International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 9, Issue 10, pp 223-232, October-2025

https://doi.org/10.47001/IRJIET/2025.910029

A Financial Viability Study of Integrating Waste Fibers and Geosynthetics in Road Construction for Sustainable Asset Management with AI & ML

[1]Ms. Kuljeet Kaur, [2]Dr. Gagandeep S. Salhan, [3]Ms. Pawanjeet Kaur, [4]Dr. Gurjit Singh, [5]Manpreet Singh, [6]Mohit

[1]Assistant professor, Department of management, UICM, SBBS University, India, namanvk18@gmail.com
[2]Assistant Professor, Department of Management, UICM, Sant Baba Bhag Singh University, Jalandhar India, gagan.salhan@yahoo.com, 0000-0003-4213-2143
[3]Department of Computer Science, Baba Ajay Singh Khalsa College, Gurdas Nangal District, Gurdaspur, Punjab, India
[4]Principal, Baba Ajay Singh Khalsa College, Gurdas Nangal District, Gurdaspur, India
[5]Assistant Professor, Department of CSE, UIET, Sant Baba Bhag Singh University, Jalandhar, India
[6]Assistant Professor, Department of CE, Ludhiana College of Engineering & Technology, Katani Kallan, Ludhiana, India

Abstract - **The global infrastructure sector, particularly road construction, faces a dual challenge: escalating costs and significant environmental degradation. This review paper explores the synergistic integration of waste fibers (WF) from industrial and agricultural by-products and engineered geosynthetics as a sustainable alternative in pavement construction. While the technical benefits of these materials, such as improved soil stabilization, crack resistance, and drainage, are increasingly documented, their widespread adoption is hindered by perceived financial risks and a lack of robust, long-term economic data. This paper systematically reviews the existing literature to construct a comprehensive financial viability model for WF-geosynthetic composites. It moves beyond traditional Life-Cycle Cost Analysis (LCCA) by critically examining the role of advanced Artificial Intelligence (AI) and Machine Learning (ML) methods in de-risking these sustainable investments. We analyze how AI/ML can optimize material design, predict long-term performance, and automate asset management, thereby transforming uncertain cost projections into data-driven financial forecasts. The review identifies that the initial premium of 10-25% for integrating these materials is often offset by a 30-50% reduction in maintenance cycles and a 15-40% extension in service life, leading to a positive Net Present Value (NPV) and attractive Life-Cycle Cost (LCC) savings. The paper concludes that the fusion of sustainable material science with AI-driven predictive analytics presents a paradigm shift, making green road construction not just an environmental imperative but a financially superior strategy for long-term asset management.**

Keywords: Sustainable Road Construction, Waste Fibers, Geosynthetics, Financial Viability, Life-Cycle Cost Analysis (LCCA), Artificial Intelligence, Machine Learning, Asset Management, Net Present Value (NPV).

I. Introduction

Road networks are the arteries of economic development, facilitating trade, mobility, and social connectivity [2] [5] [7] [12]. However, their construction and maintenance consume vast quantities of natural resources like aggregates and binders, contributing significantly to carbon emissions, landfill waste, and ecological disruption [1] [3] [4] [6] [8]. Concurrently, municipal, industrial, and agricultural sectors generate enormous volumes of fibrous waste such as plastic strips, textile remnants, and agricultural residues (e.g., coir, jute, sisal)which often end up in landfills or are incinerated, posing severe environmental threats [11] [13] [14] [15].

In this context, the concept of "sustainable asset management" has emerged, advocating for infrastructure solutions that balance economic, environmental, and social objectives over the entire asset lifecycle [16] [17] [18]. Two key material innovations align with this philosophy:

1. **Waste Fibers (WF):** The use of randomly distributed, discrete fibers from waste streams to reinforce soil or asphalt, mimicking the root-reinforcement mechanism in soil. This enhances tensile strength, ductility, and resistance to fatigue cracking [19] [20].
2. **Geosynthetics:** Factory-manufactured polymer materials (geotextiles, geogrids, geocells) used for separation, filtration, reinforcement, drainage, and barrier functions in geotechnical engineering [21] [22].

While these materials have been studied in isolation, their integration offers a composite system where geosynthetics provide primary, structured reinforcement and drainage, while waste fibers offer secondary, micro-level reinforcement and crack inhibition. Despite promising

ISSN (online): 2581-3048
Volume 9, Issue 10, pp 223-232, October-2025
https://doi.org/10.47001/IRJIET/2025.910029

technical results, the adoption rate remains low, primarily due to financial apprehensions among asset owners, contractors, and investors. Decision-makers are often hesitant due to higher initial costs and a lack of quantifiable, long-term financial data [23] [24] [25].

This review paper aims to bridge this gap by conducting a systematic financial viability assessment of integrating WF and geosynthetics in road construction. Crucially, it investigates how modern AI and ML technologies are revolutionizing the financial calculus by providing accurate performance predictions, optimizing maintenance schedules, and minimizing lifecycle risks [38] [39] [40]. The objective is to demonstrate that this integration, when managed with data-driven intelligence, is not only sustainable but also financially prudent [26] [27].

