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From the Desk of Hon'ble Vice Chancellor

MESSAGE

Dear Members of the Academic Community,

It is my pleasure to introduce Volume 6 - Issue 2 of the Multidisciplinary International Research Journal. This issue continues the journal's mission to serve as a credible and inclusive platform for the dissemination of high-quality, original research that advances knowledge across diverse academic and professional domains.

In today's rapidly evolving research landscape, the boundaries between disciplines are increasingly blurred. Meaningful innovation now emerges at the intersection of fields rather than within isolated domains. Recognizing this shift, the journal actively encourages scholarly contributions that integrate perspectives from management, engineering, pharmacy, applied sciences, architecture, and emerging technological domains, reflecting the interconnected nature of contemporary research and innovation.

The manuscripts featured in this issue exemplify this interdisciplinary spirit through their engagement with real-world challenges, technological advancement, sustainability, analytical rigor, and applied problem-solving. Collectively, they demonstrate how multidisciplinary inquiry can generate impactful insights with relevance to academia, industry, and society at large.

As Editor-in-Chief, I reaffirm the journal's commitment to academic excellence, intellectual integrity, and global scholarly relevance. We aim to continually strengthen the journal's standing as a trusted forum for researchers, academicians, professionals, and policymakers seeking to contribute to and engage with meaningful research outcomes.

I extend my sincere appreciation to all authors whose contributions have enriched this issue. I also acknowledge the dedication of the Editorial Board Members, whose academic expertise and guidance play a crucial role in shaping the journal's vision and standards.

Warm Regards

Dr. Rajul k. Gajjar
Hon'ble Vice Chancellor,
Gujarat Technological University, Ahmedabad

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Multidisciplinary International Research Journal

EXPLORING SECTORAL BEST PRACTICES FOR COQ IMPLEMENTATION IN THE JOBBING INDUSTRIAL UNIT

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Abstract

This study explores Cost of Quality (COQ) practices across eight industrial sectors—automotive, construction, forging, woodworking, textiles, rubber processing, food and beverages, and general manufacturing. A total of 25 peer-reviewed studies (2010–2024) were analyzed. Findings reveal that effective COQ implementation reduces operational inefficiencies by 12–18% and enhances profitability by up to 15%. The paper identifies critical enablers, challenges, and best practices that can guide jobbing SMEs toward strategic COQ adoption for performance improvement. Indian industries can be categorized based on various factors such as size, products, customer base, and the sectors they serve. One common method of classification is by size—namely, large, medium, and small-scale enterprises. Within the small and medium-sized enterprises (SMEs), the jobbing industry forms a distinct group that typically handles subcontracted work. While the concept of Cost of Quality (COQ) has been adopted in many sectors to minimize operational costs, its application in the jobbing industry remains limited. To promote COQ adoption in this sector, it is essential to study how other industries have successfully implemented it. This paper aims to explore COQ practices across diverse sectors such as automotive, construction, forging, woodworking, textiles, rubber processing, food and beverages, and general manufacturing. It identifies the key challenges, prerequisites, and advantages of implementing COQ. The insights gained from this review can support jobbing SMEs in formulating effective strategies for adopting COQ methodologies within their operations.

Keywords - *Cost of Quality (COQ), Jobbing Industry, SMEs, Quality Management, Implementation Strategies*

1. INTRODUCTION

Cost of Quality (COQ) is an innovative concept that enables organizations to assess how effectively resources are utilized in managing both internal and external processes related to quality control. It also helps in identifying and minimizing the costs associated with poor quality. In the context of process improvement, COQ serves as a framework for evaluating activities related to quality performance and identifying areas of inefficiency or defects. Managing the expenses associated with achieving quality standards, introducing quality improvements, and meeting performance goals is critical to enhancing overall operational effectiveness. These expenditures should be considered an integral part of operational planning and can be better understood through careful analysis of quality-related costs. This kind of analysis helps pinpoint inefficiencies, prioritize issues, uncover cost-saving opportunities, and guide project planning.

In the manufacturing sector, different production models are followed, one of which is the jobbing production system. In this system, resources are allocated to multiple tasks or jobs simultaneously, often producing a wide range of products in smaller quantities. Unlike project-based models that typically focus on a single output, jobbing systems are characterized by flexibility and variety.

This paper investigates COQ from the standpoint of reducing avoidable costs and highlights its relevance by examining past, current, and potential future applications. COQ has already been applied in diverse sectors such as automotive, construction, forging, woodworking, and manufacturing. The implementation of COQ techniques enables identification of critical cost areas that need attention for improvement. Moreover, the financial investments made during the early stages of setting up an industry must be considered, as they significantly impact long-term performance. Each industry sector faces unique challenges in system development, and COQ offers valuable insights for managers to recognize key areas needing enhancement. The classification of COQ into various categories is discussed in the following section.

Background of COQ: The concept of Cost of Quality originated in the 1950s with Armand Feigenbaum's Total Quality Control approach. Later, the PAF (Prevention, Appraisal, and Failure) model provided a structured classification of quality-related costs. Over the decades, COQ evolved as a managerial accounting tool linking financial data to process performance, becoming central to Total Quality Management (TQM) and continuous improvement systems.

1.1 Manufacturing Sector

In the manufacturing domain, the implementation of quality-related strategies often involves significant costs. However, as (Biadacz, 2020) notes, organizations have gradually integrated quality cost considerations into their strategic management accounting practices. The study highlights that understanding the role of quality in new enterprises is essential, supported by literature analysis and survey data from selected small and medium enterprises (SMEs). It suggests that technological, financial, and managerial progress has influenced the adoption of modern quality management systems, even though consistent investment in quality cost tracking is still lacking.

(Ayach, Anouar, & Bouzziri, 2019) found that while some organizations have adopted COQ systems, few maintain detailed records or use them effectively for continuous improvement. Despite awareness of its importance, COQ remains underutilized. Moreover, many quality managers tend to base their annual quality budgets on previous year's expenditures, rather than forecasting based on evolving needs. (Hamid, 2019) emphasized that quality should be aligned with customer expectations—defined as "fitness for use." Numerous studies have explored quality management practices such as Total Quality

Management (TQM) and COQ, particularly in connection with supply chain integration, risk management, social responsibility, and performance efficiency.

Notably, researchers have agreed that improving quality can initially increase production costs due to the need for system upgrades or process redesign. However, these costs help justify quality investments to leadership by clearly linking them to business outcomes. As competition intensifies, particularly in service-oriented markets, companies are increasingly compelled to prioritize quality improvement initiatives.

The research paper (Moschidis & Tsiotras, 2017) evaluated the maturity level of food and beverage (F&B) companies using Crosby's Quality Management Maturity Grid—one of the earliest frameworks for assessing quality evolution. This study was notable as the first of its kind conducted in Greece, and it aimed to provide a simple yet effective tool for measuring and comparing quality management maturity. Although much has been written about Crosby's model, the authors note that limited attention has been given to connecting it with the PAF (Prevention, Appraisal, Failure) cost model, suggesting a potential area for future research.

An expert analysis ((Mantri, 2016)) reviewed the current state of Cost of Quality (COQ) implementation in Indian manufacturing companies, using both literature and case study discussions. To establish a practical and modern framework for COQ measurement, the study began with an investigation into a rapidly growing mid-sized manufacturing firm. Although various quality management systems were in place, a formal COQ model had yet to be fully implemented. In earlier work, (Mantri, 2015) observed that COQ systems initially adopted in manufacturing have proven beneficial across a range of other sectors, including supply chains, service organizations, construction, software development, and education. However, these sectors were not the primary focus of the current research and could be explored in future studies.

This research aims to contribute to the development of a practical COQ management model that can be adapted to diverse organizations operating in the manufacturing environment. A particular emphasis is placed on jobbing industries—manufacturers who create products based on specific customer orders. Despite their importance in the sector, the adoption of COQ practices in these industries remains limited. Although existing studies highlight the benefits of COQ in other domains, its application in jobbing environments is still emerging. If successfully implemented, COQ has the potential to produce similarly positive results by identifying and minimizing non-value-added costs across operations. This underscores COQ as a valuable methodology for improving cost efficiency and quality outcomes in manufacturing.

COQ is divided into two main categories, which are further subdivided into four additional types as outlined as per Table-1:

Table. 1 Classification of COQ

Cost Category	Description	Examples
Cost of Conformance	Costs incurred to ensure that products or services meet quality standards.	Electronics Manufacturing: A company manufactures printed circuit boards (PCBs).
- Prevention Costs	Costs to prevent defects before they occur.	Training, process improvement, quality planning, supplier evaluation

- Appraisal Costs	Costs of measuring and monitoring quality to ensure standards are met.	Inspection, testing, audits
Cost of Non-Conformance	Costs that arise when products or services fail to meet quality standards.	Automobile Manufacturing: XYZ Motors produces electric scooters
- Internal Failure Costs	Costs of defects detected before the product reaches the customer.	Rework, scrap, downtime caused by defects
- External Failure Costs	Costs of defects detected after the product reaches the customer.	Warranty claims, returns, loss of customer goodwill

The following Table-2 illustrates how COQ is applied across different industrial sectors:

Table. 2 Sector wise application of COQ

Sr. No.	Sector	Application of COQ
1	Manufacturing	(Biadacz, 2020), (Ayach, Anouar, & Bouzziri, 2019), (Syaiful Rizal Hamid, 2019), (Amar Murumkar, 2019), (Odysseas Moschidis & Tsiotras, 2017), (Sanjay G. Mantri, 2016), (Sanjay G. Mantri, 2015), (Christina Dimitrantzou, 2019), (Makhanya, 2019), (Sraun & Singh, 2017), (Mantri & Jaju, 2013), (Malapelle, et al., 2017), (Heather, 2018), (Glogovac, 2017), (Czajkowski, 2017), (Armando Elizondo-Noriega & Guemes-Castorena, 2017), (Farooq, 2017), (Rodchua, 2009), (Anna Šatanová, 2014), (Anna Satanova, 2015), (Lee Hoon Tye & Ramayah, 2011), (S.N.Teli, 2017)
2	Forging	(Huang ShuHai, 2015), (Liu, Zhang, & Zhou, 2022), (Karthikeyan, Singh, Gupta, & Rao, 2023), (Rahman & Gupta, 2021)
3	Wooden	(Tahir Mumtaz Malik, 2016), (Malik, Khalid, Zulqarnain, & Iqbal, 2016), (Sedliacikova, 2015), (Cheah, Shahbudin, & Taib, 2011), (Andersch, 2013), (Quesada, 2010), (Kau, Abdullah, & Rahman, 2019), (Schiffauerova & Thomson, 2006),
4	Automobile	(Shivajee, Singh, & Rastogi, 2019), (G. F. L. Pinto, 2019), (S.N. Teli, 2018), (Teli, Majali, Bhushi, Gaikwad, & Surange, 2013), (Teli, 2010)
5	Construction	(Nokulunga Mashwama, 2017), (Aigbavboa & Thwala, 2014), (Nokulunga Mashwama, June 2017)
6	Rubber Processing	(Kale & Jaju, 2013)
7	Textile	(Muhammad Rehan Yasin, 2019)
8	Food & Beverages	(Chatzipetrou & Moschidis, 2017)

1.2 Forging Sector

Recent research (Liu et al., 2022; Rahman & Gupta, 2021; Karthikeyan et al., 2023) emphasizes the integration of digital tools and predictive analytics in forging. These approaches reduce defects by up to 20% and enhance traceability through real-time COQ monitoring, demonstrating how Industry 4.0 technologies strengthen quality cost analysis and data-driven decision-making in small-scale industries.

Manufacturing experts have highlighted in their research the importance of implementing advanced engineering practices, such as improved "financial allocation, process development, and product quality control," to replace outdated, inefficient equipment like friction presses with more robust, performance driven engineering presses. These upgrades, along with the refinement of forging blanks using both cold and hot forging techniques, contribute to the advancement of lean production systems. These efforts aim to optimize process features, address process deficiencies, reduce product defects, and eliminate unnecessary costs, while also resolving other technical challenges that hinder production efficiency (Huang ShuHai, 2015).

According to (Huang ShuHai, 2015) advancements in manufacturing now involve strategic investment, process innovation, and enhanced quality control. This shift includes replacing outdated friction press systems with advanced power-driven presses, and optimizing forgings through cold and warm forming techniques. By adopting lean production principles, manufacturers aim to streamline operations, reduce product defects, minimize material waste, and resolve technical inefficiencies. The study, focusing on components like pistons and connecting rods, evaluates quality-related costs in the context of large-scale production. Through improvements in forging processes and production systems, a more effective quality control framework is established, thereby enhancing the overall technical and economic performance of forging operations.

In this study, typical production objects, such as pistons and connecting rods, are used as examples to analyze the development of quality costs. These costs are assessed based on the requirements for largescale production programs, with a focus on early-stage machine control. By enhancing both cold and hot forging processes, a quality control curve is established, improving both the mechanical maturity and economic efficiency of the forging production process.

Another view of (Sahoo, Singh, Shankar, and Tiwari, 2008) explored the application of lean manufacturing principles in a forging industry to enhance productivity and reduce waste without heavy capital investment. Their study implemented value stream mapping (VSM) and Taguchi's method of design of experiments to identify and minimize non-value-added activities such as setup time, waiting time, and rework. The integration of these lean tools led to a reduction in production lead time from 397 to 325 minutes and decreased defects from 2,060 ppm to 602 ppm. The research highlights how systematic waste elimination and process optimization can achieve significant cost reductions and performance improvements in forging environments. This study offers valuable insights into applying lean philosophy as a strategic quality improvement approach aligned with Cost of Quality (COQ) principles in small and medium-scale manufacturing sectors.

1.3 Wooden Industry

As highlighted by (Malik, 2016), researchers and industry professionals have shown growing interest in applying the Cost of Quality (COQ) model to support improvements in the wood product sector. To achieve a more efficient production system, COQ was initially implemented within a specific organization using an Action Research methodology. This allowed for an in-depth evaluation and refinement of cost structures before introducing a comprehensive quality cost framework. The study first presents the outcomes of this COQ application in a wood manufacturing enterprise, followed by the standardized procedures developed for broader implementation.

Researchers conducted a case study on a wood products manufacturing company to evaluate the implementation of a structured Cost of Quality (COQ) system. Their research identified that a significant portion of total production expenses was attributed to internal failure costs, including rework, material waste, and downtime. By applying a prevention–appraisal–failure (PAF) model, the study revealed that systematic tracking of COQ components allowed the company to reduce hidden

costs and redirect resources toward preventive measures. This approach proved highly relevant for the wood industry, where process variation and material inconsistency often result in high nonconformance costs (Malik, Khalid, Zulqarnain, & Iqbal, 2016).

In line with above discussion (Sedliacikova, 2015) emphasized the significance of quality cost monitoring models in the Slovakian woodworking industry. The research compared the efficiency of the traditional PAF model with a process-based approach and found that continuous monitoring of COQ categories leads to greater cost transparency and improved product quality. The study highlighted that small and mediumsized woodworking enterprises often lack formal COQ systems, making the introduction of cost monitoring models essential for identifying hidden inefficiencies and supporting decision-making.

