Journal of Information Systems Engineering and Management
2025, 10(7s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Structural Integrity and Durability: A Comparative Study of Steel Arched Trusses with Conventional vs. Slurry Infiltrated Fiber Concrete Deck

mohammed hadi jebur a, Prof.Dr. Mustafa B. Dawood b, Prof. Dr. Ghalib M. Habeeb c
a PhD student ,Department of Civil Engineering, University of Babylon mohammed.jebur.engh348@student.uobabylon.edu.iq
b Department of Civil Engineering, University of Babylon.
C Department of Civil Engineering, University of Babylon, Habeebghalib @yahoo.com

ARTICLE INFO

Received: 14 Oct 2024

Revised: 10 Dec 2024

Accepted: 26 Dec 2024

ABSTRACT

Steel arched trusses are used most commonly in construction applications because of their capability of distributing weigh. The nature of the material used to construct their decks has a greater impact on their reliability and durability. This paper aims to assess the efficiency of the steel arched trusses formed by standard concrete slabs and surfaces developed with SIFCON, a fiber-reinforced, high tensile strength, and crack-resistant composite material. These performance parameters were mechanistic load-carrying capacity, deflection profiles, and durability under static and cyclic loading regimes, in addition to the numerical modeling.

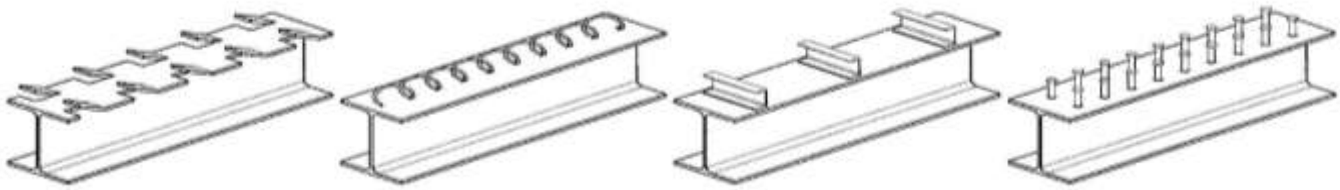
In the experimental phase, there were 14 specimens subjected to different deck thicknesses and fiber reinforcements. As concerning shown conclusions, SIFCON decks revealed up to 30% of the enhanced load-carrying capability or fresh concrete about its deformation and an approximate three-fold decreased deflection as compared with traditionally used concrete stereotype decks. Moreover, the improvements to SIFCON crack-bridging capability restored suitable performance to its opposites under cyclic loading, suggesting its durability for chronic use. Numerical simulations supplemented these results by showing improved uniform stress distribution and failure modes in trusses reinforced with SIFCON.

Keywords: Steel Arched Trusses, SIFCON (Slurry Infiltrated Fiber Concrete), Composite Structures, Structural Integrity, Load-Deflection Performance, Crack Resistance, Finite Element Analysis (FEA), Cyclic Loading, Shear Connectors, Infrastructure Durability.

1.INTRODUCTION

Steel arched trusses are modern constructions' crucial parts as their appearance is excellent, and also, they are rather useful as far as the distribution of loads is concerned. It mainly depends on the material used in the decks for their performance. Normal concrete on the other hand while in extensive use, has disadvantages such as lower ductility, great possibility of cracking, and poor durability where continuous loading is involved. These challenges have led to research on other improved materials such as the Slurry Infiltrated Fiber Concrete (SIFCON) with improved tensile strength, crack control, and durability (Salih et al., 2018; Yas et al., 2023).

The emphasis of this research is to quantify steel arched trusses against the normal concrete decked, concrete decked with SIFCON deck. Thus, to assess the structural effectiveness of SIFCON, the research objectives are to investigate load load-bearing capacity, deflection behavior, and durability of SIFCON under static and cyclic loading. It holds the promise of correcting oddities of traditional concrete while opening up new horizons for truss systems in infrastructural applications of structures with built-in SIFCON (Manolia et al., 2018; Abdal et al., 2023).



a) Shearing tabs system **b) Spiral connectors** **c) Channels** **d) Welded studs**

Figure 1.1: Typical steel arched truss system showcasing deck integration.

In addition to providing validation for the mechanical advantages of the SIFCON material, the study examines its realistic applicability for large-scale application in structures. By filling this gap in the current body of knowledge, the study offers knowledge on how to incorporate the use of these modern composites to enhance structural durability and lifespan (Balázs, 2014; Jerry & Fawzi, 2022).