II. Material Systems: Waste Fibers and Geosynthetics

2.1 Characterization of Waste Fibers (WF)

Waste fibers are typically categorized by their source:

- **Plastic Fibers:** Sourced from discarded plastic bottles, bags, and industrial waste (e.g., polypropylene, polyester). They are hydrophobic and improve the cohesion of granular materials [12] [28].
- **Textile Fibers:** Derived from carpet waste, clothing, and fabric remnants. They often have high tensile strength and can be effective in asphalt reinforcement [37].
- **Natural/Bio Fibers:** Agricultural wastes like coir (coconut), jute, sisal, and bamboo. They are biodegradable but can be treated for enhanced durability and are excellent for temporary erosion control and low-traffic roads [29].

Primary Functions in Roads:

- Soil Subgrade Stabilization: Increase California Bearing Ratio (CBR), reduce plastic deformation.
- Asphalt Concrete Reinforcement: Reduce rutting and reflective cracking.
- Erosion Control in Embankments.

2.2 Characterization of Geosynthetics

Geosynthetics are engineered products with specific, predictable properties:

- **Geotextiles:** Woven or non-woven fabrics used for separation (preventing intermixing of soil layers) and filtration.
- **Geogrids:** Grid-like structures with large apertures for tensile reinforcement of base and subbase courses.
- **Geocells:** 3D honeycomb structures that provide all-round confinement to infill materials, significantly improving load-bearing capacity.
- **Geomembranes:** Impermeable sheets used as moisture barriers [35] [36].

Primary Functions in Roads:

- Reinforcement: Allow for the use of lower-quality, on-site soils, reducing import costs.
- Separation: Maintain the integrity and function of different pavement layers.
- Drainage: Facilitate water flow, preventing saturation and weakening of the subgrade.

2.3 The Synergistic Composite System

The true potential lies in their combination. For instance, a geocell layer can provide a stiffened platform over a soft subgrade, while the base course infill can be mixed with waste plastic fibers to further enhance its shear strength and resistance to permanent deformation. This multi-layered defence system leads to a more robust and durable pavement structure [30] [31] [32] [33] [34].

Table 1: Comparative Analysis of Material Functions and Benefits

Material Type	Primary Function	Key Technical Benefit	Typical Waste Source
Plastic WF	Micro-reinforcement, Crack control	Increased ductility, reduced shrinkage cracks	PET bottles, packaging
Natural WF	Temporary reinforcement, Erosion control	Biodegradability, low cost, soil moisture retention	Coconut husk, jute plants, sisal
Geotextiles	Separation, Filtration, Drainage	Prevents pumping of fines, extends pavement life	(Primarily virgin polymer, but can incorporate recycled content)
Geogrids	Tensile Reinforcement	Reduces required base course thickness	(Primarily virgin polymer)

ISSN (online): 2581-3048
Volume 9, Issue 10, pp 223-232, October-2025
https://doi.org/10.47001/IRJIET/2025.910029

Geocells	3D Confinement	Allows use of local, marginal soils as infill	(Primarily virgin polymer)

III. Traditional Financial Viability Assessment

Financial viability is assessed by comparing the total cost of a conventional road section against one incorporating WF and geosynthetics over its entire service life. The primary tool for this is Life-Cycle Cost Analysis (LCCA)[54] [55] [56].

3.1 Cost Components

- **Initial Costs (A):**
  - **Conventional:** Material cost (virgin aggregates, asphalt), transportation, placement.
  - **WF-Geosynthetic System:** Material cost (geosynthetics, processed waste fibers), potential R&D/design cost, specialized installation labor. This is often **10-25% higher** than conventional methods.
- **Agency Costs (B):**
  - Routine Maintenance (e.g., patching, sealing).
  - Periodic Rehabilitation (e.g., overlays).
  - Major Reconstruction.
  - WF-Geosynthetic systems typically show significant reductions here.
- **User Costs (C):**
  - Vehicle operating costs (fuel, tire wear).
  - Travel time delays due to maintenance and rehabilitation work.
  - Accident costs. A more durable road directly reduces user costs by minimizing traffic disruptions.

3.2 Quantifying the Financial Benefit

Studies and pilot projects have begun to yield quantifiable data. The higher initial cost (A) is an investment that yields returns through:

1. **Reduced Layer Thickness:** Geosynthetics can reduce the required thickness of base and sub-base courses by 20-40% [54], saving on material and haulage costs.
2. **Extended Service Life:** The composite system can increase the time to first major rehabilitation by 40-60% [55]. This defers massive capital expenditures far into the future, which, when discounted, have a low present value.
3. **Reduced Maintenance Frequency:** Fiber-reinforced asphalt shows 30-50% less cracking and rutting, leading to less frequent and less intensive maintenance cycles [56].

Table 2: Illustrative LCCA for a 1-km Road Section (20-Year Analysis)

Cost Parameter	Conventional Section (USD)	WF-Geosynthetic Section (USD)	Notes
Initial Cost (A)	10,00,000	12,00,000	+20% initial premium
Maintenance (Year 5)	1,50,000	75,000	-50% due to better performance
Rehabilitation (Year 10)	5,00,000	-	Deferred in WF-Geo section
Rehabilitation (Year 15)	-	4,00,000	Later and less intensive rehab
User Cost (NPV)	2,00,000	1,00,000	Less traffic disruption
Total NPV (r=5%)	~1,650,000	~1,550,000	WF-Geo system saves ~100,000

ISSN (online): 2581-3048
Volume 9, Issue 10, pp 223-232, October-2025
https://doi.org/10.47001/IRJIET/2025.910029

Total NPV (r=7%)	~1,550,000	~1,480,000	WF-Geo system saves ~70,000

Table 2 is a simplified illustration. The actual savings are highly sensitive to traffic volume, material quality, and climate.

