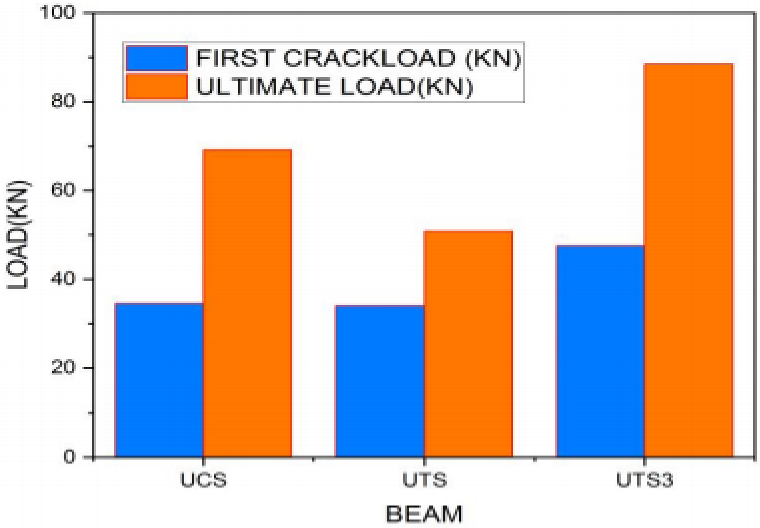


Fig. First crack and Ultimate load.

Fig. illustrates the initial crack load and ultimate load of USB beams. The study determined that the greatest central deflection at mid span was 21.81 mm, while at a distance of one-third of the span (l/3), it was found to be 15.82 mm. These deflection values were observed under the maximum load of 69.2 kN.

According to the data presented in Tab, there is a positive correlation between the applied load and the deflection, indicating that as the load increases, the deflection also increases. The magnitude of deflection has a positive correlation with the applied load. The experimental results revealed that the maximum deflection at the center of the beam was measured to be 9.74 mm at mid span and 8.84 mm at a distance of one-third of the beam length (l/3), equivalent to the application of a maximum load of 88.5 kN. It has been observed that the use of steel fiber jacketing leads to an increase in the structural strength of beams. The load carrying capacity of the system is significantly enhanced by the addition of steel fiber overlay on three sides, resulting in an observed strength increase of around 84%.The experimental setup including the application of a compression side Ultra-High Performance Concrete (UHPC) overlay on a beam resulted in a notable enhancement of 39% in terms of its strength. The experimental setup using a tension side overlayed beam demonstrated a notable enhancement in strength, with an approximate gain of 6%.

The load seen at the onset of cracking for the beam reinforced with ultra-high-performance concrete (UHPC) three side jackets including steel fibers is recorded as 47.4 kN, which is the highest value among all tested specimens. This superior performance can be attributed to the inclusion of steel fibers, which enhance the beam's crack resistance. The first cracking load for the control beam is recorded as 29.1 kN, which represents the lowest load value among all the specimens.

Crack Propagation

It has been noticed that exclusively flexural cracks were generated in all of the beams. In the scenario with UHPC overlay beams, the initiation of fractures occurred in the lower region of the beam and propagated upward till reaching the upper portion of the specimen. In this context, the propagation of cracks occurs predominantly in a near-vertical direction, from the lower portion to the upper portion. The initial fracture manifests at the midpoint of the beam. The ultra-high-performance concrete (UHPC) three-side jacketing beam reinforced with steel fiber exhibits a reduced occurrence of cracks in comparison to both other reinforced beams and the control beam.

CONCLUSIONS

A series of beams, consisting of a control beam and four beams overlaid with ultra-high performance concrete (UHPC) in various configurations, were fabricated. Based on the analysis of specimens , the following conclusion can be drawn.

• The study aimed to assess the load carrying capacity of specimens with different configurations of UltraHigh Performance Concrete (UHPC). It was noted that these specimens demonstrated an increase in weight bearing capability compared to the control specimen. • The specimens demonstrated a reduction in center deflection when compared to the control beam. • Ultra-High Performance Concrete (UHPC) is applied on the tension side and on the compression side has been found to be 50.8 kN and 69.2 kN respectively. This indicates a 6% and 39% enhancement in load capacity compared to the control beam. • In the comparative analysis of these three specimens with a control beam, it was noted that the load carrying capacity of the 50 mm thick ultra-high performance concrete (UHPC) three side jackets reinforced with steel fiber exhibited a superior performance. • The measurement of the center deflection of a beam, which is enveloped by three-side jackets made of ultra-high-performance concrete (UHPC) with a thickness of 50 mm and containing steel fiber, yields a value of 9.74 mm. When comparing, it is observed that the central deflection of a beam equipped with a 50 mm thick ultra-high performance concrete (UHPC) compression side overlay measures 21.81 mm. • The control beam displayed a central deflection measuring 22.03 mm, which exceeds the deflection measurements reported in 50 mm thick ultra-high-performance concrete (UHPC) three side jackets. The observed phenomena can be ascribed to the absence of an overlay, resulting in a reduction in thickness and a concomitant drop in resistance to failure.

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