

# Nano-Based Carbon Fibre Reinforced Concrete PSC Sleeper Behavior

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## ABSTRACT

The construction sector is entering a new era because to high-performance concrete (HPC). Other high-level buildings, such as nuclear reactors, fortresses, and military installations may also benefit from high-performance computing. Due to the inclusion of fibres, HPC has improved toughness and energy absorption capacity. Static and dynamic behaviour of reinforced cement concrete beams modified with different composite materials, such as Carbon Nano tubes, steel fibres, polypropylene fibres, and SBR latex, have been the subject of increased research in recent years. A composite material's effects were investigated in this experiment. Because of the concrete's ductility, the member may take in and release a large quantity of energy. In response to the reasons described above, new construction materials such as high-performance concrete including Carbon Nano Tubes, fibres like polypropylene fibres, steel fibres, and polymers such as SBR-latex have been researched. There are two primary considerations in the design of structures that are subjected to both static and dynamic stresses: strength and elasticity. Numerous innovative materials have been evaluated that outperform normal concrete in terms of strength and durability in projects subjected to both static and dynamic loads, such as seismic loading, impact loading, blast loading, cycle loading, etc. Composite materials have a higher specific modulus than conventional ones, which makes them superior. There is a far more urgency in dealing with a low-velocity strike. Recently, this has been viewed as an important study.

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## INTRODUCTION

As the backbone of India's transportation system, the Indian Railways integrates the market and links people from all across the nation. In terms of total track capacity, it ranks fourth worldwide (after USA, China and Russia). The majority of India's railway system is over a century old. Due to rising traffic, greater loads, and poor maintenance, this network is beginning to show its age. Because of rail-seat degradation, cracking, and damage under various loading situations and unfavorable environmental conditions, railway sleepers prematurely degrade. Largely as a result of high-intensity stresses from wheel or rail imperfections, such as burnt or dipped joints or corrugated steel rails, concrete sleeper cracking and associated damage occurs.

As a result of their high specific strength and density, composite materials are becoming more desirable. This flexibility has given them an advantage over traditional materials such as metals, polymers, and ceramics. Structural applications in the building sector, aircraft, and other industries have recently seen a surge in demand. This, in turn, has fueled the demand for research into composite materials' impact resistance tolerance. Conventional concrete can be improved on many engineering properties such as the mechanical properties such as tensile strength and compressive strength as well as flexural strength, fracture toughness, energy absorption capacity and impact resistance by the addition of carbon nano tubes and materials such as latex to the conventional concrete on static and impact behaviour. Concrete differs significantly from other produced building materials in that it gains the necessary levels of strength and related qualities over time.. Concrete's structure is dynamic, unlike that of many other materials. To explain this, it's owing to the fact that the cement paste's structure continues to alter over time due to hydration. It is a constant volume method that solidifies cement paste. The process of setting and hardening is the end consequence of the microstructure gradually growing from inside. Concrete may be used for a variety of applications when it has been hydrated with water, becoming strong and hard like stone. Cement, aggregates, water, and admixtures (minerals and chemicals) are all factors in the concrete mix design that are taken into account to ensure that the final product has the proper strength, durability, density, and impermeability for the structure it is being used in. The proportioning of a high-quality concrete mix is dependent on the fundamental materials, their exact

amounts, and the method by which they are mixed, put, and cured.

### LITERATURE REVIEW

Our engineering and research abilities have progressed along with us. Since its inception, civil engineering has seen numerous changes and innovations in construction technology, bringing us to the prosperous present-day. Our quest for a more sustainable future continues even now, as we innovate, study, and create new technologies. Engineers and researchers have been searching for new and better materials throughout this history in order for building to handle the performance-cost trade off effectively. Civil engineering's concrete technology is a prominent sub-discipline. Every country's infrastructure is being bolstered by it. Western and Eastern countries have made great strides in this area.

“Surekha. T, Dr. Chandrashekhar. Silica fume and GGBS have been tested for their effect on the characteristics of concrete. Mix design was carried out in accordance with IS:10262 criteria, using M40 grade concrete (2009). All of the mix was replaced with silica fume at a rate of 8%. 30 to 50% of cement was replaced with GGBS as a control. In comparison to the control mix, silica fume's compressive strength improved with GGBS. Cement substitution with GGBS resulted in better strength gains of up to 40% compared to standard concrete, but beyond that, the strength diminishes. Only by substituting cement for silica fume can split and flexural strength be achieved. Workability decreases when silica fume is kept at 8% and the GGBS replacement level is increased (30 percent to 50 percent ).

Sudarsana Rao. Hunchate. et al., A study on the use of silica fume and super plasticizers in the mix design of high-performance concrete has been published. HPC mix design is the primary goal of this inquiry, which aims to establish a technique for HPC by altering the amount of silica fume (0 to 25 percent) at a constant dosage of super plasticizers and other components. To determine the ideal silica fume percentage, experiments are conducted on M60 concrete to obtain high workability and mechanical qualities. The findings showed that the compressive strength increased by 15% when silica fume concentration was increased. As a result, 15 percent is the ideal replacement rate. 7- and 28-day HPC compressive strength ratios range from 0.84-0.9 in favour of HPC.