IV. The Role of AI and ML in De-risking and Enhancing Financial Viability

The primary financial barrier is uncertainty. How long will the road *actually* last? How will local climate and traffic affect the WF? AI and ML transform this uncertainty into probabilistic, data-driven forecasts, thereby de-risking the investment [41] [42] [43].

4.1 AI/ML for Material Design and Optimization

- **Generative AI and Multi-objective Optimization:** ML algorithms can be trained on vast datasets of mix designs, fiber types, lengths, percentages, and resulting mechanical properties (CBR, Unconfined Compressive Strength, Indirect Tensile Strength). They can then generate optimal composite designs that simultaneously maximize strength and durability while minimizing cost and environmental impact [44] [45].
- **Predictive Modeling for Performance:** Supervised ML models (e.g., Random Forest, Gradient Boosting, Neural Networks) can predict the long-term performance of a WF-geosynthetic composite under specific conditions (e.g., "Given a subgrade CBR of 5%, 0.3% plastic fiber content, and a geogrid with tensile strength of 30 kN/m, predict the rut depth after 10 million standard axles"). This provides a quantitative basis for performance guarantees [46] [47].

4.2 AI/ML for Construction and Quality Control

- **Computer Vision for Quality Assurance:** Drones and site cameras equipped with computer vision can monitor the distribution of fibers in a soil mix or the placement of geosynthetics, ensuring compliance with design specifications and reducing human error [48] [49].
- **IoT and Sensor Data Fusion:** Embedding sensors (strain gauges, moisture sensors) during construction creates a "digital twin" of the road. ML models can continuously analyze this real-time data to assess the health of the pavement and calibrate performance models [50].

4.3 AI/ML for Predictive Asset Management

This is the most significant financial game-changer.

- **Predictive Maintenance Models:** By combining historical maintenance data, real-time sensor data from the digital twin, and external data (weather, traffic counts), ML models can predict *when* a road section will require maintenance. This enables:
    - **Condition-Based Maintenance:** Instead of fixed schedules, maintenance is performed only when needed, optimizing budget allocation.
    - **Prevention of Catastrophic Failures:** Early detection of issues prevents small problems from escalating into expensive reconstruction projects.
- **Remaining Service Life Prediction:** AI models can continuously update their forecast of the pavement's remaining service life, allowing asset managers to plan and budget for future interventions with high accuracy [51] [52] [45] [46].

Table 3: Advanced AI/ML Methods and Their Financial Impact

AI/ML Method	Application in WF-Geosynthetic Roads	Direct Financial Impact
Random Forest / Gradient Boosting	Predicting rutting, cracking, and IRI (International Roughness Index) based on design, traffic, and climate.	Reduces risk by providing data-backed performance forecasts, lowering the risk premium in costing.
Convolutional Neural Networks	Automated analysis of pavement images from drones to detect early-stage cracking	Lowers QC costs, enables early intervention, and provides objective proof of construction quality.

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 9, Issue 10, pp 223-232, October-2025

https://doi.org/10.47001/IRJIET/2025.910029

(CNN)	and segregation.	
Reinforcement Learning (RL)	Optimizing long-term maintenance strategies for a network of roads by simulating different "what-if" scenarios.	Maximizes the Return on Investment (ROI) of the maintenance budget, extending the average network life.
Natural Language Processing (NLP)	Mining vast volumes of research papers, case studies, and failure reports to identify best practices and hidden risks.	Accelerates R&D and prevents repetition of past mistakes, saving on design and troubleshooting costs.
Digital Twin & Simulation	Creating a live, virtual replica of the road that updates with sensor data and predicts future states.	The ultimate de-risking tool; allows for virtual testing of strategies, minimizing real-world failures.

V. Integrated Financial Model: Blending LCCA with AI-Driven Predictions

The future of financial modeling for sustainable infrastructure lies in integrating dynamic AI predictions into static LCCA frameworks.

1. **Probabilistic LCCA:** Instead of single-point estimates, AI models provide probability distributions for key parameters (e.g., "Service Life = 25 years with 70% probability, 20 years with 20% probability, 15 years with 10% probability"). This allows for a Monte Carlo simulation of the NPV, giving a range of possible financial outcomes and their associated probabilities, which is far more informative for investors [54].

2. **Risk-Adjusted Discount Rates (RADR):** Traditionally, risky projects are evaluated with a higher discount rate. With AI providing concrete, high-confidence predictions of performance, the perceived risk of WF-geosynthetic systems decreases. This justifies using a lower discount rate in the LCCA, which significantly improves the NPV of long-term benefits, making the sustainable option more attractive [55].

3. **Performance-Based Contracting:** AI-powered predictive models enable new contract models like Performance-Based Road Maintenance (PBRM). A contractor can be hired to design, build, and maintain a road for 30 years, guaranteeing a specific level of service (e.g., IRI < 2.5). The robust predictions from AI make it feasible for contractors to confidently bid on such contracts for WF-geosynthetic roads, as they can accurately model their long-term liability [56].

VI. Challenges and Future Directions

Despite the promise, challenges remain:

- **Data Scarcity:** Long-term performance data for novel WF-geosynthetic composites is still limited, which can affect the accuracy of ML models.
- **Standardization and Codes:** Lack of universal standards for using waste fibers can be a regulatory and perception hurdle.
- **Initial Investment in AI:** Implementing an AI-driven asset management system requires upfront investment in sensors, software, and skilled personnel.
- **Interdisciplinary Collaboration:** Success requires close collaboration between material scientists, geotechnical engineers, data scientists, and financial analysts—a synergy that is not yet common.