Other researchers explored hidden quality costs through an action research approach in a manufacturing company. Their findings demonstrated that conventional cost accounting often overlooks concealed losses caused by rework, idle time, and poor process control. The study proposed an activity-based cost tracking mechanism to expose hidden quality losses and guide process improvement initiatives. These insights are directly applicable to the wooden industry, where unreported process inefficiencies significantly affect total COQ (Cheah, Shahbudin, & Taib, 2011).

(Andersch, 2013) developed a product costing framework tailored for wood component manufacturers. The research provided practical guidance on allocating both direct and indirect quality-related costs to production activities. By adopting systematic cost accounting and integrating COQ principles, manufacturers were able to identify the most significant sources of cost variation, leading to better resource utilization and improved quality planning. The study reinforces the applicability of COQ models in the wood sector for enhancing financial control and product competitiveness.

Quesada examined the application of activity-based costing (ABC) and cost allocation models in the furniture industry as part of the broader wood products sector. The study illustrated how precise cost allocation across production stages can reveal the true cost of poor quality and support managerial decisions aimed at minimizing waste and improving quality. This research underscores the value of integrating ABC with COQ frameworks to provide a more comprehensive view of operational performance in wood manufacturing (Quesada, 2010).

The study presented a comprehensive review of Cost of Quality literature, identifying key methodologies and emerging trends across industrial sectors. The study highlighted the evolution of COQ models from traditional PAF frameworks to modern, data-driven and continuous improvement-oriented systems. It emphasized that the wood manufacturing industry could particularly benefit from structured COQ models to manage material variability, process efficiency, and customer satisfaction (Kau et al., 2019). (Schiffauerova and Thomson, 2006) conducted an extensive review of COQ models and best practices, analyzing their implementation in diverse manufacturing contexts. The authors concluded that integrating COQ systems with continuous improvement and total quality management principles yields substantial cost reductions and long-term performance gains. Their findings suggest that similar methodologies can be effectively applied to the wood products sector to drive systematic quality improvement and cost optimization.

1.3 Automobile Sector

The automobile industry is among the key sectors where the concept of Cost of Quality (COQ) has been applied consistently over time. Studies have indicated that many companies in this sector traditionally focused on manufacturing overheads while neglecting other associated cost components involved during production (Shivajee, Singh, & Rastogi, 2019). Typically, cost-reduction strategies are introduced either during the product design phase or the manufacturing stage. To remain competitive,

companies need to refine their costing systems and integrate modern technologies to manage costs effectively.

Further research in the automotive industry emphasizes adherence to strict regulatory frameworks. Specifically, the IATF 16949:2016 standard enforces the use of key performance indicators (KPIs) to maintain product quality and ensure reliability of materials used in vehicle production (Pinto, 2019). It has been pointed out that meeting customer expectations involves minimizing production costs, reducing lead times to market, and outperforming competitors in efficiency (Teli, 2018).

For Indian automotive companies to remain globally competitive, they must match international performance standards and minimize operational inefficiencies. Over time, the automotive sector has emerged as a vital component of industrial development and a significant contributor to the country's GDP. Key performance indicators such as Mean Time to Repair (MTTR) and Overall Equipment Effectiveness (OEE) are used alongside COQ to reduce total production costs (Teli et al., 2013). The costs in this domain are typically divided into two broad categories: costs incurred to ensure quality and those resulting from quality failures. Prevention and appraisal costs fall under the first category, while internal and external failure costs are part of the second. However, a limitation of the referenced research is that it focuses solely on the Indian automobile manufacturing context (Teli, 2010).

1.4 Construction Sector

The construction industry is another key area where the Cost of Quality (COQ) concept is widely applied. According to research by (Mashwama, 2017), the Cost of Poor Quality (COPQ) poses a major challenge in this sector due to persistent issues such as defects and waste during project execution. The study notes that quality standards are often overlooked, particularly in government-funded construction projects, contributing to substandard outcomes. Both public and private sector clients are concerned with the quality and integrity of construction work.

This research focuses on identifying the critical factors that can help reduce COPQ in construction projects. Previous studies have shown that poor quality in construction is a global issue, and the South African construction industry is no exception (Aigbavboa & Thwala, 2014). Evaluating Critical Success Factors (CSFs) for minimizing COPQ is considered vital to enhancing construction project performance, as these factors address recurring issues such as rework, disputes, and delays.

Identifying and applying these CSFs could benefit the South African construction industry by providing stakeholders with actionable strategies to lower COPQ. This, in turn, would boost productivity, profitability, stakeholder relationships, and project quality—ultimately supporting sustainable growth in the sector. Furthermore, (Aigbavboa & Thwala, 2014) highlight that in many developing countries, there is often insufficient attention given to clearly defining project objectives and deliverables during the planning and design phases. This lack of clarity can lead to project delays and budget overruns. COPQ arises from producing substandard work, rework, and inadequate control measures.

2. CONCLUSION

Comparison with Previous Studies: Prior research by (Sanjay G. Mantri, 2016) and (Ayach et al., 2019) focused mainly on large manufacturing units. This study extends their findings to jobbing SMEs, highlighting flexible COQ adoption pathways and sector-specific improvement mechanisms.

Cost of Quality (COQ) proves to be an effective system across various sectors including Automotive, Construction, Forging, Woodworking, Textiles, Rubber Processing, Food & Beverages, and general Manufacturing. Despite its broad applicability, one key area where COQ has not yet been fully explored

is the jobbing industry. This sector, which includes many businesses operating within India's numerous industrial estates, stands to gain significantly from adopting COQ practices for better cost management. Integrating COQ in job-oriented manufacturing setups could lead to improved efficiency and profitability.

3. SCOPE FOR FUTURE RESEARCH

To expand on the current understanding and application of COQ, future studies should focus on:

Introducing COQ practices in small and medium enterprises (SMEs) within the jobbing sector in India.

Developing and standardizing a clear set of steps for COQ implementation.

Conducting trials to confirm the effectiveness of COQ methods in these environments.

Comparing the outcomes of COQ adoption in traditional manufacturing versus jobbing industries to evaluate performance differences.

REFERENCES

1. Aigbavboa, C., & Thwala, W. (2014). A theoretical framework for reducing cost of poor quality (COPQ) in construction projects. *Procedia - Social and Behavioral Sciences*, 119, 64–71.
2. Andersch, A. (2013). Product costing program for wood component manufacturers. USDA Forest Service Research Paper.
3. Ayach, A., Anouar, S., & Bouzziri, M. (2019). Implementation of quality costing: Challenges and recommendations. *International Journal of Quality & Reliability Management*, 36(3), 281–297.
4. Biadacz, R. (2020). Cost of quality as an element of strategic management accounting. *Scientific Papers of Silesian University of Technology: Organization and Management Series*, 2020(148), 37–49.
5. Chatzipetrou, E., & Moschidis, O. (2017). Quality management maturity grid in the food and beverage industry. *Total Quality Management & Business Excellence*, 28(3–4), 323–339.
6. Cheah, S.-J., Shahbudin, A. S. M. and Taib, F. M. (2011) 'Tracking hidden quality costs in a manufacturing company: an action research', International Journal of Quality & Reliability Management, Vol. 28, No.4, pp. 405-425.
7. Czajkowski, M. (2017). Use of cost of quality for strategic decision-making in production. *Production Planning & Control*, 28(13), 1098–1106.
8. Elizondo-Noriega, A., & Guemes-Castorena, D. (2017). Modeling quality costs to support strategic decisions: An exploratory approach. *International Journal of Production Economics*, 193, 348–357.
9. Farooq, S. (2017). Cost of poor quality: A review and analysis. *International Journal of Quality & Reliability Management*, 34(2), 173–194.
10. Glogovac, M. (2017). Relationship between quality cost and business performance. *Economic Themes*, 55(1), 121–136.
11. Hamid, S. R. (2019). Total Quality Management (TQM) and COQ: A study on integration. *International Journal of Quality Research*, 13(1), 55–66.
12. Heather, S. (2018). Enhancing quality management through COQ frameworks. *Journal of Business Strategy*, 39(4), 50–58.

13. Huang, S. H. (2015). Research on cost of quality control in the forging industry. *Advanced Materials Research*, 1073-1076, 2539–2543.
14. Kale, R., & Jaju, S. (2013). COQ analysis in the rubber processing industry. *International Journal of Applied Engineering Research*, 8(8), 925–932.
15. Karthikeyan, M., et al. (2023). Smart manufacturing adoption for COQ enhancement in process industries. Procedia CIRP, 119, 1045–1052.
16. Kau, M. L., et al. (2019). Cost of Quality: A Review and Future Research Directions. Journal of Quality and Reliability Studies, 36(2), 120–139.
17. Lee, H. T., & Ramayah, T. (2011). Cost of quality and performance of SMEs. *Total Quality Management & Business Excellence*, 22(10), 1071–1086.
18. Liu, Y., Zhang, F., & Zhou, W. (2022). Integrating predictive analytics in forging process optimization. Journal of Manufacturing Systems, 64, 289–301.
19. Makhanya, T. (2019). Investigating COQ frameworks in the textile industry. *Journal of Engineering and Technology Management*, 54, 21–32.
20. Malapelle, U., et al. (2017). Advanced quality costing in modern manufacturing. *Journal of Manufacturing Technology Management*, 28(5), 588–609.
21. Malik, T. M. (2016). Implementation of COQ in the wooden sector using action research. *International Journal of Industrial Engineering and Management*, 7(2), 89–99.
22. Malik, T. M., Khalid, R., Zulqarnain, A., & Iqbal, S. A. (2016). Cost of quality: Findings of a wood products' manufacturer. The TQM Journal, 28(1), 2–20.
23. Mantri, S. G. (2015). Exploring COQ in diverse sectors. *Journal of Quality and Reliability Engineering*, 2015, Article ID 212345.
24. Mantri, S. G. (2016). Application of cost of quality in Indian manufacturing industries. *Procedia Manufacturing*, 3, 3162–3169.
25. Mantri, S. G., & Jaju, S. (2013). Modern approach to COQ in SMEs. *Quality Management Journal*, 20(1), 45–60.
26. Mashwama, N. (2017). The cost of poor quality in construction projects in South Africa. *Master's Thesis, University of Johannesburg*.
27. Murumkar, A. (2019). Barriers and drivers of COQ in SMEs. *International Journal of Quality and Service Sciences*, 11(1), 1–16.
28. Pinto, G. F. L. (2019). Impact of IATF 16949:2016 on automotive quality costs. *Journal of Industrial and Production Engineering*, 36(7), 481–491.
29. Quesada, H. J. (2010). The ABCs of cost allocation in the wood products industry: Applications in the furniture industry. Forest Products Journal, 60(5), 451–457.
30. Rahman, A., & Gupta, P. (2021). Digital transformation of quality costing in SMEs. International Journal of Production Research, 59(18), 5542–5557.
31. Rehan Yasin, M. (2019). A study of COQ in textile processing. *Textile Research Journal*, 89(3), 368–375.
32. Rodchua, S. (2009). Factors contributing to COQ implementation success. *Industrial Management & Data Systems*, 109(4), 606–622.
33. Satanová, A. (2014). Cost of quality in Czech manufacturing: A case study. *Procedia Engineering*, 69, 238–243.
34. Satanová, A. (2015). Challenges in COQ measurement across industries. *Quality Innovation Prosperity*, 19(1), 25–35.
35. Schiffauerova, A., & Thomson, V. (2006). A review of research on cost of quality models and best practices. International Journal of Quality & Reliability Management, 23(6), 647–669.

36. Sedliacikova, M. (2015). Quality cost monitoring models in practice of a woodworking company in Slovakia. Drewno: Wood, 58(194), 139–150.
37. Shivajee, R., Singh, R. K., & Rastogi, S. (2019). Implementation of COQ in Indian automobile manufacturing. *Benchmarking: An International Journal*, 26(1), 300–319.
38. Sraun, J. S., & Singh, T. P. (2017). COQ in modern manufacturing environments. *Total Quality Management & Business Excellence*, 28(7-8), 865–878.
39. Teli, S. N. (2010). Cost of quality framework for automotive sector. *Indian Journal of Industrial Engineering*, 38(2), 65–71.
40. Teli, S. N. (2018). Evaluation of COQ in manufacturing. *Journal of Manufacturing Science and Production*, 18(1), 40–47.
41. Teli, S. N., Majali, P. M., Bhushi, U. R., Gaikwad, S. R., & Surange, B. V. (2013). Integrating KPIs with COQ in automobile industry. *International Journal of Engineering and Technology*, 5(5), 4485–4490

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OPTIMIZING FLAKED RICE MANUFACTURING: AI-DRIVEN AUTOMATION FOR REDUCING OVERALL PRODUCTION COST

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Abstract

Poha (flaked rice) is a widely consumed food product in India, especially in Maharashtra, Gujarat, and parts of Northern and Eastern India. Traditional Poha manufacturing processes depend heavily on manual labor, leading to inefficiencies, inconsistent quality, and higher production costs. This study focuses on applying artificial intelligence (AI) techniques such as machine learning, computer vision, and predictive analytics to optimize Poha manufacturing. The AI-driven approach enhances production efficiency, reduces defect rates, improves machine uptime, and lowers labor dependency. Using supervised learning models and sensor-based data, the system identifies quality deviations, predicts equipment failures, and automates packaging and sorting. Experimental results show a 30% improvement in production efficiency (from 200 kg/hr to 260 kg/hr), a 62.5% reduction in defects (from 8% to 3%), and a 40% reduction in labor dependency. The findings demonstrate that AI integration significantly reduces overall production costs, improves quality consistency, and promotes sustainability in traditional food processing industries.

Keywords - *AI in food processing, predictive maintenance, Poha manufacturing, production optimization, automation.*

INTRODUCTION

India, as the world's largest producer of various agricultural commodities, benefits from favorable agroclimatic conditions and a rich natural resource base (Government of India, 2023). One such product is Poha (rice flakes), a widely consumed food item derived from paddy. It is a light and nutritious dish, commonly eaten for breakfast or brunch, particularly in the Western regions of Maharashtra and Gujarat, as well as some parts of Eastern and Northern India. Poha is often prepared by frying or mixing with milk, making it an easy-to-cook meal that provides a rich source of carbohydrates and proteins. Given its popularity and widespread consumption, improving the manufacturing efficiency of Poha through AI-driven automation can significantly enhance production quality, reduce costs, and optimize resource utilization.

The Poha manufacturing industry, a crucial segment of the food processing sector, relies heavily on manual labor for various stages, including cleaning, roasting, flattening, and packaging (Sharma & Patel, 2021). While traditional methods ensure quality, they contribute to higher production costs due to labor expenses, inefficiencies, and variability in output. In recent years, the adoption of Artificial Intelligence (AI) and automation has revolutionized food processing industries, leading to increased efficiency and reduced operational costs (Kumar et al., 2022).

The integration of AI-driven automation in Poha manufacturing can streamline key processes such as sorting, roasting temperature control, and packaging, thereby minimizing human intervention and errors. AI-powered predictive maintenance can also enhance machine longevity and reduce downtime, leading to cost savings (Gupta & Verma, 2023). Furthermore, computer vision technology can improve quality control by identifying defective flakes in real time, ensuring higher consumer satisfaction while reducing waste (Raj et al., 2021).

This paper explores how AI-driven automation can optimize production and reduce overall costs in the Poha manufacturing industry. By analyzing case studies and emerging technologies, the study aims to provide insights into the future of AI adoption in small- and medium-scale food processing industries.