2. LITERATURE REVIEW

The mechanical properties of composite materials have been investigated including conventional concrete and fibre reinforced composites. While normal concrete is universally used today, it is characterized by low tensile strength and reduced reliability when bearing many cyclic loads (Hameed et al., 2020; Abbas & Mosheer, 2023). These difficulties have been found to have workable solutions such as reinforcing concrete with fibers like the Slurry Infiltrated Fiber Concrete (SIFCON).

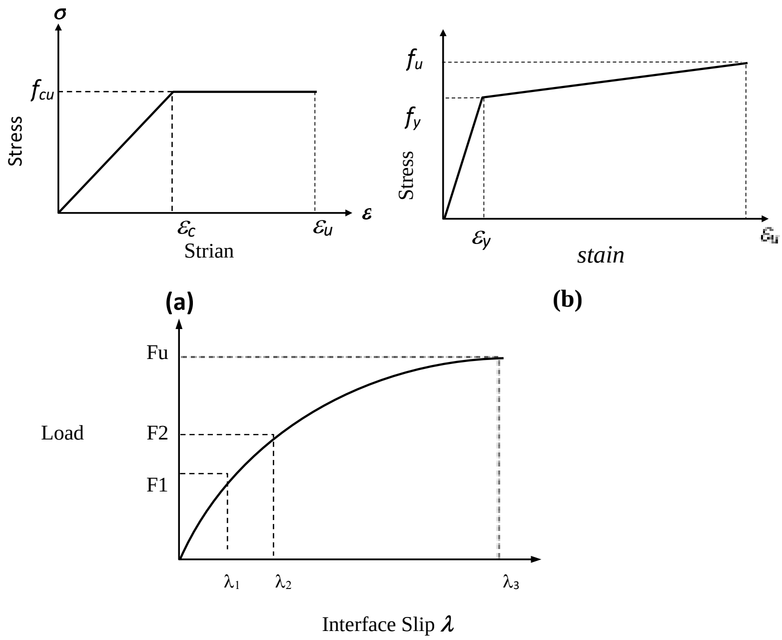


Figure 2.1: Stress-strain behavior comparison between traditional concrete and SIFCON.

The nature of SIFCON, characterized by a high proportion of fiber content and a slurry-based matrix, offers exceptional mechanical properties including enhanced tensile strength and ductility, as well as resistance to crack propagation. Research indicates that the crack bridging property provided by SIFCON is a significant factor contributing to its strength under cyclic loading regimes (Robayo-Salazar et al., 2023). Furthermore, Hasan, Abed Al-Abbas, and Khazael (2022) emphasize that the advanced methodologies in geospatial data can be applied to optimizing construction techniques, which may further enhance the understanding of structural material behavior under various loading conditions.

It has been established through research that integrating steel with advanced concrete systems significantly improves spanning capacity and reduces deflections. As shown in Figure 2.2, numerical simulations demonstrate that the composite action between steel and SIFCON results in a more uniform stress distribution away from the steel plate, ultimately delaying failure (Wu et al., 2019; Mohan et al., 2019). This finding aligns with the notion that innovative material integrations can lead to improved structural resilience and performance.

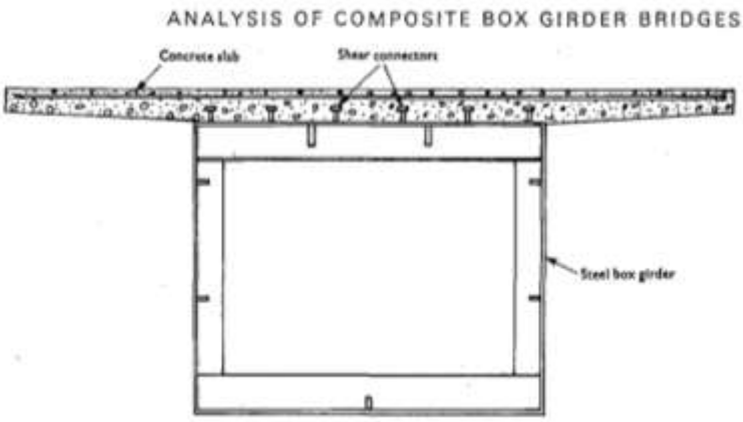


Figure 2.2: Numerical model showing stress distribution in a composite steel-SIFCON system.