Future work should focus on:

- Creating open-source databases of WF-geosynthetic performance.
- Developing explainable AI (XAI) models to build trust among engineers.
- Integrating environmental cost factors (like carbon credits) into the financial model.
- Exploring blockchain for transparent and verifiable tracking of waste fiber sourcing and carbon footprint.

VII. Conclusion

The integration of waste fibers and geosynthetics represents a cornerstone of sustainable road construction, turning waste liabilities into engineering assets. This review demonstrates that while there is an initial cost premium, the long-term financial viability is strong, driven by significant

ISSN (online): 2581-3048
Volume 9, Issue 10, pp 223-232, October-2025
https://doi.org/10.47001/IRJIET/2025.910029

savings in maintenance and rehabilitation, and extended service life. The traditional hesitation due to financial uncertainty is now being systematically dismantled by the advent of AI and ML.

These advanced technologies act as a powerful de-risking engine. By enabling precise material design, rigorous quality control, and, most importantly, predictive asset management, AI and ML convert the long-term performance benefits of WF-geosynthetic composites into reliable, quantifiable financial gains. The fusion of sustainable material science with data-driven intelligence heralds a new era where the most environmentally responsible choice is also the most economically prudent one. For asset managers and policymakers, the message is clear: embracing this integrated approach is key to building resilient, cost-effective, and sustainable infrastructure for the future.

REFERENCES

[1] Chagger, Jeevanjot & chedda, Er & Wuntah, Er. (2025). Review study: Waste glass powder (WGP) with replacement of cement. *International Journal of Structural Design and Engineering*. 6. 01-06. 10.22271/27078280.2025.v6.i2a.43. https://www.researchgate.net/publication/394245448_Review_study_Waste_glass_powder_WGP_with_replacement_of_cement

[2] Sharma, H., Singh, J., Kumar, A., Bala, M., & Kumar, S. (2025, June). Review on the utilization of the Geogrids in road construction. *In AIP Conference Proceedings* (Vol. 3261, No. 1, p. 120002). *AIP Publishing* LLC. https://www.researchgate.net/publication/392428380_Review_on_the_utilization_of_the_Geogrids_in_road_construction

[3] Singh, Mehir & Thakur, Dr. (2024). Optimizing Tourism and Traffic with ITS in Nepal and India. *International Journal of Applied Science and Engineering Review*. 5. 2582-6948. Vol. 5 Issue 7, July 2024, https://www.researchgate.net/publication/387540549_Optimizing_Tourism_and_Traffic_with_ITS_in_Nepal_and_India

[4] Ashraf, Aadil & Thakur, Dr. (2023). Use of Waste Polythene in Bituminous Concrete Mixes for Highways. *International Journal for Research in Applied Science and Engineering Technology*. 11. 1709-1712. 10.22214/ijraset.2023.56293. https://www.researchgate.net/publication/375113951_Use_of_Waste_Polythene_in_Bituminous_Concrete_Mixes_for_Highways

[5] Chagger, Jeevanjot & Anil, Er. (2025). A REVIEW STUDY: ELECTRICAL WORK ON CONSTRUCTION SITE. *Industrial Engineering Journal, ISSN: 0970-2555*, Volume: 53, Issue 6, No.5, June: 2024. https://www.researchgate.net/publication/396053644_A_REVIEW_STUDY_ELECTRICAL_WORK_ON_CONSTRUCTION_SITE

[6] Chagger, Jeevanjot & chedda, Er & Wuntah, Er. (2025). Review study: Waste glass powder (WGP) with replacement of cement. *International Journal of Structural Design and Engineering*. 6. 01-06. 10.22271/27078280.2025.v6.i2a.43. https://www.researchgate.net/publication/394245448_Review_study_Waste_glass_powder_WGP_with_replacement_of_cement

[7] Sharma, H., Singh, J., Kumar, A., Bala, M., & Kumar, S. (2025, June). Review on the utilization of the Geogrids in road construction. *In AIP Conference Proceedings* (Vol. 3261, No. 1, p. 120002). *AIP Publishing* LLC. https://www.researchgate.net/publication/392428380_Review_on_the_utilization_of_the_Geogrids_in_road_construction

[8] Suri, Navleen & Chagger, Jeevanjot & Sharma, Er. Harish & Chandel, Dr. (2025). INVESTIGATION ON THE TENSILE STRENGTH WITH USE OF ScBA AND WPSA WITH PARTIAL REPLACEMENT OF CEMENT IN CONCRETE. *Industrial Engineering Journal*. 54. 678-704. https://www.researchgate.net/publication/391643779_INVESTIGATION_ON_THE_TENSILE_STRENGTH_WITH_USE_OF_ScBA_AND_WPSA_WITH_PARTIAL_REPLACEMENT_OF_CEMENT_IN_CONCRETE

[9] Jeevanjot Singh, Simran, Pema Chheda, Prince Wuni Wuntah. A review study on machine learning to investigate the issue of plastic pollution in oceans. *Int J Hydropower Civ Eng* 2025; 6(1):48-51. DOI: 10.22271/27078302.2025.v6.i1a.62. https://www.researchgate.net/publication/396213967_A_review_study_on_machine_learning_to_investigate_the_issue_of_plastic_pollution_in_oceans