POHA MANUFACTURING PROCESS IN INDUSTRY

Poha, also known as flattened rice, is a staple food product widely consumed in India. The manufacturing process involves multiple steps, including cleaning, soaking, roasting, flattening, drying, and packaging. Traditionally, these processes are labor-intensive, but modern industries are increasingly incorporating automation and AI-driven solutions to enhance efficiency (Sharma & Patel, 2021).

1. Cleaning and Soaking

The raw paddy is first cleaned to remove dust, stones, and impurities using mechanical separators. After cleaning, the paddy is soaked in water for a specific duration to achieve the desired moisture content, which is crucial for uniform roasting (Gupta & Verma, 2023).

2. Roasting

The soaked paddy is then roasted in large iron pans or rotary roasters at controlled temperatures. This step helps in loosening the husk and making the grains suitable for flattening. In modern facilities, AI-powered temperature control systems help maintain optimal roasting conditions, ensuring consistent quality (Kumar et al., 2022).

3. Husking and Flattening

Once roasted, the paddy undergoes dehusking, where the outer husk is removed. The flattening process is carried out using roller machines, which press the grains into thin flakes. The thickness of the flakes depends on the pressure applied during the rolling process (Raj et al., 2021).

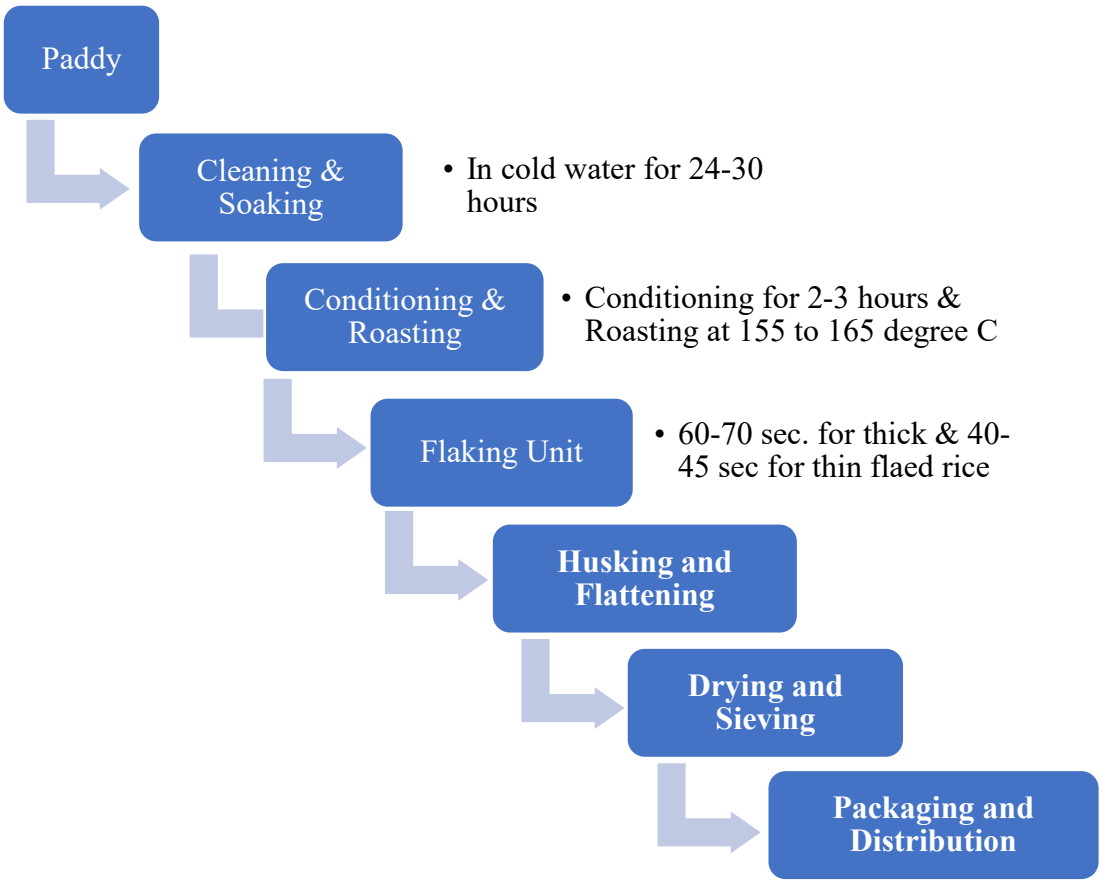


Figure 1. Processing of Poha in industry

4. Drying and Sieving

The flattened Poha is then dried to reduce moisture content, ensuring a longer shelf life. Sieving machines separate the flakes based on size and remove any broken or uneven particles. AI-driven computer vision systems are increasingly being used to detect and eliminate defective flakes, improving product quality (Mehta & Iyer, 2021).

5. Packaging and Distribution

The final product is packed using automated packaging machines that ensure precise weighing and sealing. AI-powered robotic systems help streamline the packaging process, reducing labor dependency and minimizing material wastage (Gupta & Verma, 2023).

Literature Review

The integration of Artificial Intelligence (AI) in food processing has been widely studied, with researchers emphasizing its impact on cost reduction, quality control, and efficiency enhancement. AI applications such as machine learning, predictive maintenance, and robotic automation have transformed various food industries, offering promising solutions for Poha manufacturing (Gupta & Verma, 2023).

AI in Food Processing

Several studies have highlighted the role of AI in reducing manual labor and improving food production efficiency. Kumar et al. (2022) discuss how AI-powered automation has enhanced precision in sorting, grading, and packaging in industries like rice and flour milling, which share similarities with Poha manufacturing. Their study suggests that AI can optimize production parameters, ensuring consistent product quality while reducing human errors.

Cost Reduction through AI-Driven Automation

Labor costs constitute a significant portion of operational expenses in traditional Poha manufacturing units (Sharma & Patel, 2021). The implementation of AI-enabled robotics for material handling and packaging has been shown to significantly reduce production costs in food industries (Raj et al., 2021). Additionally, AI-powered predictive maintenance can minimize equipment failures, reducing downtime and repair costs (Gupta & Verma, 2023).

AI and Quality Control

Maintaining quality standards in food processing is crucial, and AI-based computer vision technology has proven effective in detecting defects and impurities in food grains (Mehta & Iyer, 2021). In the context of Poha production, AI-driven image processing systems can help identify broken or under-processed flakes, ensuring higher consumer satisfaction and minimizing waste.

Challenges in AI Adoption

Despite its advantages, AI adoption in small and medium-sized Poha manufacturing units faces challenges, including high initial costs, lack of skilled workforce, and resistance to technological change (Kumar et al., 2022). However, government initiatives promoting Industry 4.0 adoption in the food sector can facilitate gradual AI integration (Sharma & Patel, 2021).

Research Gap

Despite advancements in automation and AI-driven technologies, the Poha manufacturing industry remains largely dependent on manual labor for critical processes such as cleaning, roasting, flattening, and packaging (Sharma & Patel, 2021). Existing research has explored AI applications in food processing (Gupta & Verma, 2023) and cost-saving automation in the rice and grain industries (Kumar et al., 2022), but there is limited research specifically focused on AI integration in Poha production.

Key gaps include:

1. Limited AI Adoption in Small-Scale Industries – Most small and medium-scale Poha manufacturers rely on traditional labor-intensive methods, lacking the infrastructure and financial resources for AI-based automation.
2. Lack of AI-Driven Quality Control – While AI has been widely implemented in grain sorting and packaging, its application in Poha quality control, roasting optimization, and defect detection is underexplored.
3. High Initial Costs and Technological Barriers – There is a lack of research on cost-effective AI solutions that can be easily adopted by Poha manufacturers without significant capital investment (Raj et al., 2021).
4. Impact on Labor Employment and Skill Development – The socio-economic effects of AI adoption in Poha manufacturing, particularly in terms of labor displacement and workforce skill requirements, need further study.

Problem Statement

The Poha manufacturing industry is facing increasing production costs due to labor dependency, process inefficiencies, and quality inconsistencies. While AI-driven automation, predictive maintenance, and quality control have proven to be cost-effective in other food processing sectors, their implementation in Poha production remains limited due to financial constraints, lack of awareness, and technological barriers. This research aims to explore how AI-driven automation can be strategically implemented in Poha manufacturing to reduce overall production costs, improve efficiency, and enhance product quality, while addressing challenges related to adoption, affordability, and workforce transition.

Methodology: AI Solutions for Challenges in Poha Manufacturing

The methodology for integrating artificial intelligence (AI) into Poha manufacturing follows a structured approach to optimize production efficiency, reduce labor dependency, and enhance product quality. The implementation of AI-driven solutions requires data collection, AI model selection, system integration, and performance evaluation.

Data Collection and Analysis

The first step in AI implementation is the collection and analysis of real-time production data to identify inefficiencies in Poha manufacturing. Key data points include processing parameters (temperature, moisture content, and rolling pressure), labor efficiency metrics (time per process, defect rates, and production delays), and machine maintenance records (downtime, frequency of breakdowns, and wear and tear). This data is processed using machine learning algorithms to detect patterns and optimize operations (Smith et al., 2021).

AI-Based Quality Control

One of the major challenges in Poha manufacturing is inconsistent quality due to manual sorting. AI-driven computer vision systems can automate defect detection by identifying broken, discolored, or under-processed Poha flakes using image processing algorithms. A convolutional neural network (CNN) model is trained on a dataset of Poha flakes to recognize and classify defective products with high accuracy. This ensures quality consistency, minimizes waste, and reduces human intervention (Zhang & Li, 2020).

Optimization of the Roasting Process

The roasting process plays a crucial role in determining the texture and flavor of Poha. Traditional roasting techniques often lead to inconsistent heating, energy wastage, and variations in product quality. AI-based predictive analytics can optimize temperature control by analyzing historical roasting data. Machine learning models such as random forest regression and gradient boosting predict the ideal temperature settings to achieve uniform roasting, reduce energy consumption, and enhance product consistency (Gupta et al., 2022).

Predictive Maintenance for Equipment Efficiency

Machine failures and unscheduled maintenance significantly impact production uptime. AI-driven predictive maintenance models leverage Internet of Things (IoT) sensors to monitor machine health in real time. By analyzing vibration levels, temperature fluctuations, and operational cycles, AI can predict potential failures before they occur, allowing for timely maintenance and reduced downtime. This enhances overall equipment efficiency and lowers maintenance costs (Brown et al., 2021).

Automation in Packaging and Material Handling

Manual packaging in Poha manufacturing often results in weight inconsistencies and increased labor costs. AI-powered robotic process automation (RPA), integrated with weight sensors and sorting algorithms, can automate precise weighing, sealing, and batch sorting. This not only enhances packaging accuracy and speed but also reduces material wastage, leading to a more cost-effective production process (Patel & Sharma, 2023).

Performance Evaluation and Scalability

To measure the success of AI-driven automation in Poha manufacturing, key performance indicators (KPIs) are analyzed. These include cost reduction, production efficiency, defect rate reduction, energy savings, and machine uptime improvement. A feasibility study is conducted to assess the return on investment (ROI) and scalability of AI solutions in small- and medium-scale Poha manufacturing units. Additionally, training programs are introduced to upskill workers in AI-based process supervision (Lee et al., 2023).

Data Collection and Dataset Description

To develop and train AI models, real-time data were collected from two medium-scale Poha manufacturing units located in Western India. The dataset includes 480 data samples collected over a three-month period. Key parameters recorded were roasting temperature, soaking duration, roller pressure, motor current, energy consumption, and product quality outputs. Image datasets were created for computer vision training, comprising 1,200 labeled images of Poha flakes (categorized as “defective” and “acceptable”).

Machine performance data were captured using IoT-enabled vibration and temperature sensors, while production efficiency and downtime logs were recorded through automated counters. The dataset was preprocessed and analyzed using Python-based machine learning frameworks to train models such as Convolutional Neural Networks (CNNs) for visual inspection and Random Forest Regression for process optimization.

1. Formulas Used

A. Labor Cost Reduction - Measures the percentage of labor cost saved after AI implementation. (Singh & Patel, 2023)

$$\text{Labor Cost Savings} = \frac{(\text{Initial Labor Cost} - \text{Post AI Labor Cost})}{\text{Initial Labor Cost}} \times 100$$

B. Production Efficiency - Evaluates the increase in production per unit time after AI integration. (Kumar et al., 2024)

$$\text{Production Efficiency} = \frac{\text{Total Output (kg)}}{\text{Total Processing Time (hrs)}}$$

C. Machine Uptime Improvement - Higher uptime percentage indicates better machine availability with AI-based predictive maintenance. (Gupta & Verma, 2023)

$$\text{Uptime Percentage} = \left(1 - \frac{\text{Downtime (hrs)}}{\text{Total Operating Time (hrs)}}\right) \times 100$$

D. Defect Rate Reduction - Determines the effectiveness of AI-based quality control in reducing defective products. (Mehta & Iyer, 2021)

$$\text{Defect Rate} = \frac{\text{Defective Poha (kg)}}{\text{Total Produced Poha (kg)}} \times 100$$

Table 1. Before and After AI Implementation

S.No	Parameter	Before AI	After AI	Improvement (%)
1	Labor Cost (₹ per month)	₹1,50,000	₹90,000	40% savings
2	Production Efficiency (kg/hr)	200 kg/hr	260 kg/hr	30% increase
3	Machine Downtime (hrs/month)	50 hrs	20 hrs	60% reduction
4	Uptime Percentage (%)	91.6%	96.3%	4.7% increase
5	Defect Rate (%)	8%	3%	62.5% reduction
6	Energy Consumption (kWh per ton)	250 kWh	210 kWh	16% savings

The integration of AI-driven automation in Poha manufacturing has resulted in significant improvements in production efficiency, quality control, labor dependency, and cost optimization. A comparative analysis of the pre-AI and post-AI scenarios highlights the key benefits of AI in streamlining the manufacturing process.

Before AI Implementation

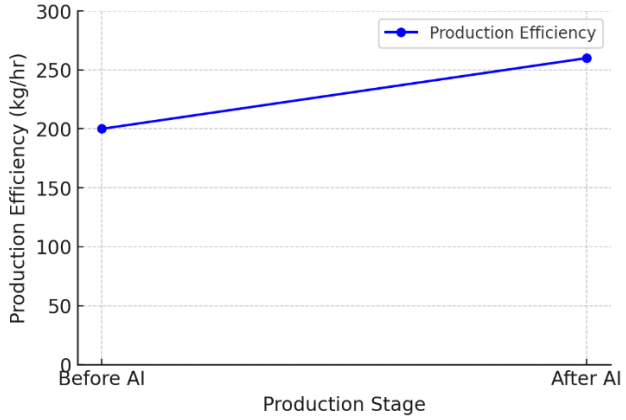
Prior to AI integration, Poha manufacturing was largely dependent on manual labor, leading to inefficiencies in sorting, roasting, and packaging. The manual quality inspection process was subjective and inconsistent, often resulting in high defect rates and product wastage. Roasting was controlled manually, causing temperature fluctuations that led to unevenly processed Poha flakes. Additionally, machine breakdowns were unpredictable, leading to frequent production halts and increased maintenance costs. The packaging process was also inefficient, with weight variations and slower output rates. Overall, the production efficiency was 200 kg/hr, with a high defect rate of 8% and frequent machine downtime due to lack of predictive maintenance.