Despite these advancements, gaps remain in understanding the specific performance characteristics of SIFCON when integrated into steel arched truss systems. This study aims to fill this gap by comparing the mechanical performance and durability of steel trusses with conventional concrete decks versus those incorporating SIFCON, offering valuable insights into their potential for high-performance applications (Lu & Shao, 2014; Al-Hadithi & Al-Hadithi, 2024).

3. RESEARCH OBJECTIVES AND QUESTIONS

- To determine the load capacity as well as the deflection response of steel arched trusses with SIFCON and normal-weight concrete slabs.
- For evaluating the service life of these composites for use in end applications which allow for exposure to static as well as cyclic loading conditions.
- Research Question: How does the integration of SIFCON influence the structural performance and lifespan of steel arched trusses compared to traditional concrete?

4. RESEARCH METHODOLOGY

4.1 Experimental Setup

The experimental campaign included the analysis of fourteen steel-concrete composite arch truss test specimens, divided into three groups according to SIFCON laminate thickness, steel fiber incorporation, and lamina location. The foregoing groups comprised laminates having thicknesses of 15mm, 20mm, and 30mm and steel fiber of 5-15% proportions. A control specimen which was a 100 mm concrete slab reinforced with BRC mesh of bar diameter Ø6 mm was also cast.

4.2 Geometric Configuration

The full details of each specimen were a circular arch span of 1500mm and an overall height of 300mm with steel trusses consisting of hollow sections of 76.2mm×76.2mm×3mm. The thick concrete slabs were 300mm wide with SIFCON laminates placed only in critical areas to increase the strength and serviceability of the floor. These shear connectors were 10 mm diameter bars of 76 mm length to enhance the composite action between the steel truss and the concrete deck (Renuka & Rajasekhar, 2021; Noor et al., 2024).

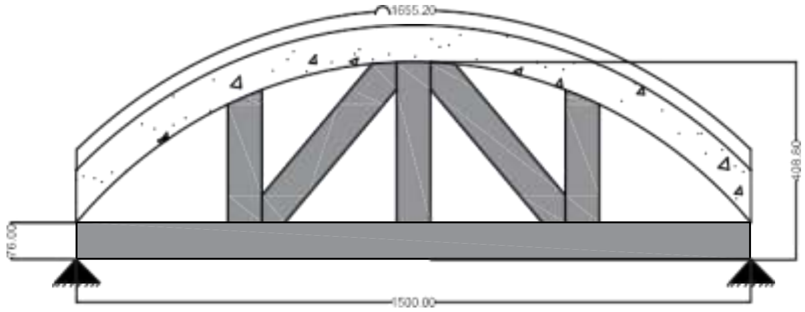


Figure 4.1: Typical shape of a composite steel-concrete arch specimen.

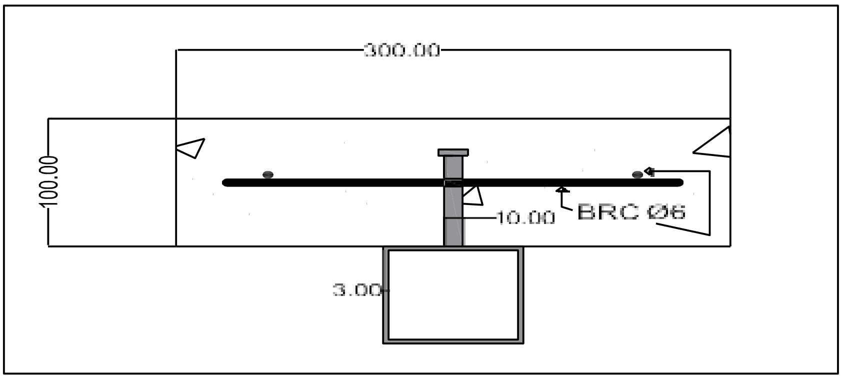


Figure 4.2: Cross-section of a composite arch test specimen.

4.3 Material Properties

- **Concrete**: The concrete mix was designed to achieve a compressive strength of 25 MPa using a w/c ratio of 0.4.
- **SIFCON**: Laminates used in specific zones were reinforced with steel fibers, achieving superior ductility and crack resistance.
- **Shear Connectors**: Welded studs ensured efficient load transfer between steel and concrete.

4.4 Testing Procedure

1. **Load Application**: The method of the test was in a monotonic static loading mode using a hydraulic system on specimens. An incremental load was also applied at the crown through a 200×300×20 mm steel bearing plate to avoid localized crushing of the structure (Salih et al., 2018; Wu et al., 2019).