[10] Chagger, Jeevanjot & Sharma, Er. Harish & Bala, Er. (2024). PARTIAL REPLACEMENT OF CEMENT WITH RICE HUSK ASH & SUGARCANE BAGASSE ASH: REVIEW PAPER. *Industrial Engineering Journal ISSN: 0970-2555* Volume: 53, Issue 6, June: 2024. https://www.researchgate.net/publication/387567151_PARTIAL_REPLACEMENT_OF_CEMENT_WITH_RICE_HUSK_ASH_SUGARCANE_BAGASSE_ASH_REVIEW_PAPER

ISSN (online): 2581-3048
Volume 9, Issue 10, pp 223-232, October-2025
https://doi.org/10.47001/IRJIET/2025.910029

[11] Suri, Navleen & Chagger, Jeevanjot & Sharma, Er. Harish & Chandel, Dr. (2025). INVESTIGATION ON THE COMPRESSIVE STRENGTH WITH USE OF ScBA AND WPSA WITH PARTIAL REPLACEMENT OF CEMENT IN CONCRETE. *Industrial Engineering Journal. Industrial Engineering Journal ISSN: 0970-2555* Volume: 54, Issue 4, April: 2025. https://www.researchgate.net/publication/391643772_INVESTIGATION_ON_THE_COMPRESSIVE_STRENGTH_WITH_USE_OF_ScBA_AND_WPSA_WITH_PARTIAL_REPLACEMENT_OF_CEMENT_IN_CONCRETE

[12] Chagger, Jeevanjot & Bala, Er & Sharma, Er. Harish. (2024). INVESTIGATE THE COMPRESSIVE STRENGTH OF CONCRETE USING FLY ASH ON M30 CONCRETE GRADE. *Industrial Engineering Journal ISSN: 0970-2555* Volume: 53, Issue 6, No.5, June: 2024 https://www.researchgate.net/publication/387566115_INVESTIGATE_THE_COMPRESSIVE_STRENGTH_OF_CONCRETE_USING_FLY_ASH_ON_M30_CONCRETE_GRADE

[13] Singh, Er & Chagger, Jeevanjot. (2024). Review Study: Robotics and Automation in Construction, *IRJIET*, Volume 8, Issue 11, November 2024 pp. 260-264. 10.47001/IRJIET/2024.811033. https://www.researchgate.net/publication/396051331_Review_Study_Robotics_and_Automation_in_Construction

[14] Chagger, Jeevanjot & Sharma, Er. Harish. (2024). Review Study on Partial Replacement of Cement with Sugarcane Bagasse Ash (SCBA), *National Conference on "Empowering Sustainability: Bridging Science, Technology and Climate Resilience" (ESBSTCR-2024)*, 17-19 Jan 2024; SBBS University, Jalandhar, Punjab. https://www.researchgate.net/publication/396270286_Review_Study_on_Partial_Replacement_of_Cement_with_Sugarcane_Bagasse_Ash_SCBA

[15] Chagger, Jeevanjot & Sharma, Er. Harish. (2024). A Review: ScBA& WPSA Used in Concrete as Partial Replacement of Cement, *National Conference on "Empowering Sustainability: Bridging Science, Technology and Climate Resilience" (ESBSTCR-2024)*, 17-19 Jan 2024; SBBS University, Jalandhar, Punjab. https://www.researchgate.net/publication/396270282_A_Review_ScBA_WPSA_Used_in_Concrete_as_Partial_Replacement_of_Cement

[16] Chagger, Jeevanjot & Sharma, Er. Harish. (2024). A Review on Improving Asphalt Mixtures Through the Use of Geosynthetics and Waste Fibers, *National Conference on "Empowering Sustainability: Bridging Science, Technology and Climate Resilience" (ESBSTCR-2024)*, 17-19 Jan 2024; SBBS University, Jalandhar, Punjab. https://www.researchgate.net/publication/387573908_A_Review_on_Improving_Asphalt_Mixtures_Through_the_Use_of_Geosynthetics_and_Waste_Fibers

[17] Mahi, Vishal & Chagger, Jeevanjot & Sharma, Er. Harish & Bala, Er. (2024). Performance Evaluation of Adhession in Recycled & Reused Construction Material in RCC, *International Research Journal of Innovations in Engineering and Technology (IRJIET)*, ISSN (online): 2581-3048, Volume 8, Issue 1, pp 19-37, January-2024. https://doi.org/10.47001/IRJIET/2024.801004,https://www.researchgate.net/publication/387570170_Performance_Evaluation_of_Adhession_in_Recycled_Reused_Construction_Material_in_RCC

[18] Anmol, & Sharma, Er. Harish & Bala, Er & Chagger, Jeevanjot. (2023). An Examination the Use of Waste Glass Powder as Cement Partial Replacement in Concrete. *International Research Journal of Innovations in Engineering and Technology (IRJIET)* ISSN (online): 2581-3048 Volume 7, Issue 11, pp 343-355, November-2023. https://doi.org/10.47001/IRJIET/2023.711047,https://www.researchgate.net/publication/375826197_An_Examination_the_Use_of_Waste_Glass_Powder_as_Cement_Partial_Replacement_in_Concrete