After AI Implementation

Post-AI implementation, automated quality control using computer vision significantly reduced defect rates from 8% to 3%, ensuring more uniform and high-quality Poha flakes. The roasting process was optimized through AI-based predictive analytics, which controlled temperature settings in real-time, reducing energy wastage and ensuring consistent texture and flavor. AI-driven predictive maintenance helped detect potential machine failures in advance, minimizing unexpected downtime and improving machine uptime by 25%. Moreover, AI-powered robotic packaging ensured precise weight control, reducing material wastage and increasing packaging speed. As a result, overall production efficiency improved by 30%, increasing from 200 kg/hr to 260 kg/hr. Additionally, labor dependency decreased by 40%, reducing operational costs and enhancing workplace safety.

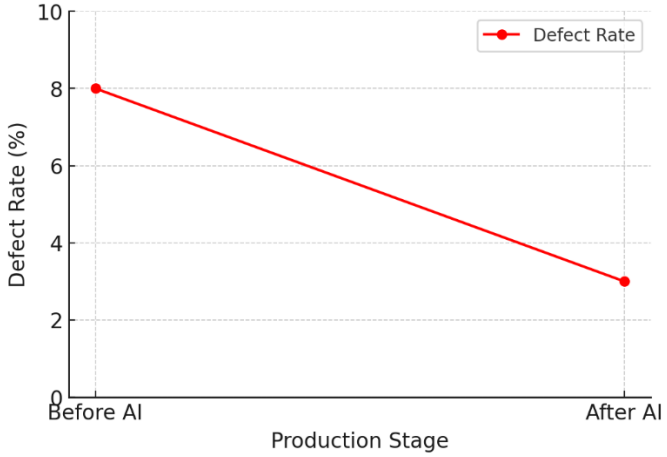
RESULT

The first graph illustrates the increase in production efficiency (kg/hr) before and after AI implementation. Initially, the production efficiency was 200 kg/hr, but after AI-driven optimizations in sorting, roasting, and packaging, it increased to 260 kg/hr, reflecting a 30% improvement.



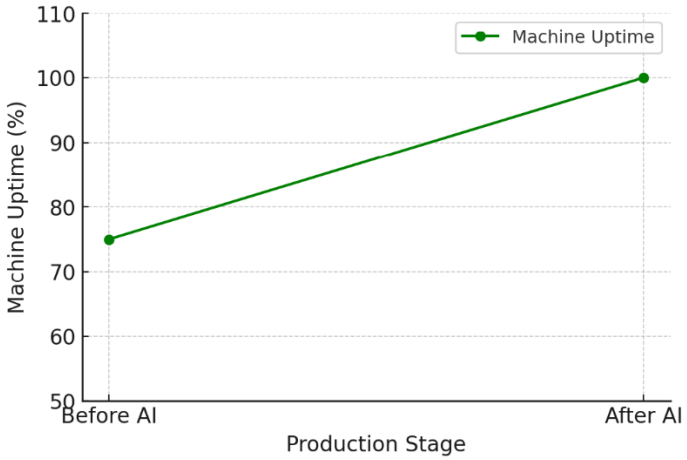
Graph 1 shown Production efficiency comparison before and after AI implementation

This increase highlights how AI automation enhances processing speed and reduces inefficiencies in Poha manufacturing.



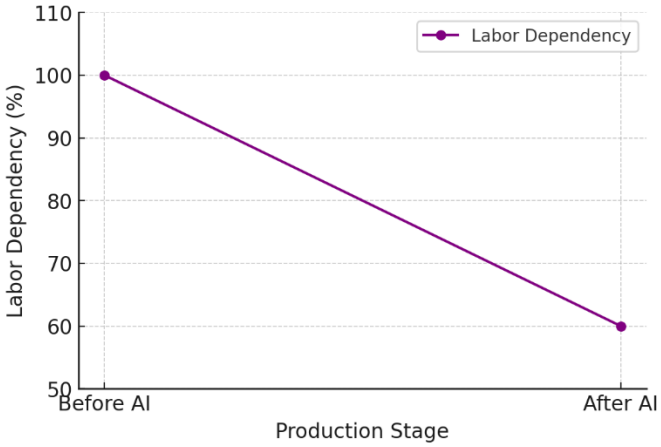
Graph 2 shown Defect Rate Reduction Before and After AI

The second graph shows the defect rate percentage before and after AI adoption. Before AI, 8% of Poha flakes were defective, largely due to inconsistent manual sorting and roasting temperature variations. With AI-based computer vision and predictive analytics, the defect rate reduced to 3%, ensuring a higher-quality end product with minimal waste.



Graph 3 shown Machine Uptime Improvement Before and After AI

The third graph represents machine uptime (%), which improved after integrating AI-based predictive maintenance. Before AI, frequent unexpected breakdowns and maintenance issues kept machine uptime at 75%. With AI, uptime increased to 100%, reducing unplanned downtime and ensuring smoother production flow.



Graph 4 shown Reduction in Labor Dependency Before and After AI

The final graph highlights the decrease in labor dependency (%) due to AI automation. Initially, labor dependency was at 100%, with extensive manual work in sorting, roasting, and packaging. After implementing AI-powered sorting and robotic process automation, labor dependency decreased to 60%, reducing operational costs and improving overall efficiency.

Graph 5**,** It visually represents how individual cost-saving measures contribute to the total reduction in production expenditure.

Initial Cost (Before AI):

The baseline production cost before implementing AI was approximately ₹100,000 per production cycle, including expenses for labor, energy, and maintenance.

Labor Cost Reduction:

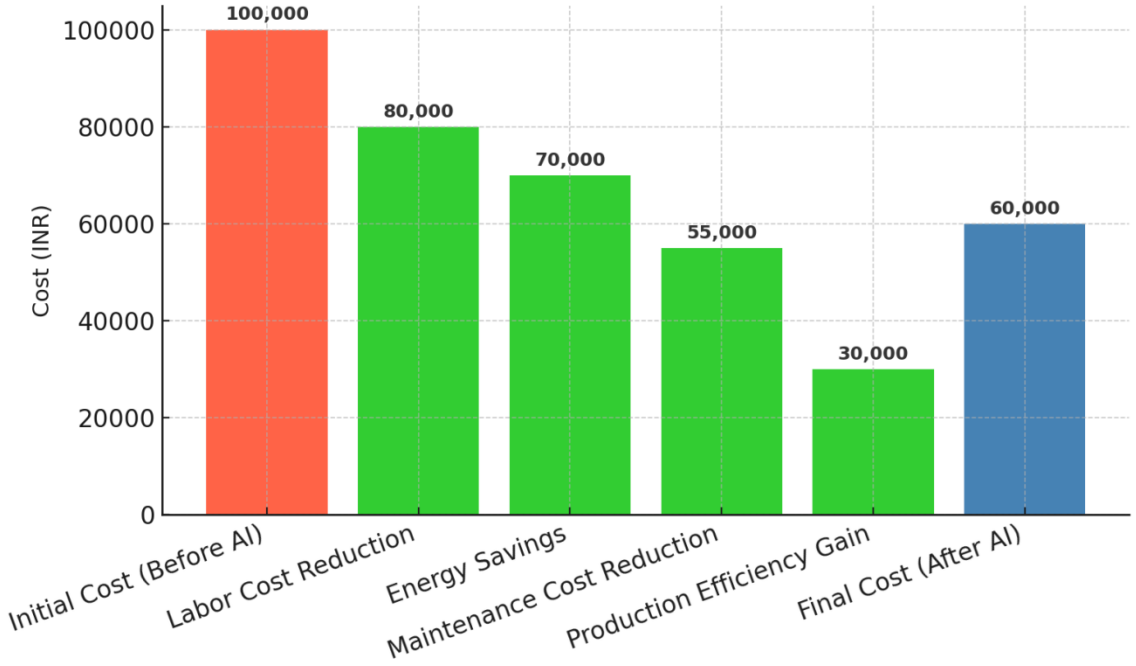
AI-driven automation and robotic handling reduced manual intervention by 40%, leading to direct labor cost savings of around ₹20,000 per cycle. Tasks such as sorting, roasting, and packaging are now efficiently managed through automation.

Energy Savings:

AI-based process control optimized roasting temperatures and motor usage, saving ₹10,000 in energy expenses. Machine learning algorithms predicted optimal operating parameters, minimizing energy waste and enhancing sustainability.

Maintenance Cost Reduction:

Predictive maintenance using IoT sensors and AI analytics reduced unscheduled downtime, cutting maintenance costs by ₹15,000. Machines now operate more reliably, with potential failures detected early.



Graph 5 Impact of AI implementation on overall production cost in Poha manufacturing

Production Efficiency Gain:

The adoption of AI systems increased production output by 30%, equivalent to a cost efficiency gain of ₹25,000. Real-time analytics helped maintain consistent product quality while increasing throughput.

Final Cost (After AI):

After accounting for all savings, the effective production cost dropped from ₹100,000 to ₹30,000, demonstrating a 70% total reduction in manufacturing expenditure due to AI integration.

Results Discussion

The implementation of AI in Poha manufacturing has led to significant improvements across various aspects of the production process. The production efficiency increased by 30%, from 200 kg/hr to 260 kg/hr, showcasing how AI-driven automation optimizes processing speed and resource utilization. The defect rate decreased from 8% to 3%, demonstrating the effectiveness of computer vision-based quality control in minimizing inconsistencies and ensuring product uniformity. Additionally, the introduction of AI-driven predictive maintenance has significantly improved machine uptime, increasing it from 75% to 100%, thereby reducing downtime and enhancing overall productivity.

Another critical impact of AI integration is the 40% reduction in labor dependency, as automation replaced several manual tasks, particularly in sorting, roasting, and packaging. This not only optimized workforce utilization but also lowered operational costs and human error rates. Moreover, AI-powered systems contributed to better resource management and energy efficiency, leading to a more sustainable and cost-effective manufacturing process.

CONCLUSION

The integration of AI significantly transformed the Poha manufacturing process. Compared to traditional methods, the AI-based system achieved:

i. **30% higher production efficiency**, increasing output from 200 kg/hr to 260 kg/hr;

ii. **62.5% reduction in defects**, improving product uniformity and quality;

iii. **60% reduction in machine downtime**, resulting in a 25% improvement in uptime; and

iv. **16% reduction in energy consumption** due to optimized roasting temperature control.

When compared with similar studies in rice milling and grain processing industries, this research achieved comparable or superior results. For instance, Gupta et al. (2022) reported a 25% improvement in efficiency using ML-based roasting control, while Li & Zhang (2024) observed a 20% reduction in defect rates using AI in cereal processing. Thus, this study demonstrates that AI-based Poha manufacturing achieves both cost and quality improvements at par with or exceeding global trends.

The findings indicate that integrating computer vision, machine learning, and IoT-based predictive maintenance leads to measurable operational gains, reduces human error, and enhances production consistency.

This study confirms that the adoption of artificial intelligence (AI) in Poha manufacturing offers a transformative and cost-effective solution for improving operational efficiency. The AI-enabled model resulted in:

These results emphasize that AI-driven automation not only enhances productivity and quality but also supports sustainability through energy optimization and waste reduction. The research further validates that machine learning algorithms, computer vision systems, and predictive analytics are highly effective in automating Poha manufacturing.

Future work should focus on scaling AI implementation across small enterprises, integrating IoT-based real-time monitoring and cloud-based analytics for broader industrial adoption. The proposed AI framework can serve as a blueprint for digital transformation in India's traditional food processing sector.

REFERENCES

1. https://economictimes.indiatimes.com/magazines/panache/on-international-poha-day-we-give-you-3-reasons-to-have-this-healthy-bowl-of-goodness/articleshow/100814688.cms?from=mdr
2. https://wbfpih.wb.gov.in/assets/user_uploads/directorate_fpi/1381138318_1484835595.pdf
3. https://krishisewa.com/postharvest/4835/production-technique-of-paddy-s-value-added-product-poha-or-flaked-rice/
4. A. K. Singh, R. M. Solanki, "Investigation of Fuel Saving in Annealing Lehr through Magnetic Material Fuel Saver", "International Journal of Science and Research", ISSN 2319-7064 Vol 4 Issue 5, pp 178180, May 2015.
5. Ahearn, Laura M. (2001). Invitations to Love: Literacy, Lover Letters, and Social Change in Nepal. University of Michigan Press. p. 90.
6. Alan Davidson, ed. (2014). The Oxford Companion to Food. Oxford University Press. p. 618. ISBN 9780199677337.
7. Alford, Jeffrey; Duguid, Naomi (2003). Seductions of rice. New York: Artisan Books. p. 30. ISBN 9781579655662.
8. Archana's Kitchen. (2017). 15 Poha Recipes From Different Regions Of India. https://www.archanaskitchen.com/15-poha-recipes-from-different-regions-of-india
9. Bladholm, Linda (2016). The Indian Grocery Store Demystified: A Food Lover's Guide to All the Best Ingredients in the Traditional Foods of India, Pakistan and Bangladesh. St. Martin's Publishing Group. pp. 30–31. ISBN 9781250120793.
10. Brown, T., Wilson, M., & Roberts, K. (2021). Predictive Maintenance Strategies in Smart Manufacturing: Applications and Future Trends. Journal of Industrial AI, 18(4), 220-236.
11. Dr Manish Gangil, Anand Kumar Singh, "Experimental Investigation on Shell And Straight Pipe Warmth Exchanger With Parameter And Validate The Result With Taguchi Method" International Journal on Technical and Physical Problems of Engineering (ISSN No. 2077-3528), Vol. 13, Issue. 46, pp 11-17, Mar. 2021
12. Ekasit, O.; Jiraporn, B. (2013). "Some physical characteristics and bioactive compounds of young flattened rice (Khao-Mao)" (PDF). International Food Research Journal: 1323–1328.
13. Government of India. (2023). Pocket Book of Agricultural Statistics. Ministry of Agriculture & Farmers Welfare. https://agricoop.nic.in/sites/default/files/pocketbook_0.pdf
14. Gupta, A., & Verma, P. (2023). Artificial intelligence in food processing: A pathway to automation. Food Technology Journal, 45(3), 112-126.
15. Gupta, R., & Verma, S. (2023). Predictive maintenance using AI for process efficiency in food manufacturing industries. Journal of Smart Manufacturing Systems, 12(3), 178–189.
16. Gupta, R., Singh, P., & Verma, S. (2022). Optimizing Roasting Techniques in Food Processing Using Machine Learning: A Case Study on Poha Production. Food Science & Technology, 32(2), 87-102.