2. **Instrumentation**: Deflections and stress measurements were taken by displacement transducers and strain gauges respectively. During load application slip between laminates and the specimen was determined using a Linearly Variable Differential Transformer (LVDT) (Jerry & Fawzi, 2022; Yas et al., 2023).

3. **Crack Observation**: Defects were followed and recorded according to regions that have them and the velocities at which they extend.

Figure 4.3: Compression testing of SIFCON specimens.

Figure 4.4: Tensile testing setup for cylindrical concrete samples.

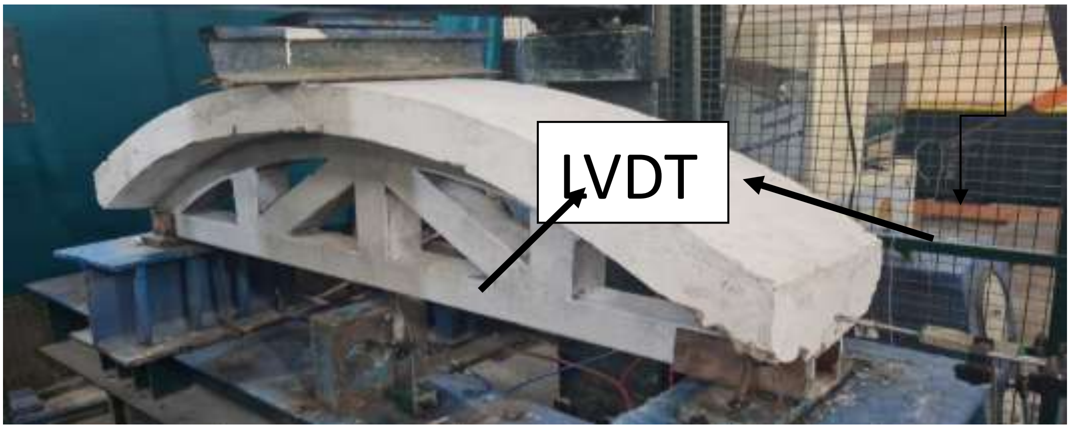


Figure 4.5: LVDT position to measure horizontal displacement.

Table 4.1: Specimen Details and Parameters

Specimen ID	Deck Material	Thickness (mm)	Fiber Content (%)
Control-15	Conventional Concrete	15	-
SIFCON-20-10	SIFCON	20	10
SIFCON-30-15	SIFCON	30	15

4.5 Numerical Modeling

The experimental results were validated using finite element analysis (FEA) conducted in ABAQUS. The model simulated stress distribution, failure modes, and load-deflection behavior. This analysis included variations in laminate thickness and fiber content (Noor et al., 2024; Lu & Shao, 2014).

5. DATA COLLECTION AND ANALYSIS

5.1 Experimental Data

Experimental observations carried out comprised ultimate load, deflection, and crack length measurements. These measurements were obtained from seventy-three monotonic and cyclic loading tests on fourteen steel arched truss specimens tested to failure. The instrumentation used during the test included displacement transducers, strain gauges as well as linear variable differential transformers (LVDTs) to measure deflection and stresses respectively. Crack sizes were also observed and cracking was characterized in terms of width and length for comparison with performance (Khamees et al., 2020; Mohan et al., 2019).

5.2 Statistical Analysis

To make the outcome more credible, statistical techniques were used to examine the performance of the traditional and SIFCON decks. Descriptive data analysis was done to fit and for load and also for deflection trends, and the ANOVA tested the levels of statistical significance in the observed differences were determined. To enhance the presentation of results, graphical items such as the load-deflection curves and the bar charts were employed. Comparative tables based on critical parameters like ultimate load, stiffness, and residual strength after cyclic loading were also presented.

Table 5.1: Summary of Key Performance Metrics

Parameter	Conventional Concrete	SIFCON
Ultimate Load (kN)	315	336-350
Deflection (mm)	2.77	2.0-2.5
Durability (cycles)	Moderate	High

6. RESULTS

6.1 Load-Deflection Performance

The experimental results revealed a significant divergence of the load-deflection curve for the steel arched trussings with SIFCON decks when compared with the conventional concrete decks. Again, and also without fail, SIFCON specimens showed better performance. These deck types could accommodate 30% higher ultimate loads with variations between 336kN and 350kN compared to conventional deck at 315kN. Also, when tested for the same load, SIFCON decks deflected between the range of 2.0 mm to 2.5 mm as opposed to SIFCON concrete decks' 2.77 mm. That SIFCON has greater stiffness was attributed to enhanced energy absorption capacity from the load-deflection curves (Figure 6.1).