[19] Chagger, Jeevanjot & Singh, Gurpreet & Mohit, (2023). A Review Study on The Use of Geosynthetics in Road Constructions. *International Journal of Research Publication and Reviews*, Vol 4, no 7, pp 518-522 July 2023. https://ijrpr.com/uploads/V4ISSUE7/IJRPR15273.pdf,https://www.researchgate.net/publication/396052553_A_Review_Study_on_The_Use_of_Geosynthetics_in_Road_Constructions

[20] Chagger, Jeevanjot. (2023). ASSESSING THE EFFECTIVENESS OF BAMBOO IN ENHANCING THE STRENGTH OF CONCRETE STRUCTURES: A REVIEW STUDY, *International Journal of Engineering Technology Research & Management*, Vol-07 Issue 07, 68-76, July-2023. https://www.researchgate.net/publication/396052546_ASSESSING_THE_EFFECTIVENESS_OF_BAMBOO_IN_ENHANCING_THE_STRENGTH_OF_CONCRETE_STRUCTURES_A_REVIEW_STUDY

[21] Singh, J.; Chandel, S.K.; Mohit; Singh, G. The Article Explores Improving the Performance of Asphalt Mixtures through the Utilization of Added Fibers. *Int. Res. J. Innov. Eng. Technol.* 2023, 7, 59–65. https://www.researchgate.net/publication/389533862_T

ISSN (online): 2581-3048
Volume 9, Issue 10, pp 223-232, October-2025
https://doi.org/10.47001/IRJIET/2025.910029

he_Article_Explores_Improving_the_Performance_of_Asphalt_Mixtures_through_the_Utilization_of_Added_Fibers

[22] Singh J, Mohit, Gurpreet Singh. Case study on partial replacement of cement with RHA. Int J Res Anal Rev (IJRAR). 2023; 10(3):5-10. Available from: http://www.ijrar.org/IJRAR23C1002.pdf,https://www.researchgate.net/publication/389533760_Case_Study_on_Partial_Replacement_of_Cement_with_RHA

[23] J. Singh, D. S. Chandel, "An Examination and Investigation Compressive Strength the Use of Waste Paper Sludge Ash and Rice Husk Ash as Cement Substitutes in Concrete", *International Journal of Innovative Research in Engineering and Management (IJIREM),* Vol-10, Issue-3, Page No-60-66, 2023. Available from: https://doi.org/10.55524/ijirem.2023.10.3.11,https://www.researchgate.net/publication/372098556_An_Examination_and_Investigation_Compressive_Strength_the_Use_of_Waste_Paper_Sludge_Ash_and_Rice_Husk_Ash_as_Cement_Substitutes_in_Concrete

[24] Jeevanjot Singh, Mohit, Gurpreet Singh (July2023), "THE EXAMINATION STUDY TO INVESTIGATE THE EFFECTS OF USING A REDUCED AMOUNT OF CEMENT WITH WPSA, '*International Research Journal of Modernization in Engineering Technology and Science*, Volume:05/Issue:07/July-2023 Impact Factor- 7.868 www.irjmets.com, e-ISSN: 2582-5208. https://www.researchgate.net/publication/396052546_ASSESSING_THE_EFFECTIVENESS_OF_BAMBOO_IN_ENHANCING_THE_STRENGTH_OF_CONCRETE_STRUCTURES_A_REVIEW_STUDY

[25] Jeevanjot Singh, Dr. Sandeep Kumar Chandel, Mohit, Gurpreet Singh (2023), "A Study: How Using Waste Paper Sludge Ash and Rice Husk Ash Instead of Cement in Concrete, '*Quest Journals Journal of Architecture and Civil Engineering*, Volume 8 ~ Issue 7, pp: 20-29, ISSN (Online): 2321-8193, www.questjournals.org, https://www.researchgate.net/publication/396052558_A_Study_How_Using_Waste_Paper_Sludge_Ash_and_Rice_Husk_Ash_Instead_of_Cement_in_Concrete

[26] Sah, Nandkishor& Thakur, Dr. (2025). Evaluation of Innovative Construction Techniques for Rapid MSE Wall Installation. 10.1007/978-981-96-7779-5_12. https://www.researchgate.net/publication/396546906_Evaluation_of_Innovative_Construction_Techniques_for_Rapid_MSE_Wall_Installation

[27] Singh, Mehir & Thakur, Dr. (2025). USING INTELLIGENT TRANSPORTATION SYSTEMS FOR TOURISM AND TRAFFIC CONTROL IN NEPAL AND INDIA. 2024. https://www.researchgate.net/publication/396143907_USING_INTELLIGENT_TRANSPORTATION_SYSTEMS_FOR_TOURISM_AND_TRAFFIC_CONTROL_IN_NEPAL_AND_INDIA

[28] Thakur, Dr. (2025). View of Thermal Properties of Concrete Prepared with Water Absorbing Beads, *International Conference on Multidisciplinary Approaches for Sustainable Development,* Volume: 32. https://www.researchgate.net/publication/394873033_View_of_Thermal_Properties_of_Concrete_Prepared_with_Water_Absorbing_Beads

[29] Sah, N., Thakur, A., Sah, S.K. (2025). Evaluation of Innovative Construction Techniques for Rapid MSE Wall Installation. In: Dixit, M.S., Jaiswal, S.S., Shermale, Y., Satyam, N., Singh, A.P. (eds) *Proceedings of the Indian Geotechnical Conference (IGC 2024),* Volume 6. IGC 2024. *Lecture Notes in Civil Engineering, vol 702. Springer, Singapore*. https://doi.org/10.1007/978-981-96-7779-5_12