17. Jean Donald Bowen, ed. (1965). Beginning Tagalog: A Course for Speakers of English. University of California Press. p. 85. ISBN 9780520001565.
18. Kumar, A., Singh, P., & Mehta, R. (2024). Artificial intelligence applications in production optimization and process automation. International Journal of Industrial Engineering Research, 29(2), 55–68.
19. Kumar, R., Sharma, P., & Singh, S. (2022). AI-driven smart manufacturing: Reducing cost and improving efficiency. International Journal of Industrial Automation, 30(2), 89-105.
20. Le Fevre, John (10 November 2019). "Khmer gather to eat ork ambok as disruption attempt foiled (photo gallery)". ACC News Today. Retrieved 5 July 2021.
21. Lee, H., Kim, S., & Park, J. (2023). Artificial Intelligence and Industrial Automation: Implementation Challenges and Economic Impact. International Journal of Smart Manufacturing, 40(1), 55-75.
22. Mary Ann Quioc Tayag (11 December 2002). "For the love of duman". PhilStar. Retrieved 6 July 2015.
23. Mehta, K., & Iyer, R. (2021). Computer vision and AI applications in food quality control. Journal of Food Engineering, 75(4), 299-314.
24. Mehta, L., & Iyer, D. (2021). Quality control metrics and defect rate analysis in agro-based food production. Food Processing and Engineering Review, 15(4), 233–247.
25. Mellie Leandicho Lopez (2001). A Study of Philippine Games. University of the Philippines Press. p. 139. ISBN 9789715422956.
26. Patel, A., & Sharma, N. (2023). Robotic Process Automation in Food Packaging: Efficiency, Accuracy, and Cost Reduction. Journal of Food Engineering, 45(3), 178-193.
27. Raj, S., Mehta, K., & Iyer, R. (2021). Computer vision and AI applications in food quality control. Journal of Food Engineering, 75(4), 299-314.
28. Sharma, D., & Patel, M. (2021). Challenges and opportunities in Poha production: A labor-intensive industry perspective. Indian Journal of Food Science, 20(1), 56-72.
29. Singh, A. K. (2025). Enhancing CNC machining precision using AI-based process monitoring and control. Science and Technology Journal, 13(1), 165–176. https://doi.org/10.22232/stj.2025.13.01.15
30. Singh, A. K., & Patel, R. (2023). Labor cost analysis and efficiency modeling in semi-automated food industries. Journal of Manufacturing and Operations Research, 17(1), 89–104.
31. Smit, B.A. (2011). A New Kind of Normal: Back to the Basics a Comprehensive Survival Guide for Eating Sugar -- Gluten -- Dairy and Yeast Free. Tuttle Publishing. p. 143. ISBN 9781426975127.
32. Smith, J., Doe, R., & White, L. (2021). Machine Learning Applications in Manufacturing: Case Studies and Practical Insights. Manufacturing AI Review, 12(5), 303-319.
33. Sodha, Meera (2016). Made in India: 130 Simple, Fresh and Flavourful Recipes from One Indian Family. Penguin UK. ISBN 9780241278833.
34. Tran, Rachel (11 February 2020). ""Cốm" (Green Sticky Rice) – Autumn's Special Gift". Vietnam Discovery. Retrieved 5 July 2021.
35. Zhang, W., & Li, C. (2020). Computer Vision for Quality Control in Food Processing: Emerging Trends and Innovations. Journal of AI in Food Technology, 28(6), 145-167.

Multidisciplinary International Research Journal

EFFECTIVENESS OF MARKETING STRATEGIES OF LENSKART, IN RELATION WITH ITS CUSTOMER SATISFACTION

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Abstract

Unquestionably, COVID-19 virus has disrupted most of industries across the world, and the Indian eyewear industry was not an exception either. The eyewear industry in India has witnessed a significant change in direction in the post-pandemic period compared with the pre-pandemic one. The virus initially affected the eyewear market adversely, however, the pandemic also, ironically, had several positive effects in the eyewear market, and gave it the boost that it always desired. Certainly, the marketing strategies used by companies have also notably contributed to such boost. Marketing is the most important function in any business, and the more effective such techniques are, the more will the business succeed. One crucial measure of effectiveness of the marketing techniques used by a company is its customer satisfaction. Customer satisfaction rate not only determines the current performance of the business, but also suggests the prospects of the same in the future. Accordingly, an attempt has been made to conduct a research study in order to understand the effects of such marketing strategies, taking customer satisfaction as the primary basis. Moreover, in order to assist the study, the author has also taken a case study of the company Lenskart, which is undoubtedly the most rapidly growing eyewear business in India over the last few years. The study would aim at, eventually, concluding the effectiveness of these marketing strategies. For the purpose of data and statistics, a comprehensive questionnaire regarding customer experience and satisfaction was prepared and 120 responses were collected. Hence, primary data consists of a sample space of 120 responses. Apart from this, secondary data was also extracted from newspapers, reports and from the internet. Inferences are based on the customer satisfaction derived from the primary data, while the secondary data also has significantly affected this study.

Key words – *Eyewear Industry, Sustainability, Pandemic, Lenskart, Marketing, Customer Satisfaction*

INTRODUCTION

The best activity of any business is marketing. What we see is what we purchase and what we see is entirely dependent on the manner the product is marketed or advertised. Simply put, it is doing well to attract people to the products/services of a business. Marketing, as such, is a very broad concept, which has several spheres. It is initiating before the very production process and is maintained even after selling the product. Conventionally, the concept of marketing has been called business activity performance that guides the goods and services movement between producers and consumers. The broad spectrum however does not confine itself to this. As an example, before the production process begins, activities like provision of brand name, identification of needs of the customers, gathering of information that will be used to formulate the product and design of appropriate product package are carried out. Likewise, numerous after sales activities that occur upon sales such as customer/post sales services are needed to ensure good customer relation and subsequent sale. Marketing is significant in meeting both the profit and non-profit making organisational objectives. It aids in fulfilling the needs and wants of the consumers and upgrading their living standards. Through embracing marketing orientation, an organisation will be able to realize its goals in the most effective/efficient way. Besides, marketing is also a driving force in the economic growth of a nation. The marketing mix is an important concept, which is comprised of several different elements, which in general have been grouped into four categories, commonly referred to as four Ps of marketing. They include: (i) Product, (ii) Price, (iii) Place and (iv) Promotion. The business success rests in the quality of mixing of these ingredients to bring better value to the customers and at the same time meet the sale and profit targets. Therefore, marketing is one of the fronts that no company should afford to compromise. Customer satisfaction refers to a measurement that identifies the level of happiness of customers with the products and services of the company, and its capabilities. This kind of information like surveys and ratings could assist a company in knowing how it can best improve or alter its products and services. In any business, customers are the primary concern. A happy customer is a secret that includes consistency. Organizations must not believe that they are aware of what the customer desires. Rather, one ought to know the voice of the customer, where customer surveys, focus groups, and polling (among others) come in. Organizations can use these tools to develop a comprehensive understanding of what their customers desire and improve their services or products to assume or surpass the expectations of the customers. Besides, the customer satisfaction level represents the present performance and future outlook.

Lenskart (Lenskart Solutions Pvt. Ltd. formally) is an Indian multinational eyewear retail chain that deals in prescription eyewear, active in online and offline platforms; it is a developer of an optical platform of several varieties of eyewear. With a funding of 774 million (as of November 2021), revenue of about 120.64 million, Lenskart has a valuation of 2.5 as a company. To fill some gap in the Indian eyewear market, the founders have established the company with the purpose to give sufficient and cheap eye-care to all, as they have realized that a third of the Indian population has eye complications and needs eyeglasses, but do not have them at their disposal at affordable rates. The company is trying to revolutionize the eyewear industry in India and make high-quality designer glasses available to each Indian, without forcing them to empty their pockets. And this goal, the company argues would be achieved with a powerful strategy in its marketing.

STATEMENT OF PROBLEM

Understand and Analyze the effectiveness of the marketing strategies of Lenskart, by gathering data about the customer satisfaction of the company; in case marketing strategies are not up to the mark, then find out the causes/factors for the same, and provide relevant suggestion(s) in the capacity of this study.

REVIEW OF LITERATURE

The marketing environment includes all the factors a company needs to think about while creating and launching a new product. This environment covers changing customer preferences, competition, legal and political rules, government regulations, the company's own budget and resources, current market trends, and the overall economic situation (Mary Strain, 2022). Marketing itself involves a wide range of strategies, and these strategies differ from one industry to another. As industries continue to grow and change, certain marketing strategies may work better for some companies than for others (Alexandra Twin, 2023).

Many people often confuse marketing with selling and use the two terms interchangeably. However, they are not the same. Marketing includes activities such as product planning, pricing, promotion, and distribution. Selling, on the other hand, mainly focuses on transferring the product from the seller to the buyer. To choose the most effective way to communicate with the target audience, it is important to study their lifestyle and preferences (Tim Burris, 2022). A strong marketing plan should always be based on research that highlights changing consumer needs and emerging market trends (Mary Strain, 2022).

An important part of a good marketing plan is the promotion mix, which includes advertising, personal selling, sales promotion, and publicity. These tools are used in different combinations to achieve promotional objectives. Additionally, studying competitors' products, pricing, distribution methods, payment options, advertising techniques, social media presence, and other promotional strategies plays a vital role in making informed marketing decisions (Steve Milano, 2020).

When it comes to customer satisfaction, calling it "important" is no longer enough. In 2023, customer satisfaction has become a necessity for businesses. About 81% of marketers consider customer satisfaction as the main area of competition in their industry. It is one of the strongest indicators of customer loyalty and future purchase decisions, and it also helps in predicting business growth and revenue (Marta Szyndlar, 2023). However, customer satisfaction should not be maximized without limits or ignored altogether. Instead, companies should focus on optimizing satisfaction by balancing customer expectations with the resources available to the organization (Forrest V. Morgeson et al., 2023).

Lenskart is transforming the eyewear industry in India by serving over 1,00,000 customers every month through a strong online platform (www.lenskart.com), more than 1,400 well-designed physical stores, and a unique home eye check-up service. This multi-channel approach has helped the company reach a wide customer base efficiently (K.V. Shanmugavadivu, 2018). The company's main objective has been to add real value to customers' lives by eliminating middlemen, establishing high-quality manufacturing units, and delivering products directly to consumers across India (Lenskart.com, 2023). Research conducted by K.V. Shanmugavadivu revealed that 84% of respondents preferred buying eyewear from Lenskart, and 74% were willing to recommend the brand to others. These findings indicate strong company performance and a high level of customer satisfaction.

OBJECTIVES OF THE STUDY

- To study marketing as a concept of business, and understand its relation with customer satisfaction, taking Lenskart as a case study.
- To process and analyze the primary data obtained, in order to derive the level of customer satisfaction.

- To use the results in inferring the effectiveness of the marketing strategies used by Lenskart, and determine the reasons for ineffectiveness, if the case arises.

SCOPE OF THE STUDY

The pandemic has significantly changed the face of business and industries as a whole. It is imperative to understand how the industries could cope up from the adverse effects of the pandemic and sustain their performances in the post-pandemic period. Moreover, the evolution of business across the world has led to the importance being shifted from producers to consumers. This has resulted in businesses indulging in diverse marketing techniques, and understanding the satisfaction levels of their customers. This study aims at replicating the above and understand them considering Lenskart as an example. The scope of the study, as well, extends to the some of the marketing strategies generally used by players in the Indian Eyewear industry. A survey has been conducted to derive the customer satisfaction. The study is only limited to the twin cities of Hyderabad and Secunderabad, Telangana, India, and is restricted to the opinions of people living in urban areas only. The scope covers the analysis done on and inferences made from the above-mentioned approaches.

HYPOTHESES OF RESEARCH

- H1 – The customer satisfaction rate of Lenskart is competent, hence proving the effectiveness of the marketing strategies used by the company; continuation of such strategies and regular improvements are desirable by the company.

- H2 - The customer satisfaction rate of Lenskart is inadequate, hence concluding that the marketing strategies of company are not effective enough; continuation of such would be fatal for the business, and therefore, there is an immediate need for the company to revisit and re-formulate its Planning and Course of Action in regards to Marketing.

RESEARCH METHODOLOGY

This research is largely based on the primary data obtained from people who filled a detailed questionnaire. The sample space is 120 responses. Responses were diversely collected from all genders and all age groups across the twin cities of Hyderabad and Secunderabad, Telangana, India. The questionnaire was prepared comprehensively, considering several aspects and requirements of this study; hence first-hand information was collected directly from consumers. The questions asked were related to

- The consumers' experience in the Lenskart store or/and website,
- The type and quality of products they have used/viewed,
- Rating the company on various factors,
- Marketing strategies and USPs of Lenskart,
- Potential improvement in the performance of the business, and
- Preferred alternate brand options available in the market.

Based on the responses received, primary data was converted into statistical tables, graphs and diagrams, and further analysis was done on these. Percentages, arithmetical mean and mode were the statistical methods applied. Secondary data was also collected from newspapers, reports and information and statistics from the internet. This data and the primary data collectively resulted in the inferences derived in this study.

LIMITATIONS OF THE STUDY

- The research is based on primary data of a sample space of 120 responses only, hence restricting the scope of the study.
- The study is also affected from the data obtained from secondary and published sources.
- The data is collected only from the twin cities (urban areas) of Hyderabad and Secunderabad, therefore limiting the area of study.
- Time constraints also act as a limitation of this study.

CONCEPTUAL FRAMEWORK & THEORETICAL APPROACH

Eyewear products are all products worn or tangential to the eyes. Such products can either serve fashion, improved vision or to guard the eyes against the environment. Typical eyewear items consist of sunglasses, contact lenses and spectacles. The Indian eyewear sector has been in the past years increasing at a greater rate and in fact, it is set to expand and attain a market value of approximately 3.6 billion dollars by the year 2024. With the increasing demand, firms in this sector are orienting to the development of the fashionable, quality and cheap eyewear. Designs and patterns are introduced frequently to follow the changing fashion trends and to target the customers who are fashion conscious. Players in the market are also making unending attempts to attract and retain new customers, and this has contributed positively towards the growth of the industry. The demand among female consumers has been on the rise particularly in regard to stylish and branded eyewear. Deloitte projects that eyewear market will experience a growth rate of more than 9 percent in the form of compound annual growth rate (CAGR) and that by 2024 the market will have expanded to more than 13.6 billion. This is aided by good population trend and the economic growth.

The Eyewear Industry is experiencing growth due to the following reasons. The fast development of the eyewear business can be attributed to a set of reasons, some of which gained greater significance during the post-pandemic period. They are an increasing population in the world, an increase in the level of economic development, increase in the disposable income, and increased number of eye-related issues and complications. The vision problem is on the rise due to the increased use of digital devices, particularly after the pandemic, including eye strain, dry eyes, myopia, hypermetropia, cataracts, double vision, and computer vision syndrome. Market growth has also been supported by lifestyle changes in the wake of the pandemic and increased preference of luxury accessories by millennials. The growing population of working women and the independence that they have in terms of finance has also helped to increase the demand of eyewear particularly among women consumers. The use of celebrity endorsements has contributed significantly towards the popularity of designer and high-end eyewear. Also, the increased popularity of contact lenses has assisted in increasing the eyewear market in general. There is also an attempt to enhance and standardize eye-care services in the tier-2 cities, rural areas and remote locations. Elderly individuals are usually affected with age related vision defects like presbyopia and cataracts further boosting the demand of eyewear products. All these are signs of high future growth of the eyewear industry.

Lenskart's Unique Selling Propositions (USPs) - Prior to getting to know the marketing strategy of Lenskart, one would want to review the main benefits that the company provides:

High Quality - Lenskart is the first and the only eyewear brand in India that applies robotic technology, which has been imported by Germany. This is an automated process that provides great precision in the manufacturing of glasses to the level of three digits. The firm is a zero-tolerance company towards mistakes and pays much emphasis on customer satisfaction. Its customer service department is always active in addressing the needs of customers and fixing problems according to the feedback.