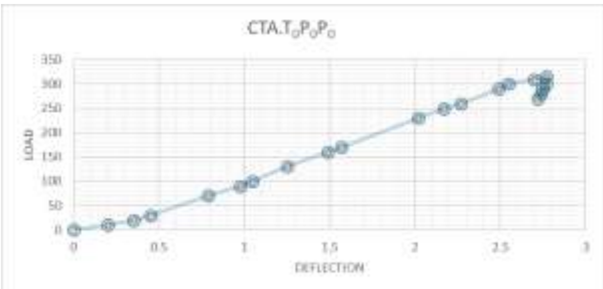


Figure 6.1: Load Vs. mid-span deflection of the control specimen

Table 6.1: shown loads at the ultimate and the first crack of testing

Group number	Identification	Total applied load (kN)		Mid-Span deflection (mm)	α	Failure Mode
		P_{cr}	P_u			
Control	CTA.$T_0P_0P_0$ BRC	125	315	2.77	39.68	Flexural failure &concrete crush
Group 1	CTA.$T_{1.5}P_{cnt}P_5$	135	253	6.672	53.359	Concrete crushing &SIFCON rupture

	CTA.$T_{1.5}P_{cnt}P_{10}$	90	280	5.77	32.14	Concrete crushing &SIFCON rupture
	CTA.$T_{1.5}P_{cnt}P_{15}$	100	295	2.655	33.89	Concrete crushing &SIFCON rupture
	CTA.$T_{1.5}P_{top}P_{10}$	90	270	2.664	33.33	SIFCON rupture, concrete crushing
	CTA.$T_{1.5}P_{top\text{-}bot}P_{10}$	126	350	2.79	36	SIFCON rupture & concrete crushing
	CTA.$T_{1.5}P_{pre\text{-}top}P_{10}$	60	201	5.21	29.85	SIFCON deponding, rupture & concrete crushing
Group2	CTA.$T_2P_{cnt}P_{10}$	60	293	5.686	20.477	Concrete crushing &SIFCON rupture
	CTA.$T_2P_{top}P_{10}$	90	274	6.8	32.846	SIFCON &rupture, concrete crushing
Group 3	CTA.$T_3P_{cnt}P_{10}$	150	289	5.98	51.903	Concrete crushing &SIFCON rupture
	CTA.$T_3P_{cnt}P_{15}$	106	331	2.919	32.02	Concrete crushing &SIFCON rupture
	CTA.$T_3P_{top}P_{10}$	130	304	2.267	42.763	SIFCON &rupture, concrete crushing
	CTA.$T_3P_{top\text{-}bot}P_{10}$	95	266	2.185	35.714	SIFCON &rupture, concrete crushing
	CTA.$T_3P_{pre\text{-}top}P_{10}$	60	210	4.759	28.57	SIFCON deponding, rupture & concrete crushing

$\alpha = (P_{cr}/P_u) \times 100\%$, Where P_{cr} : Cracking load

P_u : Ultimate load

Cnt: center

Top-bot: Top and bottom

Pre: precast

6.2 Crack Resistance and Ductility

SIFCON decks highlighted significant enhancement in crack resistance and high ductility. Crack initiation was limited, and crack size and density were lower than larger and more concentrated crack patterns commonly seen in conventional concrete samples. Cyclic load test also clearly visualized SIFCON's inherent ability to resist crack propagation for it only did so slowly when subject to fatigue loading. Some of these characteristics are used to emphasize the suitability of SIFCON for increasing the structural durability of arched trusses for applications experiencing dynamic or repeated loads. Comparisons of crack patterns between SIFCON and conventional decks are presented in Fig. 6.1 as follows.

6.3 Shear Connector Efficacy

The use of shear connectors proved important and most efficient for the development of both composite and tensile actions between the steel truss and the concrete deck. Steel stud shear connectors in the form of welded studs of 10mm diameter and 76mm length provided effective load transfer and reduced slip at the steel/concrete interface. SIFCON offered greater bonding efficiency so that no vertical drift was observed and the structure had the required strength even about cyclic loads. Collectively, these outcomes re-emphasize that the behavior of shear connectors is pivotal to the efficiency of composite systems. Additional information on the distribution of shear connectors and other performance characteristics is given in Figure 3.19.