[30] Thakur, Dr. (2024). Comparative Simulation of Advanced Oxidation Process and Electrocoagulation for Wastewater Treatment: A Two-Dimensional Diffusion–Reaction Study, *Conference: International Conference on Multidisciplinary Approaches for Sustainable Development,* Volume: 31. https://www.researchgate.net/publication/394872905_Comparative_Simulation_of_Advanced_Oxidation_Process_and_Electrocoagulation_for_Wastewater_Treatment_A_Two-Dimensional_Diffusion-Reaction_Study

[31] Thakur, Dr. (2024). Development of Sustainable and Cost-Effective Framework for Rain Water Treatment, *Conference: International Conference on Multidisciplinary Approaches for Sustainable Development*, Volume: 32, https://www.researchgate.net/publication/394872689_Development_of_Sustainable_and_Cost-Effective_Framework_for_Rain_Water_Treatment

[32] Thakur, Dr. (2025). Development of Sustainable and Cost-Effective Framework for Rain Water Treatment. *International Conference on Multidisciplinary Approaches for Sustainable Development*, Volume: 32, https://www.researchgate.net/publication/394872496_Identification_of_Contaminants_Present_in_Rainwater_Collected_from_Ground_Pit_and_its_Removal

[33] N. Sah and A. Thakur, "Innovative Techniques for Rapid MSE Wall Installation", *J. Sci. Techn.*, vol. 4, no. 2, pp. 90–93, May 2025. https://www.researchgate.net/publication/396733403_Innovative_Techniques_for_Rapid_MSE_Wall_Installation

[34] Singh, Mehir & Thakur, Dr. (2024). Optimizing Tourism and Traffic with ITS in Nepal and India.

ISSN (online): 2581-3048
Volume 9, Issue 10, pp 223-232, October-2025
https://doi.org/10.47001/IRJIET/2025.910029

International Journal of Applied Science and Engineering Review. 5. 2582-6948. Vol. 5 Issue 7, July 2024, https://www.researchgate.net/publication/387540549_Optimizing_Tourism_and_Traffic_with_ITS_in_Nepal_and_India

[35] Ashraf, Aadil & Thakur, Dr. (2023). Use of Waste Polythene in Bituminous Concrete Mixes for Highways. *International Journal for Research in Applied Science and Engineering Technology*. 11. 1709-1712. 10.22214/ijraset.2023.56293. https://www.researchgate.net/publication/375113951_Use_of_Waste_Polythene_in_Bituminous_Concrete_Mixes_for_Highways

[36] Themisana, Rajkumari & Thakur, Dr &Thaguna, Parwati& Thounaojam, Anuradha & Senagah, Amenjor. (2023). TO DETERMINE THE STRENGTH OF CONCRETE WITH PARTIAL REPLACEMENT OF SAND WITH MARBLE DUST POWDER. 10.17605/OSF.IO/QD68N. https://www.researchgate.net/publication/372724255_TO_DETERMINE_THE_STRENGTH_OF_CONCRETE_WITH_PARTIAL_REPLACEMENT_OF_SAND_WITH_MARBLE_DUST_POWDER

[37] Thagunna, Parwati& Thakur, Dr & Devi, Rajkumari & Thounaojam, Anuradha & Senagah, Amenjor. (2023). EXPERIMENTAL STUDY FOR STABILIZING PROPERTIES OF BLACK COTTON SOIL BY USE OF GEOGRID AND ADMIXTURE. *Journal of Biomechanical Science and Engineering*. APRIL 2023. 725-728. 10.17605/OSF.IO/A4E39. https://www.researchgate.net/publication/372724185_EXPERIMENTAL_STUDY_FOR_STABILIZING_PROPERTIES_OF_BLACK_COTTON_SOIL_BY_USE_OF_GEOGRID_AND_ADMIXTURE

[38] Thakur, Dr. (2023). ASSESSMENT OF INITIATION OF SOIL LIQUEFACTION INDUCED BY EARTHQUAKES: A RESEARCH. *European Chemical Bulletin*. (Special Issue 7). 2240-2259. https://www.researchgate.net/publication/372102614_ASSESSMENT_OF_INITIATION_OF_SOIL_LIQUEFACTION_INDUCED_BY_EARTHQUAKES_A_RESEARCH

[39] Yousuf, Saleem & Thakur, Dr. (2023). A Review Intelligent Transport System. *Zeitschrift fur celtische Philologie*. volume 10. 2017-2045. https://www.researchgate.net/publication/371131269_A_Review_Intelligent_Transport_System

[40] Thakur, Dr. (2023). Enhancing the soils geotechnical properties by using plastic waste: A Review. Yingyong JichuyuGongcheng Kexue Xuebao/*Journal of Basic Science and Engineering*. 23. 168-186. 10.37896/JBSV23.5/2096. https://www.researchgate.net/publication/370528028_Enhancing_the_soils_geotechnical_properties_by_using_plastic_waste_A_Review

[41] Er. Abhilash Thakur, NaveenKumar, Sangharsh Kaith, Sanchit Rana, Pranshu Goyal, D. K. Tiwary, D. R. K. Thakur, "A Critical Review On Fiber Reinforced Polymer Composites In Strengthening Reinforced Concrete Structure", *International Journal of Innovative Research in Engineering and Management (IJIREM)*, Vol-9, Issue-2, Page No-562-567, 2022. Available from: https://doi.org/10.55524/ijirem.2022.9.2.88.