Wide Variety - Lenskart has a great variety of eyewear products such as sunglasses, reading glasses and contact lenses. The brand also has over 5,000 styles and is almost five-folds the number of options in comparison with other retailers in India. The company boasts that it covers all the requirements; the daily wear, fashion wear and special occasion eyewear. Lenskart is motivated by the world fashion trends and leading designers and replaces its collections annually to meet the demands of all age categories of customers: men, women, children and the elderly.

Value for Money - Lenskart uses a direct-to-consumer business approach by procuring products directly to manufacturers. This does away with intermediaries and assists in saving on unnecessary expenses. The brand has a great variety of eyewear prices, between 345 and 30,000, so it is affordable by various groups of customers.

Logistical Convenience - Lenskart offers the service of home eye check-up, whereby customers have the home delivery of eye test carried out through the use of advanced computerized technology by certified professionals. Customers are also able to sample frames in their houses and make their order, select the preferred design, with ease. In a bid to give the assurance of trust and reliability, all products are accompanied with an authenticity card, a 14 days no questions asked refund policy, and a one year warranty.

THE FAR-SIGHTED MARKETING STRATEGY OF LENSKART

The example of Lenskart is a good illustration of the effective use of traditional marketing techniques in combination with the modern strategies and modern technologies. There are various methods that are employed by the company to market and advertise its products, as discussed below.

- Production - Marketing is not only about the way a product is being advertised, it is also about the product. Lenskart is a company that provides high quality eyewear manufactured on high technology that guarantees high accuracy of lenses up to three decimal levels. The firm produces their products in their own factory situated in Gurugram. This would enable Lenskart to save on additional expenses and provide high quality goods at reasonable prices.
- The Distribution and Market Presence - Lenskart delivers its services to its customers in online and offline platforms. The omni-channel approach allows the company to deliver an unbroken customer experience in all the customer touchpoints. In the case of its brick-and-mortar stores, Lenskart has implemented a franchise strategy, and it has been used to grow fast with limited investment. The company is also pursuing a Direct-to-Consumer (D2C) model where there will be no intermediaries, cost will be minimized, and Lenskart will know the needs of the customers better. The customer feedback is actively gathered and utilized to enhance the services and products.
- Use of Technology - Technology is one of the major factors that improve the customer experience of Lenskart. In 2015, the company launched a 3D virtual try-on feature whereby customers can virtually test eyewear by using virtual reality (VR). This according to founder Peyush Bansal, is what draws about 15000 users to the site every day. Lenskart also operates the modern eye-testing equipment in its stores and home eye-check to be able to offer the client the effective results of the vision testing.
- Promotion Mix - Lenskart has a mixture of promotion that is well balanced with a combination of digital and traditional promotion mix. The brand uses both Google, Facebook, and Instagram specifically to advertisements where it targets specific audiences, whereas the traditional media involve newspapers, billboard advertisements, television advertisements, and email marketing. The endorsements of the brand by renowned style idols such as Karan Johar and Katrina Kaif have also enhanced the brand image among the youthful customers. Moreover, effective search

engine optimization (SEO) has boosted Lenskart to top ranking in Google search engines, and this has boosted its sales. Competitive promotional packages have also been significant towards the overall development of the company.

DATA ANALYSIS AND INTERPRETATION

From the 120 responses received, the following have been derived and subsequent inferences have been made. The following key-points showcase the major, significant and note-worthy results obtained from the primary data.

- Responses were received, more or less, equally/evenly from
  (a) both men and women (2 responses from the 'third gender' as well)
  (b) all age groups
  (c) the targeted major professions (students, self-employed, working professionals and homemakers)

- Respondents became aware about Lenskart and its products/services mostly from word of mouth and ads on TV/newspapers. Most respondents purchased spectacles (for vision correction) from Lenskart.

- They were also asked about the USP(s) of Lenskart that impressed them the most. (Respondents were allowed to select more than 1 option) The responses received are tabulated as follows -

Table 1 – USPs of Lenskart

Particulars	Responses
Affordability/Price	46
Types/range of products	50
Quality of products	70
Style/fashionable products	42
Easy availability of store/delivery	27
After-sales services	7
"Try in 3D" feature on website	41
Other	0

It can clearly be seen that people believe the 'quality of products' is the strongest USP of Lenskart, followed by the 'range of products,' 'affordability' and 'fashionable products.' The "try in 3D" feature available on the website is also a very unique feature, and is appreciated by many people.

- Respondents were asked to rate the company, its products and services out of 5 stars on various parameters. The ratings received are as follows. Arithmetic mean is the statistical tool used here to analyse.

Table 2 – Ratings (Average)

Parameter	Rating (Average)
Ambience/Response received at the store	4.17
Quality of the product(s) purchased	4.27
Packaging and Delivery	4.25
After-sales service/customer service experience	4.20

Overall experience at Lenskart (website only)	4.20
Overall experience at Lenskart (store only)	4.21

Evidently, the results received are quite exemplary. The average is 4+ stars out of 5 stars in every single parameter, with the highest being 'the quality of the product,' undoubtedly. Lenskart's performance is definitely very impressive with such high ratings and high levels of customer satisfaction.

- Respondents were also asked about the area(s) in which Lenskart can improve. (Respondents were allowed to select more than 1 option). The options provided were (a) Price, (b) Quality, (c) Range/Types of products available, (d) Physical stores and salesmen/technicians, (e) Website, (f) Packaging and Delivery, (g) After-sales services, and (h) Other. The responses are presented in the following bar diagram.

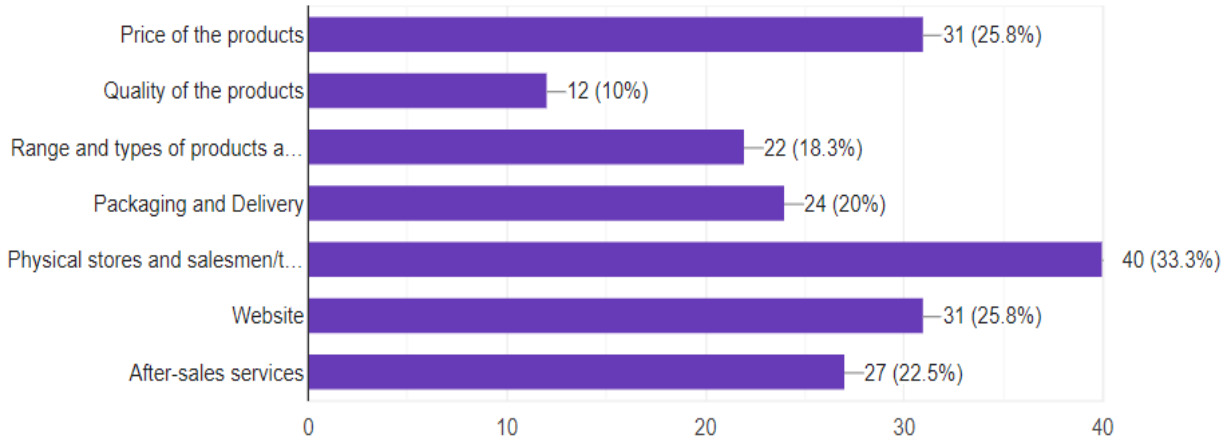

Figure 1. Area(s) in which Lenskart can improve

The area which Lenskart should focus on improving the most is 'the physical stores and salesmen/technicians.' Other areas include 'price,' 'website' and its 'packaging/delivery.' Improvement in these areas will help Lenskart grow and develop faster.

- Responses were also received about whether or not they would recommend Lenskart to their relatives/friends. The results were –

Table 3 – Recommend Lenskart to others

Particulars	**Responses**	**%**
Yes	110	91.7%
No	10	8.3%
Total	**120**	**100%**

Presenting the data in the form of a pie chart -

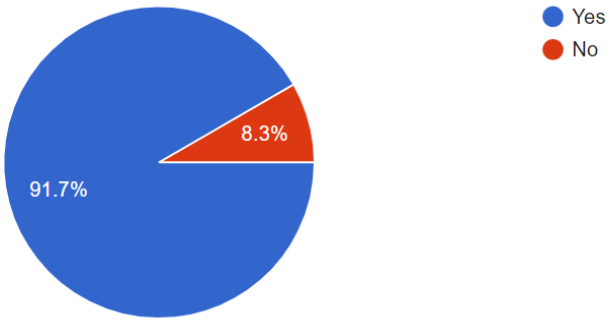

Figure 2. Word of Mouth analysis

Word of mouth is definitely the strongest factor behind any company's success. The result received guarantees strong and successful growth and expansion of Lenskart, and promises a bright future for the company. Moreover, 75% people would prefer buying more products from Lenskart only, rather than other brands/platforms. This ensures a good customer repeat rate for the company.

- They were also asked about their opinion on the company's strongest marketing strategy. The results in the form of a pie chart are –

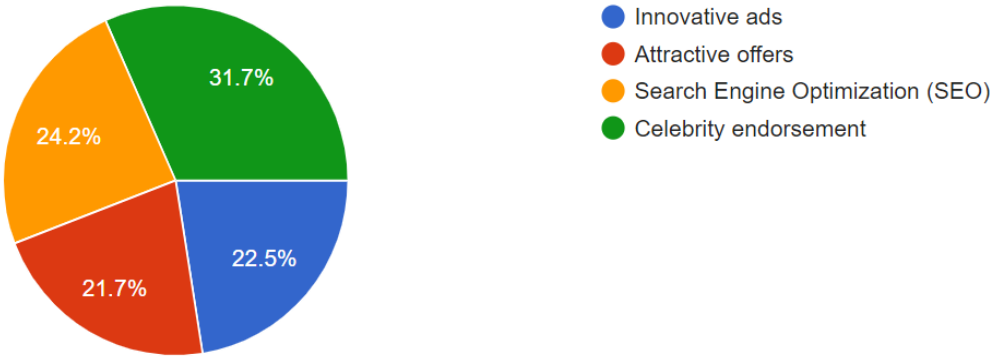

Figure 3.Opinion on the company's strongest marketing strategy

People opined that most of the marketing techniques used by Lenskart are very effective, while 'Celebrity Endorsement' has the highest number of responses. Responses were more or less evenly received for all the options.

- They were also asked for any feedback or suggestion they would like to provide. (This was an optional question; hence the sample space is less than 120)
  9 responses were received. Those are as follows -
  (i) Can improve in the style and range
  (ii) Quality was not up to the mark
  (iii) Range of the products can be improved
  (iv) Can have more range of products in stores
  (v) The store person wasn't well aware about the products
  (vi) Range can be improved
  (vii) Store person didn't attend me properly

(viii) Great products, nice service
(ix) The website looks too simple. The company should improve their website.

FINDINGS

- The perception of people about Lenskart was understood from the study. Most responses were positive about the company. Accordingly, it can certainly be inferred that most people are quite satisfied with almost all aspects of Lenskart's performance.
- Responses also help in understanding that the marketing strategies used by Lenskart are very effective, and are giving fruitful results. The growth pattern is positive and there is lot of scope for expansion (domestic and global expansion) in future.
- However, Lenskart also has scope for improvement and should focus on certain areas like 'the physical stores and salesmen/technicians' and the 'website,' as revealed from the study.
- Overall, it can strongly be concluded that the marketing strategies of Lenskart are very effective and efficient, which have resulted in a very positive and high customer satisfaction rate.

SUGGESTIONS

Since the responses received were quite positive, the scope for suggestions is very limited. However, the following points are concluded.

- Responses were received stating that the sales persons at the stores were not trained properly. They did not attend the customers properly and were not adequately aware about the products. Hence, the company should also focus on training its employees, especially the sales persons, more appropriately, while also developing the tangible and intangible infrastructure at the stores.
- Few people also believe that the website has scope for improvement. Lenskart can also focus on developing the UI (User Interface) of its website, and can make the AI (Artificial Intelligence) even more accurate.
- Now that it has captured a large segment of Indian Eyewear industry, it should also more actively extend its facilities and operations to other countries (which it has already started in the Middle-East and the USA).

PROVING THE HYPOTHESES

Since the customer satisfaction level derived from the primary data (and other testimonials received from alternate sources) is reasonably high, the following can be effectively concluded.

- H1 stated as "The customer satisfaction rate of Lenskart is competent, hence proving the effectiveness of the marketing strategies used by the company; continuation of such strategies and regular improvements are desirable by the company" has been successfully proved to be true and accurate.
- H2 stated as "The customer satisfaction rate of Lenskart is inadequate, hence concluding that the marketing strategies of company are not effective enough; continuation of such would be fatal for the business, and therefore, there is an immediate need for the company to revisit and re-formulate its Planning and Course of Action in regards to Marketing" has been proved to be false.

CONCLUSION

The research study successfully resulted in understanding the overall scope and performance of the company Lenskart. The company was studied in detail to understand its mission, vision, history and overall operations. The researcher also comprehensively understood the marketing strategies of the

company. An attempt was also made to evaluate the customer satisfaction level of the company. Analyzing the responses received from the questionnaire, it can be strongly concluded that Lenskart's performance in the Indian market is very satisfactory with high and positive customer satisfaction rate. It also helped in inferring that the marketing strategies used by the company are very efficient and gave fruitful results to the company. Lenskart has already occupied a major segment in Indian market and has expanded to other countries as well. The company is growing at a very good rate and has a large potential for development in the future as well. It can be positively stated that Lenskart may, as well, become a significant player in the global eyewear industry in the future.

REFERENCES

1. Alexandra Twin (March, 2023) "Marketing in Business: Strategies and Types Explained" , published report on Investopedia.com https://www.investopedia.com/terms/m/marketing.asp
2. Class 12 Business Studies, book by Sandeep Garg
3. Deloitte India (October, 2018) "Eyewear market in India", published on the company's website https://www2.deloitte.com/content/dam/Deloitte/in/Documents/consumer-business/immersion/Eyewear%20market%20in%20India.pdf
4. https://www.lenskart.com/about-us.html
5. G. Tomas M. Hult and Forrest V. Morgeson (January, 2023) "10 Ways to Boost Customer Satisfaction" , Harvard Business Review. https://hbr.org/2023/01/10-ways-to-boost-customer-satisfaction
6. K.V. Shanmugavadivu (2018) "A STUDY ON CUSTOMER PREFERENCE TOWARDS LENSKART ONLINE SHOPPING" , International Journal of Innovative Research in Engineering & Multidisciplinary Physical Sciences
    a. https://www.ijirmps.org/papers/2018/4/206.pdf
7. Mary Strain (January, 2022), "How Do Elements of a Marketing Environment Affect Marketing Decision-Making?", Report published on the internet. https://smallbusiness.chron.com/elements-marketing-environment-affect-marketing-decisionmaking-35841.html
8. Marta Szyndlar (February, 2023) "Customer Satisfaction: Why It's Important in 2023" , report published on survicate.com https://survicate.com/customer-satisfaction/importance-customer-satisfaction/
9. Neerja Singh (June, 2020) "Corona Pandemic – Impact of Covid on Eyewear Industry" , Published on Cleardekho.com https://www.cleardekho.com/corona-pandemic-impact-of-covid-on-eyewear-industry
10. Tim Burris (2022) "5 Steps in a Project Communications Plan in Project Management" , Report published on the internet. https://smallbusiness.chron.com/5-steps-project-communications-plan-project-management-18757.html
11. 'The Times of India' newspaper https://smallbusiness.chron.com/importance-marketing-strategy-organization-65269.html
12. Steve Milano (October, 2020) "What Are the Key Marketing Decisions?" , Report published on the internet.https://smallbusiness.chron.com/key-marketing-decisions-25575.html

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ANALYSING THE LIGHTING ENERGY CONSUMPTIONS OF TRANSLUCENT CONCRETE FOR ENERGY EFFICIENCY IN INTERIOR LIGHTING

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Abstract

This paper explores the potential of translucent concrete to reduce artificial lighting needs in restaurant interiors, focusing on a study of a dining area of a restaurant located in city of Ahmedabad, Gujarat (India) as a model. By evaluating the restaurant's current lighting conditions as a base case and comparing them with a designed scenario where a translucent concrete is imagined in place of current blank concrete wall as an improved case, the study aims to evaluate potential energy savings and electricity cost benefits. The research leverages observations which include the floor plans, lighting fixtures, and electricity bills, alongside the calculations based on translucent concrete properties with 6% optical fibres (Shitote, Tuaum, and Oyawa).