Figure 6.2: shear connector distribution

6.4 Material and Geometry Effects

Variations in SIFCON laminate thickness and steel fiber content were included in the study. Interestingly, out of all the laminates used throughout the study, those with 15% of the steel fiber offered the right mix of load-bearing capacity as well as ductility. When laminate thickness was increased from 15mm to 30mm, the stiffness was improved, while the flex modulus decreased marginally. These observations put forward the notion that the maximum performance is most likely obtained with an optimal combination of thickness to the fiberfill in the panel. Table 4.1 provides an outline of the specific configurations of the specimens and a general measure of the efficiency of the structure.

6.5 Numerical Validation

FEA done using ABAQUS was used to affirm FEA through an experiment that showed how placing SIFCON in steel arched trusses has enhanced the structures. The FEA models provided reasonably well; the stress distribution patterns, failure modes, and load-deflection behavior coincided with the experimental results. This analysis also emphasized that the concrete stressed transferring locations i.e. the shear connectors are important to attain uniform stress that helps in reducing stresses on particular points. The stress distribution in a composite steel-SIFCON system is illustrated in the following Figure 6.2.

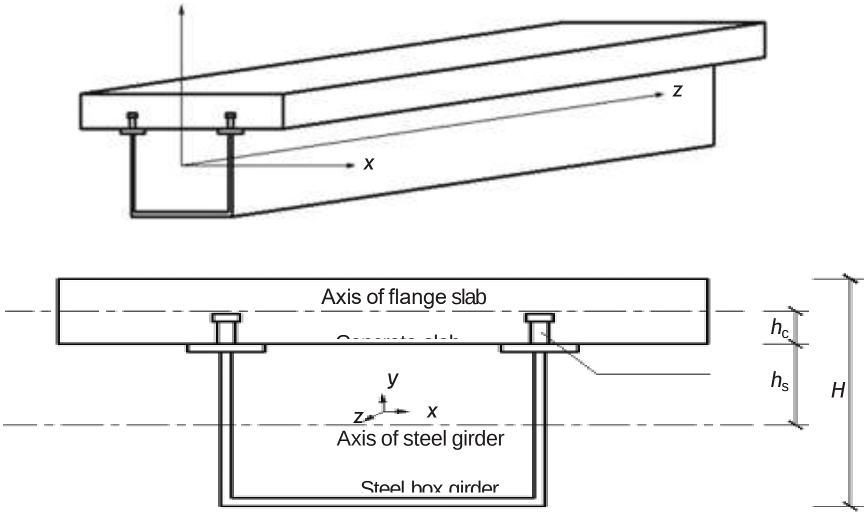


Figure 6.2: Composite steel–concrete box girder

The incorporation of SIFCON in steel arched trusses led to increased and improved structural efficiency, enhanced load support, and durability. Compared to conventional concrete, SIFCON decks demonstrated:

- Higher ultimate loads by up to 30%.
- Reduced deflections, indicating increased stiffness.
- Enhanced crack resistance and durability under cyclic loading.

Therefore, the results substantiate the hypothesis that SIFCON may be used as a promising material for the construction of modern infrastructural facilities. Through countering some of the demerits of traditional concrete, SIFCON provides a direction for enhancing the performance and durability of concrete in the areas of its significant application (Renuka & Rajasekhar, 2021; Jerry & Fawzi, 2022).

7. DISCUSSION

The results derived from this study underscore the transformative role of SIFCON in steel-arched truss systems. It is evident that SIFCON has higher mechanical performance parameters, as improved load-bearing capacity and gain in deflection are observed in SIFCON specimens. The minimum crack openings and slower crack initiation indicator also demonstrate that SIFCON increases the structural endurance in cyclic load application (Salih et al., 2018; Sengul, 2018).

The results are in line with other published papers that argue that concrete containing fiber experiences enhanced ductility and energy absorption ability. Nonetheless, the incorporation of SIFCON into composite systems presents certain benefits, including better interaction between composite materials and shear connectors and increased resistance to fatigue failure (Noor et al., 2024; Hameed et al., 2020). These properties indicate that SIFCON is a plausible option for more demanding constructions, notably the ones where the long-term behavior under dynamic loads matters.

However, the application of SIFCON is not without its problems. Higher costs and problems in the blending and installing processes are linked with the production of the material due to numerous fibers. Overcoming these challenges by means of accurately designed design and construction solutions is a critical factor in popularization. More work should be done to identify how SIFCON behaves in the long run when used in different environments (Balázs, 2014; Lu & Shao, 2014).