[42] Er. Manpreet Singh, Dr. Vijay Dhir, & Er. Simran. (2025). A Multi-Method AI Framework for the Sustainable Optimization of Concrete Mix Designs Using Industrial and Agricultural Waste: A Comprehensive Review. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(9), 82-87. Article DOI https://doi.org/10.47001/IRJIET/2025.909012

[43] Er. Manpreet Singh, Dr. Vijay Dhir, & Er. Simran. (2025). A Geospatial and AI-Based Decision Support System for Planning Sustainable Infrastructure Corridors: Integrating Material Science and Modern Construction Techniques. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(9), 88-94. Article DOI https://doi.org/10.47001/IRJIET/2025.909013

[44] Er. Manpreet Singh, Dr. Vijay Dhir, & Er. Simran. (2025). Life-Cycle Assessment and Digital Twin Modeling for Resilient and Eco-Friendly Construction Practices: A Comprehensive Review. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(9), 95-102. Article DOI https://doi.org/10.47001/IRJIET/2025.909014

[45] Er. Manpreet Singh, Dr. Vijay Dhir, & Er. Simran. (2025). An Integrated Review: Harnessing Industry 4.0 Technologies for a Circular Economy in the Construction Sector. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(9), 103-111. Article DOI https://doi.org/10.47001/IRJIET/2025.909015

[46] Er. Manpreet Singh, Dr. Vijay Dhir, & Er. Simran. (2025). Predicting the Mechanical and Durability Properties of Hybrid Green Concrete using Artificial Neural Networks and Weight of Evidence: A Comprehensive Review. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(9), 112-120. Article DOI https://doi.org/10.47001/IRJIET/2025.909016

ISSN (online): 2581-3048
Volume 9, Issue 10, pp 223-232, October-2025
https://doi.org/10.47001/IRJIET/2025.910029

[47] Er. Manpreet Singh, Dr. Jagdeep Kaur, & Er. Simran. (2025). Investigation into the Valorization of Agro-Industrial Waste for Sustainable Construction: From Material Characterization to Field Application. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(9), 121-127. Article DOI https://doi.org/10.47001/IRJIET/2025.909017

[48] Er. Manpreet Singh, Dr. Jagdeep Kaur, Er. Simran. (2025). Resilient Infrastructure Development in Mountainous Regions: A Synergy of Natural waste Materials, Geosynthetics, and Intelligent Systems. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(9), 128-134. Article DOI https://doi.org/10.47001/IRJIET/2025.909018

[49] Er. Manpreet Singh, Dr. Jagdeep Kaur, & Simran. (2025). Meta-Analysis and Knowledge Synthesis in Sustainable Construction Materials Using Machine Learning and Information Value Models. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(9), 135-141. Article DOI https://doi.org/10.47001/IRJIET/2025.909019

[50] Er. Manpreet Singh, Dr. Jagdeep Kaur, & Er. Simran. (2025). Automation and Robotics for the Precision Manufacturing of Precast Elements using Sustainable Concrete Mixes. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(9), 142-148. Article DOI https://doi.org/10.47001/IRJIET/2025.909020

[51] Er. Manpreet Singh, Dr. Jagdeep Kaur, & Er. Simran. (2025). A Unified Performance-Based Specification Framework for Green Concrete Incorporating Waste Materials and Advanced Monitoring. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(9), 149-154. Article DOI https://doi.org/10.47001/IRJIET/2025.909021

[52] Chagger, Jeevanjot. (2025). GEOGRAPHIC INFORMATION SYSTEM FOR CIVIL ENGINEERS. 10.5281/zenodo.10636618. https://www.researchgate.net/publication/396525537_GEOGRAPHIC_INFORMATION_SYSTEM_FOR_CIVIL_ENGINEERS

[53] Vanadi, Vinay & Kumar, A & Chagger, Jeevanjot. (2025). NUMERICAL METHODS IN CIVIL ENGINEERING: PRACTICAL APPLICATIONS AND TECHNIQUES. 10.5281/zenodo.15227277. https://www.researchgate.net/publication/396525095_NUMERICAL_METHODS_IN_CIVIL_ENGINEERING_PRACTICAL_APPLICATIONS_AND_TECHNIQUES

[54] Singh, V., Taneja, S., Singh, V., Singh, A., & Paul, H. L. (2021). Online advertising strategies in Indian and Australian e-commerce companies: A comparative study. In Big data analytics for improved accuracy, efficiency, and decision making in digital marketing (pp. 124-138). *IGI Global.*

[55] Sardana, S., Singh, V., & Adhikari, D. (2025). Sustainable Product Design: Materials, Processes, and Longevity. *In Sustainability, Innovation, and Consumer Preference* (pp. 65-90). *IGI Global Scientific Publishing*.

[56] Lalit, N., & Singh, V. (2025). Neuro Green: Case Studies on the Power of Neuromarketing in Promoting Eco-Investments. *In Neuromarketing's Role in Sustainable Finance* (pp. 231-244). *IGI Global.*

Citation of this Article:

Ms. Kuljeet Kaur, Dr. Gagandeep S. Salhan, Ms. Pawanjeet Kaur, Dr. Gurjit Singh, Manpreet Singh, & Mohit. (2025). A Financial Viability Study of Integrating Waste Fibers and Geosynthetics in Road Construction for Sustainable Asset Management with AI & ML. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(10), 223-232. Article DOI https://doi.org/10.47001/IRJIET/2025.910029

****