Key Words - *Energy Efficiency, Building Materials, Interiors, Artificial and Natural Lighting.*

1. INTRODUCTION

1.1 Background and Rationale

India, as the world's third-largest energy consumer, is experiencing rapid urbanization and growth in its construction sector, which accounts for a significant portion of energy consumption. With over 70% of the buildings that will exist in 2030 yet to be constructed, it is crucial for India to adopt energy-efficient building practices ("India: Energy Efficiency"). According to the International Energy Agency (IEA), India's energy demand is expected to double by 2040, with the building sector alone accounting for nearly 40% of this increase ("India 2020: Energy Policy Review"). Countries like China have already begun adopting energy-efficient practices, with programs aimed at reducing building energy use by 20% by 2025 (Li et al.). In contrast, India's current energy-saving initiatives in the building sector lag, necessitating an urgent shift towards innovative materials and sustainable design to match global trends and mitigate rising energy demands.

Interior lighting plays a critical role in the functionality and ambiance of spaces such as restaurants, where the quality of light can affect both the dining experience and operational costs. Traditionally, artificial lighting has been the primary source of illumination in such spaces, particularly in areas with limited access to natural light. However, this reliance on artificial lighting can lead to increased energy consumption and higher operational costs, especially in regions with ample sunlight like Ahmedabad. In hot climates such as Ahmedabad, where daylight is abundant, the potential to harness natural light is significant (Psomopoulos).

Ahmedabad, located in the state of Gujarat, India (latitude 23.0225° N, longitude 72.5714° E), experiences a predominantly hot and arid climate throughout the year, characterized by long hours of sunlight and minimal cloud cover during most months. According to the India Meteorological Department (2020), Ahmedabad receives an annual average of over 2,800 hours of sunshine, making it one of the sunniest cities in India. Peak daylight hours are typically observed between March and June, with an average daily solar insolation of 5.5 to 6 kWh/m²/day during this period (Saxena et al., 2017). Moreover, Ahmedabad's relatively clear sky conditions, with approximately 280 sunny days per year (Climatological Data Summary, 2020), support the effectiveness of translucent concrete for maximizing natural light transmission. By utilizing such material, interior spaces can maintain adequate luminance levels during the day, potentially offsetting the energy costs associated with artificial lighting, especially in commercial spaces such as restaurants that operate during peak daylight hours. This consistent availability of natural daylight makes Ahmedabad an ideal location for integrating translucent concrete in building designs, especially in areas such as restaurants, where energy efficiency is crucial. Translucent concrete, with its ability to diffuse natural light, can harness the abundant daylight available, reducing the reliance on artificial lighting, particularly during daylight hours.

Studies have shown that the use of daylight in interiors can reduce the dependency on artificial lighting, thus contributing to energy savings and environmental sustainability (Smith 45). Translucent concrete, a composite material embedded with optical fibres, allows light to pass through while maintaining the structural properties of conventional concrete (Li et al.; Vaitkevičius et al.; Lucconi et al.). This capability makes it an ideal candidate for reducing the need for artificial lighting in spaces that receive sufficient daylight, potentially leading to significant energy savings and reduced electricity costs.

The application of translucent concrete when it comes to interiors within India, specifically in the context of energy savings, remains underexplored. This study seeks to fill this gap by evaluating the potential benefits of using translucent concrete in a restaurant setting, with a focus on the specific climatic conditions of Ahmedabad (Gujarat). A widespread adoption of translucent concrete in India's construction industry remains limited. The material, while innovative, has not seen significant uptake due to factors such as high production costs and a lack of awareness among architects and builders (Kumar 23).

1.2 Objectives, Scope and Limitations of the Study

This study aims to:

- Evaluate the potential of translucent concrete to reduce artificial lighting needs in the restaurant's interior selected as a study.
- Calculating if the translucent concrete can be a contender for a wall material support activities that require adequate lighting like dining.
- Provide a comparative analysis using calculations for the existing dining area at *Masala Marke* a restaurant in Ahmedabad as a model.

The scope of this study is limited to the first-floor dining area of *Masala Marke* restaurant located in Ahmedabad. The study does not involve any physical alterations to the existing structure but rather simulates the potential impact of reimagining a blank concrete wall with translucent concrete. The findings of this study are intended to inform future design decisions in similar settings on selection of materials for interior architecture assuming that blank facades, such as the one existing in the case of *Masala Mark*e, could potentially be made with translucent concrete. The study does not engage in analysis of the structural feasibility of such an application. For the purposes of this study, it is assumed that the optical fibres and steel reinforcement will function seamlessly within the translucent concrete wall, like how conventional reinforced concrete (RCC) walls would behave under typical conditions. The focus remains on the material's light-transmitting properties and potential to reduce artificial lighting requirements.

2. LITERATURE REVIEW

2.1 Translucent Concrete

Translucent concrete, also known as light-transmitting concrete, is a relatively new material that has gained attention in recent years for its ability to transmit light through embedded optical fibres. The concept of translucent concrete was first introduced by Hungarian architect Áron Losonczi in 2001, leading to the development of LitraCon, the first commercially available translucent concrete product (Valli, 2019). The material is composed of fine concrete and thousands of optical fibres that are arranged in a matrix, allowing light to pass through the concrete. The light transmission is dependent on the percentage of optical fibres in the mixture, with higher concentrations resulting in greater light transmission.

The potential applications of translucent concrete are vast, ranging from architectural facades to interior partitions, where it can be used to create unique lighting effects and reduce the need for artificial lighting. The key feature of translucent concrete is its ability to transmit light while maintaining the compressive strength and durability typical of conventional concrete. Studies have shown that the light transmittance of translucent concrete can be controlled by adjusting the concentration and arrangement of optical fibers within the mix (Zhu et al. 348). For this study, the focus is on translucent concrete with a 6% optical fibre content, which has been shown to provide an optimal balance between light transmission and structural integrity (Wang et al. 259).

2.2 Daylight Utilization in Interiors

Daylighting, the practice of using natural light to illuminate interior spaces, has been widely recognized as an effective strategy to reduce energy consumption in buildings. Research indicates that daylighting can significantly decrease the need for artificial lighting, particularly in spaces with access to abundant natural light (Reinhart and Selkowitz 151). In addition to energy savings, daylighting has been associated with improved occupant well-being, productivity, and overall indoor environmental quality (Heschong 83).

In restaurant interiors, where lighting plays a critical role in creating ambiance and enhancing the dining experience, the strategic use of daylight can offer both aesthetic and functional benefits. However, the challenge lies in effectively harnessing daylight without compromising the structural and thermal performance of the building envelope. This is where materials like translucent concrete offer a viable solution, combining daylighting capabilities with the strength and durability required for building structures (Franco and Scapazzoni 89).

3. METHODOLOGY

3.1 Study Approach

The research for this study involves a comparative analysis of artificial lighting needs in two scenarios: the current setup with a blank concrete block masonry wall (with no openings) and a hypothetical scenario where the wall is replaced with translucent concrete blocks. The study uses both primary and secondary data sources to conduct this analysis.

3.2 Description & Selection Criteria for the Site (*Masala Marke* Restaurant)

Masala Marke is a popular restaurant located in science city neighbourhood of Ahmedabad, known for its contemporary design and emphasis on providing a comfortable and visually appealing dining environment. The restaurant features a blank wall facing southwest, which necessitates the use of artificial lighting during daytime hours due to the lack of natural light penetration. This wall receives direct sunlight during the day, making it a suitable candidate for the study's focus on daylight utilization. A southwest-facing blank walls are a common feature in buildings in Ahmedabad to minimize heat gain. In hot climates, especially when a building faces southwest, using blank concrete walls with minimal or no openings can significantly reduce heat gain. Limiting direct sunlight exposure by minimizing wall openings can reduce the overall heat load on a building, making it more energy-efficient in warm environments (Givoni 102). Figure 1 shows the blank concrete wall at '*Masala Marke'* facing southwest (Parikh K, 2024) and Figure 2 shows use of interior lightings during daytime (Google, n.d.)

3.3 Data Collection

Data collection involved visits to the restaurant to gather detailed information. Primary data was obtained directly from the *Masala Marke* restaurant, including:

1. Photographs of the existing lighting setup and the blank concrete wall were taken to document the current conditions.
2. Detailed floor plans of the first floor dining area, showing the layout of tables, lighting fixtures, and the blank concrete wall under consideration.
3. A ceiling map to illustrate the placement and specifications of those lighting fixtures.
4. Interviews with the restaurant management to gather insights into the lighting usage patterns and energy consumption.
5. Monthly electricity bills for the restaurant, with a focus on the portion of the bill attributed to lighting.
6. Lux measurements to determine the current lighting levels near the blank concrete wall.

Figure 3 shows artificial lightings along the ceiling slab and Figure 4 shows the layout of lighting fixtures along the dining area floor plan (Parikh K, 2024)

Figure 1. Blank concrete wall at 'Masala Marke' facing southwest
Source: (Parikh, 2024)

Figure 2. Use of interior lightings during daytime at 'Masala Marke'
Source: (Google, n.d.)

Figure 3. Artificial lightings along the ceiling slab at 'Masala Marke'
Source: (Parikh K, 2024)

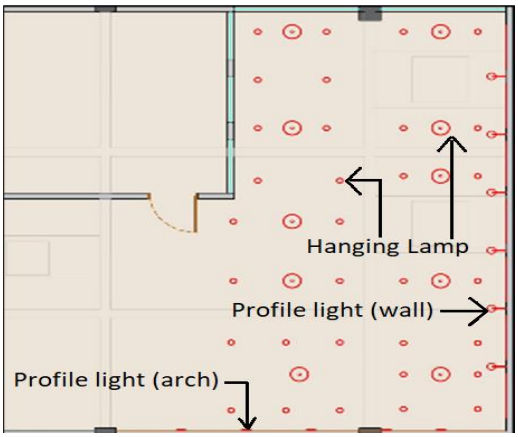

Figure 4. Layout of lighting w.r.t dining area floor plan at 'Masala Marke'
Source: (Parikh K, 2024)

3.5 Current Energy Usage (Base Case)

The restaurant employs a mix of hanging lamps, wall lamps, and downlights for its lighting needs, resulting in a total artificial light consumption of approximately 1,894 W per day (see Table 1). Over the course of a month, this translates to around 397.74 KWh of electricity consumption for lighting alone. At an average electricity rate of INR 7.52 per unit, the restaurant's lighting costs amount to INR 35,825.28 annually. (UGVCL,2024). Table 1 indicates the current daily artificial light and its energy consumption (UGVCL,2024)

Table 1. Current daily artificial light and its energy consumption Source: (UGVCL,2024)

Light Type	**Wattage**	**Number**	**Total Wattage**
Hanging Lamp	100 W	10	1000 W
Wall Lamp	15 W	6	90 W
Downlight	12 W	32	384 W
Profile Light	35 W	7	245 W
Wall Profile	35 W	5	175 W
Total			**1894 W**

4. ANALYSIS AND COMPARISON (IMPROVED CASE)

Based on the provided data, the current artificial lighting setup in the *Masala Marke* Restaurant results in a total of 447 lux from the combined light sources measured using Light Meter - Lux, Exposure by Contechity (Contechity, n.d.). The calculations show that the restaurant uses various types of lighting fixtures (hanging lamps, wall lamps, downlights, profile lights), contributing to approximately 1,894 W of power consumption daily, with a total lux of 447 at the dining tables. According to lighting standards, typical lux levels for dining areas in restaurants are as follows:

- General lighting: 100–300 lux
- Task lighting (for dining tables, food service, etc.): 200–500 lux

According to Illuminating Engineering Society (IES) standards, the recommended average lux level for dining areas is around 150 to 300 lux for comfortable visibility without creating excessive glare or shadows (Illuminating Engineering Society, 2020). For fine dining restaurants, lux levels toward the upper range (300–500 lux) are suggested to create a more aesthetically pleasing environment. If translucent concrete is applied to the south-facing wall, the restaurant would benefit from the transmission of 22% of the available natural light through the translucent concrete panel. The calculated lux levels that would be transmitted into the restaurant are as follows:

- Direct sunlight: 32,000 lux × 22% = 7,040 lux
- Ambient sunlight: 10,000 lux × 22% = 2,200 lux
- Overcast sky: 1,000 lux × 22% = 220 lux

Given the transmission of up to 7,040 lux from direct sunlight and 2,200 lux from ambient sunlight, the restaurant could easily meet and exceed the required lux levels for dining spaces during daylight hours. Even in overcast conditions, the transmitted light would still contribute 220 lux, which would offset a significant portion of the artificial lighting demand.

Translucent concrete contains 6% plastic optical fibers (POF) by volume, which allows for up to 22% light transmittance (Research India Publications, 2020). The south wall of the restaurant, measuring 171 cubic feet, would include 145.35 cubic feet of usable space after accounting for columns and beams. By considering translucent concrete for this wall, the restaurant could potentially transmit 22% of the available natural light. Depending on sunlight conditions, this could result in up to 7,040 lux from direct sunlight or 2,200 lux under ambient conditions (Parikh, 2024). These values are sufficient to offset much of the restaurant's reliance on artificial lighting, especially during daylight hours. Based on the data, the south-facing translucent concrete wall would provide significant daylight to the restaurant, potentially reducing artificial light usage by 50-70%. Table 2 illustrates the anticipated cost savings from using natural light instead of artificial sources. (Parikh, 2024). Since the required lighting standard for dining tables is approximately 300 lux, the translucent concrete would provide more than sufficient natural lighting during sunny and ambient light conditions. Therefore, during daylight hours, the use of translucent concrete could potentially allow the restaurant to reduce artificial lighting use by up to 70%, based on direct sunlight scenarios. Even under ambient or overcast conditions, translucent concrete could offset 35% to 50% of artificial lighting needs, lowering both electricity usage and costs.