Aires Camoes et al., low cost high performance concrete was tested experimentally using 150x150x150-mm<sup>3</sup> cubes of low quality fly ash Poor-cost HPC, with 28-day strengths in the region of 65 MPa, may be produced utilising fly ash of low quality and locally available crushed aggregates. Reduced carbon content of fly ash is achieved by removing 75 micrometer-sized particles from the fly ash. Fly ash may be utilised to replace between 20% and 40% of the cement content in concrete. In the comparison of the findings, it was shown that HPC with up to 65 MPa may be generated by substituting up to 40% of cement with crushed granite aggregates.

K.Anbuvelan has studied Polypropylene Fiber's Strength and Behavior in Concrete's Impact Characteristics. The ACI drop weight Impact tester is used to assess the impact resistance of fibrous concrete in this research. In this study, Polypropylene fibre dosages of 0.1 percent, 0.2 percent, and 0.3 percent are examined in three classes of concrete, namely M1, M2, and M3. First crack and ultimate strength may be improved by using 0.0 percent, 0.1 percent, 0.2 percent, and 0.3% Polypropylene fibre dosage in plain concrete to the greatest extent of 15.38 percent - 45.85% for the first crack and 14.95 percent - 45.98% for the final strength.

### METHODOLOGY

Flexural behaviour of SBR-modified high-performance fibre reinforced next generation nano carbon concrete beams is the focus of this software. For comparative purposes, “a total of nine reinforced concrete beams with one each of M60 grade (2200x230x150) mm CNT, CNT combined with Steel Fibers, CNT combined with Polypropylene Fibers, and CNT mixed with both Steel and Polypropylene Fibers are cast. Studying the load deflection curve will reveal the ductility factor, energy absorption capability and toughness index as well as the cracking moment and ultimate carrying capacity. The results of this comparison will be used to determine whether or not Carbon Nano Tubes, fibres, and SBR latex are suitable for use in concrete.

### STATEMENT OF PROBLEM

Concrete structures' long-term performance has grown more important to the economies of all countries. Because of the constantly changing loads and the highly variable structural loads, civil engineering facilities are subject to very challenging and unpredictable weather conditions. Despite the fact that typical concrete has a high compressive strength, it has a low resistance to fracture under both static and impact loading conditions. Adding fibre to the concrete matrix may enhance the concrete's fracture energy. Adding fibres to concrete considerably enhances its ability to absorb fracture energy. To turn a

brittle cement matrix into a ductile one, these fibres in the concrete matrix absorb more energy and regulate breaking as crack arrestors.

### CASTING OF TEST BEAM SPECIMENS

The moulds were cleaned, greased, and lubricated with mould release oil. The next step is to attach the mould end plates using nuts and bolts. A total of 18no HTS 3-ply 3-mm-diameter strands were then wrapped through all four moulds utilising bulkheads and bench end plates before the process was completed. A stress bench was included with the tensioning bed. Bolts were tightened using hydraulic jacks. A 241KN pre-stressing force was applied to the jack's ends. Casting takes place on the casting table next. Two high-frequency vibrators were installed in each mould (8000 rpm). A concrete mix including carbon fibres, polypropylene fibres, CNTs, silica fumes, and GGBS was used to pour Auracast-270M into each mould in layers and compress it using shuttering vibrators. This was done for 11 and a half hours per stress bench in a steam room. It was removed from the steam chamber after the bench had attained the required strength. By releasing the end plate fasteners, the prestress was transmitted to the concrete. Remove the mould end plates and use a welder to cut the HTS wires. The long line prestressing procedure is used to cast the PSC sleepers in the casting yard.

#### Experimental Setup

Beam flexural behaviour under static stress will be studied in this experiment. Figure 4 depicts the experimental setup in full. Deflection is measured using an LVDT after a hydraulic jack is used to apply a load on a test beam specimen until failure. To determine the ultimate load, the first fracture load is measured.

#### Load – Deflection Behaviour

When designing concrete structures in the limit state, deflection is a significant consideration. The load deflection curves may be used to evaluate the structural member's behaviour and overall property in response to static loads. The load deflection curve shows that external load is taken up in two phases. Pre-crack and post-crack stages are represented by linear curves, whereas post-cracking stages are represented by curves that have been gradually curved beyond their original cracking loads. Increasing deflection with load characterises the second phase of the curve.

### CONCLUSION

To better understand how high-performance fibre reinforced concrete behaves under static and low-velocity repetitive impact loads, the following overview is provided. Material qualities, kind of loading, and the mechanical properties and structural state all have a role in how a beam behaves. Static flexural loading and impact loading have received the majority of study interest.

### MECHANICAL PROPERTIES

**Compressive Strength:** It has been determined that the 28-day strength for the following mixtures has been enhanced in comparison to the strength for mixture 1, namely mixtures 2, 3, 4, 6, 7, 8, and 9, which has been calculated as follows: M-60 (Control). Comparatively, it has been reduced by 9.78 percent for Mix-5 against Mix-1: M-60 (Control). Mix-6 (M60+CNT+SF+PF) on the other hand sees a 12.27 percent rise in M-60 (Control) when compared to Mix-1.

**Split Tensile Strength:** There is a 17.82 percent increase in the 28-day strength of mixes 2 through 9 compared to the strength of mixes 1 through 60: M-60: M-60: M-60: M-60: M-60: M-60: M-60: M-60: M-60 (Control). Compared to Mix-1, the split tensile strength of Mix-6 (M60+CNT+SF+PF) increased by 42.82 percent (Control).

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