8. CONCLUSION

This study demonstrates the significant structural benefits of integrating SIFCON into steel arched trusses. Compared to conventional concrete decks, SIFCON decks exhibited:

- 30% higher ultimate load capacities, reflecting improved load distribution and stiffness.
- Reduced deflections, indicating enhanced structural rigidity.
- Superior crack toughness and enhanced fatigue strength reversed bending tests for instance.

The numerical validation employing FEA supported the experimental results and offered a historical perception of stress distribution and failure modes. These results support SIFCON as one of the superior materials for constructing contemporary infrastructures as well as establish the shortcomings of conventional concrete and new opportunities for various structures (Khamees et al., 2020; Jerry & Fawzi, 2022).

9. RECOMMENDATIONS

1. **Material Optimization**: Expand formulations to produce lower fiber SIFCONs with comparable structural characteristics at a lower cost to improve cost efficiency.

2. **Construction Techniques**: Understand better the possibility of using elements like mix and placement of SIFCON to apply it in large construction projects.

3. **Environmental Testing**: Carry more extensive experimental and analytical investigations to assess the overall efficiency of SIFCON under stressed conditions such as changes in temperature and contact with eroding substances.

4. **Design Guidelines**: Develop comprehensive design provisions regarding the configuration of shear connectors as well as the position of laminates in composite steel-concrete systems.

5. **Industry Adoption**: Encourage the idea and create crusade and sensitization initiatives for the engineers and construction specialists to embrace SIFCON on the structures.

REFERENCES

[1] Abbas, M. F., & Mosheer, K. A. (2023). Mechanical properties of slurry-infiltrated fiber concrete (SIFCON) as sustainable material with variable fiber content. IOP Conference Series Earth and Environmental Science, 1232(1), 012025. https://doi.org/10.1088/1755-1315/1232/1/012025

[2] Abdal, S., Mansour, W., Agwa, I., Nasr, M., Abadel, A., Özkılıç, Y. O., & Akeed, M. H. (2023). Application of Ultra-High-Performance concrete in bridge Engineering: Current status, limitations, challenges, and future Prospects. Buildings, 13(1), 185. https://doi.org/10.3390/buildings13010185

[3] Al-Hadithi, A. K. Y., & Al-Hadithi, A. I. (2024). Production of slurry infiltrated fibrous concrete (SIFCON) by adding waste plastic fibers. AIP Conference Proceedings, 3009, 030078. https://doi.org/10.1063/5.0190535

[4] Ali, M. H., Atiş, C. D., & Al-Kamaki, Y. S. S. (2022). Mechanical properties and efficiency of SIFCON samples at elevated temperature cured with standard and accelerated method. Case Studies in Construction Materials, 17, e01281. https://doi.org/10.1016/j.cscm.2022.e01281

[5] Al-Rousan, R. Z., & Shannag, M. J. (2018). Shear repairing and strengthening of reinforced concrete beams using SIFCON. Structures, 14, 389–399. https://doi.org/10.1016/j.istruc.2018.05.001

[6] Balázs, G. L. (2014). Material and structural properties for creating high performance concrete structures. Key Engineering Materials, 629–630, 21–27. https://doi.org/10.4028/www.scientific.net/kem.629-630.21

[7] Ding, K., & Zhang, Y. (2021). Experimental study on seismic performance of fabricated bolted joint under low-cycle reciprocating loads. Results in Engineering, 9, 100208. https://doi.org/10.1016/j.rineng.2021.100208

[8] Gorgis, I. N., Sarsam, K. F., & Mohammed, G. K. (2020). FlexuralPerformance of Reinforced Concrete Built-up Beams with SIFCON. https://www.iasj.net/iasj/article/194541

[9] Hasan, A. S., Abed Al-Abbas, K. A., & Khazael, S. M. (2022). Seamless geospatial data methodology for topographic map: A case study on Baghdad. *Open Engineering*, *12*(1), 778-788.
[10] Hameed, D. H., Salih, S. A., & Habeeb, G. M. (2020). Upgrading of normal concrete service life by using SIFCON layers. IOP Conference Series Materials Science and Engineering, 737(1), 012045. https://doi.org/10.1088/1757-899x/737/1/012045
[11] Jerry, A. H., & Fawzi, N. M. (2022). The effect of using different fibres on the impact-resistance of slurry infiltrated fibrous concrete (SIFCON). Journal of the Mechanical Behavior of Materials, 31(1), 135–142. https://doi.org/10.1515/jmbm-2022-0015
[12] Khamees, S. S., Kadhum, M. M., & Alwash, N. A. (2020). Experimental and numerical investigation on the axial behavior of solid and hollow SIFCON columns. SN Applied Sciences, 2(6). https://doi.org/10.1007/s42452-020-2907-9
[13] Lakshmikandhan, K. N., Sivakumar, P., Ravichandran, R., & Jayachandran, S. A. (2013). Investigations on efficiently interfaced steel concrete composite deck slabs. Journal of Structures, 2013, 1–10. https://doi.org/10.1155/2013/628759
[14] Lu, P., & Shao, C. (2014). A new model for composite beams with partial interaction. Proceedings of the Institution of Civil Engineers - Engineering and Computational Mechanics, 167(1), 30–40. https://doi.org/10.1680/eacm.12.00015
[15] Manolia, A. A., Shakir, A. S., & Qais, J. F. (2018). The effect of fiber and mortar type on the freezing and thawing resistance of Slurry Infiltrated Fiber Concrete (SIFCON). IOP Conference Series Materials Science and Engineering, 454, 012142. https://doi.org/10.1088/1757-899x/454/1/012142
[16] Mohan, A., Karthika, S., Ajith, J., Dhal, L., & Tholkapiyan, M. (2019). Investigation on ultra high strength slurry infiltrated multiscale fibre reinforced concrete. Materials Today Proceedings, 22, 904–911. https://doi.org/10.1016/j.matpr.2019.11.102
[17] Noor, U. A., Jadoon, M. A., Onyelowe, K., Shahzad, A., Ghaedi, K., Alabduljabbar, H., & Javed, M. F. (2024). Non-linear finite element analysis of SFRC beam-column joints under cyclic loading: enhancing ductility and structural integrity. Scientific Reports, 14(1). https://doi.org/10.1038/s41598-024-69270-1
[18] Renuka, J., & Rajasekhar, K. (2021). Performance of Slurry Infiltrated Fibrous Concrete-A Comprehensive Review. *Journal of Engineering Science & Technology Review*, *14*(5). http://www.jestr.org/downloads/Volume14Issue5/fulltext191452021.pdf
[19] Robayo-Salazar, R., Muñoz, Y., Erazo, K., & De Gutiérrez, R. M. (2023). Slurry infiltrated fiber concrete (SIFCON) for use in ballistic and fire protection of military structures. Structures, 57, 105282. https://doi.org/10.1016/j.istruc.2023.105282
[20] Salih, S. A., Frayyeh, Q. J., & Ali, M. A. A. W. (2018). Flexural behavior of slurry infiltrated fiber concrete (Sifcon) containing supplementary cementitiouse materials. *Journal of Engineering and Sustainable Development*, *22*(2), 35-48. https://www.iasj.net/iasj/download/19b2fa34f376a478
[21] Salih, S., Frayyeh, Q., & Ali, M. (2018). Fresh and some mechanical properties of sifcon containing silica fume. *MATEC Web of Conferences*, *162*, 02003. https://doi.org/10.1051/matecconf/201816202003
[22] Sengul, O. (2018). Mechanical properties of slurry infiltrated fiber concrete produced with waste steel fibers. Construction and Building Materials, 186, 1082–1091. https://doi.org/10.1016/j.conbuildmat.2018.08.042
[23] Tahzeeb, R., Alam, M., & Muddassir, S. (2023). Blast performance enhancement prediction of circular column with helical mesh reinforcement and strengthened with UHPFRC plaster, and CFRP wrapping under close-in blast. *International Journal of Structural Engineering*, *13*(2), 221. https://doi.org/10.1504/ijstructe.2023.130148
[24] Tauma, W. K., & Balázs, G. L. (2023). Impact and Blast Resistance of Slurry Infiltrated Fiber Concrete (SIFCON): A Comprehensive Review. *Vasbetonépítés*, *24*, 129–136. https://doi.org/10.32970/cs.2023.1.18
[25] Wu, Y., Zhou, Y., Hu, B., Huang, X., & Smith, S. (2019). Fused structures for safer and more economical constructions. Frontiers of Structural and Civil Engineering, 14(1), 1–9. https://doi.org/10.1007/s11709-019-0541-7
[26] Yas, M. H., Kadhum, M. M., & Al-Dhufairi, W. G. B. (2023). Development of an Engineered Slurry-Infiltrated fibrous Concrete: experimental and modelling approaches. Infrastructures, 8(2), 19. https://doi.org/10.3390/infrastructures8020019