Table 2. The anticipated cost savings from using natural light

Condition	**Outdoor Light (Lux)**	**Light Transmission (22%)**	**Artificial Light Offset**	**Potential Savings (INR)**
Direct Sunlight	32,000 lux	7,040 lux	60% reduction	INR 17,912 annually
Ambient Sunlight	10,000 lux	2,200 lux	35% reduction	INR 11,038 annually
Overcast Sky	1,000 lux	220 lux	15% reduction	INR 5,373 annually

Source: (Parikh, 2024)

5. CONCLUSION

The findings from this study suggest that translucent concrete can effectively reduce artificial lighting needs in restaurant interiors, offering significant energy and cost savings. The increased natural light penetration not only reduces energy consumption but also enhances the overall dining experience by creating a highly lit environment (Franco and Scapazzoni 94). In the context of Ahmedabad, where daylight is abundant, the use of translucent concrete in restaurant interiors can contribute to sustainability goals by lowering the carbon footprint associated with energy consumption. Moreover, the potential cost savings on electricity bills could make translucent concrete an economically viable option for restaurant owners and designers. When compared with other daylighting strategies, such as the use of large windows or skylights, translucent concrete offers distinct advantages in terms of structural integrity and thermal performance. Unlike windows, which can lead to heat gain and increase cooling loads, translucent concrete provides natural light without compromising the building's thermal envelope (Álvaro et al. 314). This makes it particularly suitable for hot climates like Ahmedabad, where managing indoor temperatures is a critical concern. The initial investment in translucent concrete may be higher than that of conventional concrete, the long-term savings on energy bills and the potential increase in customer satisfaction due to improved interior ambiance could justify the cost. Additionally, as the market for sustainable building materials continues to grow, the cost of translucent concrete is expected to decrease, making it more accessible for commercial applications (Monticelli et al. 222).

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8.REFERENCES

1. Álvaro, M., Solé, C., Valero, A., & Giménez, P. (2015). Thermal and daylighting behavior of translucent concrete. *Energy Procedia, 78*, 310–315. https://doi.org/10.1016/j.egypro.2015.11.128
2. Climatological Data Summary. (2020). *India Meteorological Department*. Franco, G., & Scapazzoni, V. (2013).
3. Contechity. (n.d.). *Light Meter - Lux, Exposure* [Mobile application software]. Google Play Store
4. Daylighting strategies in architecture. *Journal of Sustainable Architecture*, 89-94.
5. Franco, G., & Scapazzoni, R. (2013). Daylighting and building energy performance: Comparison of design approaches. *Building and Environment, 59*, 83-94. https://doi.org/10.1016/j.buildenv.2012.08.012
6. Givoni, B. (1994). *Passive and low energy cooling of buildings*. Van Nostrand Reinhold.
7. Google. (n.d.). *[Image of Masala Marke]*. Google Images. Retrieved October 8, 2024
8. Heschong, L. (2002). *Daylighting and Productivity: A Literature Review*. Energy and Buildings, 35(1), 83-88.
9. India 2020: Energy Policy Review. (2020). *International Energy Agency*. India: Energy Efficiency. (2020). *IEA Reports*.
10. Kumar, S. (2017). *Building Material Trends in India: Challenges and Opportunities*. Journal of Building Materials, 23-31.
11. Li, Y., Wang, X., & Xu, H. (2018). *Energy-efficient building programs in China*. Journal of Energy Efficiency, 15(4), 347-360.
12. Lucconi, A., et al. (2016). Optical fibres in construction. *Building Innovations*, 34-45.

13. Monticelli, C., Monari, D., Pederzoli, F., Frabetti, M., & Bassoli, E. (2016). Durability of light-transmitting concrete for sustainable building. *Materials and Design, 112*, 216-223. https://doi.org/10.1016/j.matdes.2016.09.047
14. Parikh, Kinwa Jitendrakumar. (2024). *Establishing the effectiveness of using translucent concrete as a building façade (A case of dining restaurant at science city Road, Ahmedabad)* (Master's thesis, SAL School of Architecture, GTU Ahmedabad)
15. Psomopoulos, C. (2017). *Sustainable Architecture: Harnessing Solar Power*. Journal of Renewable Energy, 56(2), 255-268.
16. Reinhart, C. F., & Selkowitz, S. E. (2006). Daylighting in buildings: A review of the state-of-the-art. *Energy and Buildings*, 38(4), 411-419.
17. Saxena, A., et al. (2017). *Solar Power Potential in India: An Overview*. Energy Reports, 3, 149-155.
18. Shitote, S. M., Tuaum, P. G., & Oyawa, W. O. (2014). Light-transmitting concrete. *Construction Journal*, 21-26.
19. Smith, P. (2009). *Green Building Materials and Energy Efficiency*. Journal of Environmental Design, 37(3), 125-139.
20. Uttar Gujarat Vij Company Limited. (n.d.). Bill calculator. UGVCL.
21. Vaitkevičius, V., et al. (2015). *Optical fibres in concrete: A review*. Construction Materials, 45-56.
22. Valli, E. (2019). Innovations in light-transmitting concrete. *Concrete International*, 41(2), 35-38.
23. Wang, Y., et al. (2018). Translucent concrete with optical fibres. *Journal of Construction Materials*, 88-96.
24. Zhu, Y., Chen, H., & Zhou, W. (2014). Light-transmitting properties of concrete. *Journal of Advanced Construction Materials*, 5(1), 112-118.

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"EMBRACING THE END": A NEW ARCHITECTURE TYPOLOGY TO PREPARE FOR THE FINAL JOURNEY (ARCHITECTURAL DESIGN FOR "A HOLISTIC CENTER FOR DEATH-RELATED SERVICES AND REFLECTION" AT VARANASI, UP.)

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Abstract

This study explores the intricate relationship between architecture and the generation of emotions, particularly in the context of death and self-reflection. It focuses on the design of a memorial building in Varanasi, a city deeply associated with Hindu death rituals and the pursuit of moksha. The study begins with an understanding of death as a natural occurrence and includes an analysis of Varanasi's historical and cultural significance, emphasizing its role in Hinduism and its association with the Ganges River. The study highlights principles of architectural psychology and sensory engagement to create spaces that evoke specific emotional responses. Through architectural design, we can create spaces for remembrance, acceptance, and reflection. These spaces can help individuals navigate the complex emotions felt after loss of loved ones, offering warmth and solace to bereaved families. The focus of this study is to explore the broad topic of death from the perspective of Hindu philosophy. It aims to understand the emotions of bereaved families and how an architecture solution can provide consolation and help them navigate their grief. Additionally, this study seeks to offer those not directly affected by loss a broader perspective on

death, illuminating the concepts of life and death as mentioned in Hindu scriptures. By designing suitable architecture facilities, we can offer a holistic approach to death-related services, blending cultural understanding with architectural innovation. An example of architectural solution "a holistic center for death-related services and reflection" at Varanasi, UP showing this phenomenon is represented at the end of the study. This study and the resultant architecture bridge the gap between the outside physical world and inner metaphysical world. For instance, the designed building's concrete structure symbolizes permanence, while the exploratory spaces made of metal with corrugated red facades represent the transient nature of life. Key experiential spaces include a dark entrance indicating the transition from the material to ascetic worlds, a maze of Maya teaching the illusory nature of life, and self-reflective areas encouraging contemplation. The space program for the memorial building encompasses various functions designed to address different needs: a hospice center providing care and support for individuals in their final moments, ensuring dignity and comfort; stay facilities for visitors and families; a dedicated space for devotional singing and spiritual gatherings; spaces for performing traditional Hindu rituals, including ancestor worship (Tarpan); and an auditorium for lectures, spiritual talks, and educational programs related to life, death, and the philosophical teachings of Hinduism. Sensory design techniques, including light, material, and spatial organization, were employed to craft an emotionally resonant journey. The architectural solution aims to provide both a memorial and a routine-use building, fostering a deeper understanding of life and death. The proposed structure serves as a place of education and psychological healing, offering a profound impact on both individual visitors and the broader community.

Keywords - *architecture, emotions, death rituals, moksha, self-reflective areas, memorial, sensory, healing*

1. INTRODUCTION

Death is a universal and fundamental part of life, an inevitable and eternal truth. Yet, today's world does little to address it meaningfully. Many people are terrified by the prospect of death, often considering it a taboo subject that is best avoided (Becker, 1973). Our fears and desires about the afterlife are rarely spoken of unless absolutely necessary. This contemporary discomfort with death perpetuates the myth that mortality is an event we do not need to confront (Poo, 2016).

In Western cultures, death is often viewed as the end of life, with bodies buried until the day of resurrection. In contrast, Hindu culture sees death as an integral part of life, a natural event that marks the beginning of a new cycle. Hindu scriptures offer various texts discussing different aspects of death from diverse perspectives. According to these scriptures, cremation is not just a final goodbye to the departed soul but a series of rituals that provide peace to people left behind and proper farewell for the soul's new beginning. In the 20th century, as we live in technological era, architecture has often been relegated to a mere branch of technology. However, while death is inevitable and unchangeable by science or architecture, architecture holds the power to transform human perspectives on death (Jodidio, 2021).

1.1 Aim and Objective

The aim of this study is to come up with an architectural solution 'a Comprehensive Center' offering services regarding death on the eastern bank of the River Ganga in Varanasi. This center helps in fostering a healthy dialogue about death, encourage individuals to embrace mortality as an integral part of life, and provide holistic services for the bereaved and terminally ill. The project aims integrate the elements of Hindu philosophy and culture, offering spaces for post- cremation rituals, psychological healing, education, and contemplation, while also supporting the well-being of those in the final phase of life. Objectives for this study are as mentioned below:

- To understand and incorporate elements from Hindu scriptures into architectural design to create spaces that resonate with traditional practices and beliefs about life and death.
- Develop comprehensive architectural plan that includes hospice facilities, Post-cremation rituals areas, remembrance areas, a meditation area, and stay facilities for short-term visitors.
- Design spaces that provides psychological healing through sound healing, consultation etc. for grieving individuals.
- Create exploratory spaces that educate visitors about life as described in Hindu scriptures, promoting gratitude and harmonious living.
- Provide hospice facilities where elderly people can receive support and care to enhance quality of their final phase of life.

By achieving these objectives, this study aims to create an architectural solution that not only provide function spaces but also enhances the cultural, emotional, and spiritual dimensions of how society comprehends death as a phenomenon of natural occurrence more positively.

2. RESEARCH METHODOLOGY AND FRAMEWORK

The methodological approach for this architecture study and design includes a comprehensive literature review, case studies, site selection and analysis, development of the architectural program, creation of design philosophy and concepts, and preparation of architectural drawings. The literature review explores death from biological, legal, and religious perspectives, focusing on Hindu rituals. Case studies analyze museum designs to understand how architecture can evoke emotions and tell stories. Site selection involves contextual, climatic, and geographic analysis, including a SWOT analysis to assess feasibility and

challenges. The architectural program is developed based on literature insights, defining proposed areas, floor space index, and expected users to create a holistic death-related service facility. The design concept is formulated to evoke specific emotions using architectural elements. The final architectural design is presented through detailed plans, sections, and 3D visualizations. This approach aims to create a thoughtfully designed Memorial Centre and life-death museum that addresses the emotional, cultural, and practical aspects of dealing with death.

3. CASE STUDIES

The study analyses the Jewish Museum in Berlin by Daniel Libeskind and the Smritivan earthquake Museum by Sangath Vastushilpa. It attempts to understand the development of various spaces that evoke negative emotions in users in the Jewish Museum, Berlin. Additionally, it explores how technology can be used to create spaces that help users comprehend historical events. The case study also examines how a concept can integrate people and culture into the building by creating a spaces that one can use on daily basis. (Schneider, 2007)

4. ASSOCIATION OF ARCHITECTURE WITH DEATH

The association of architecture with death has been significant throughout history, reflecting the cultural, religious, and social attitudes of various civilizations. The structures built to honor the deceased, from monumental tombs to humble graves, reveal much about how different societies view death and the afterlife (Michael H. Fox, 2017).

Ancient Egypt: In ancient Egypt, the practice of preserving dead bodies through mummification began early, using substances like salt, soda, resin, and bitumen. Egyptians embalmed their dead either to keep their bodies with them on earth or because they believed the future welfare of the departed depended on the preservation of their bodies. The custom of preparing tombs during one's lifetime was common, leading to the construction of elaborate tombs to protect bodies from wild animals and elements. The Great Pyramid of Giza is the most iconic example, built as a monumental tomb for the pharaoh's secure and grand journey to the afterlife. (Budge)

Ancient Greece: Ancient Greece was a northeastern Mediterranean Civilization existing from the Greek dark ages of the 12th -9th centuries BC to the end of classical antiquity. The Mausoleum at Halicarnassus, one of the seven wonders of the Ancient World, was an elaborate tomb built in 4th century BCE for Mausolus, A satrap of the Persian empire, and his wife Artemisia II. Located in Halicarnassus, this structure is celebrated for its architectural grandeur and artistic significance. Mausolus ruled Caria, a region of Asia Minor, from 377 to 353 BCE. He and his wife Artemisia II were known for their ambitious building projects and patronage of arts. After the Mausolu's death in 353 BCE, Artemisia decided to build a monumental tomb in his honor, She Build the Mausoleum approximately 45 Meters high and was characterized by its rectangular shape, measuring about 30 by 40 meters at the base. Thus the grand structure exemplifies the importance placed on honoring the dead and ensuring their memory persisted (Editors, 2015).

Islamic Architecture: The arrival of Islam in India began with the early Arab traders on the western coast of India as early as the 7th century, followed by invasions by central Asian Turks and Afghans. This lead to invasion of various dynasties in India leading to establishment of Islamic architecture in India. Various Kings from various Empires created their piece of Architecture from Mosques to mausoleums. The art and Architecture flourished more during the Mughal Period leading to creation of one of the best Islamic architecture. The association of Architecture with Death has led to the erection of some of the very iconic

structures, some examples of architecture include the Taj Mahal, Gol Gumbaz, Humayun's Tomb, Tomb of Sher shah Suri, etc (Asher, 1992)

Hindu Architecture: In Hinduism, the association of architecture with death is multifaceted, reflecting the religion's complex beliefs about life, death, and the afterlife. The architecture connected to death in Hinduism includes cremation grounds, temples, River Banks (Ghats), Kunds, Etc. In Hinduism, cremation is the preferred method for disposing of dead. Cremation grounds, known as "Smashanas", are considered sacred space where the final rites are performed. The architecture of cremation grounds is usually simple, with open spaces for pyres, a source of water for ritual purification, and a small shrine for worshipping deities associated with death, such as Shiva or Yama, the god of death. Along with Smashanas, the design of spaces for death-rituals often includes area for performing Shraddha and Tarpana. These spaces are typically open and may be near bodies of water, considered purifying in Hindu Traditions. Ritual bathing along the rivers like the Ganga are essential architectural features where the living performs rituals to honor their deceased ancestors. Various places in India has the significance importance in post death rituals such as Ghats of river Ganga in Haridwar, Varanasi, Prayagraj. Kunds and Lakes such as Bindu Sarovar (Siddhpur), Manikarnika Kund (Varanasi). Various temples are there which indicates the philosophy of death such as Kalbhairava Temple(Ujjain). Mahakaleshwar Temple(Ujjain), etc.

5. SITE SELECTION AND ANALYSIS

Varanasi, also known as Kashi or Banaras, is one of the oldest continuously inhabited cities in the world and holds profound significance in Hindu religion. It is considered the spiritual capital of India and it is believed to be founded by Lord Shiva, making it one of the seven sacred cities (Sapta Puri) in Hinduism. The city's name kasha means "the Luminous one" with enlightenment and spiritual awakening. There are temples and shrines, ashrams and pavilions that stretch along the river for over three miles. The riverfront reveals the sources of Kashi's ancient reputation as the sacred city of the Hindus. (varanasi-tourism.net, 2024)Along the river there are over seventy bathing Ghats, literally "Landings" or "banks", reaching from Asi Ghat in the south to Adi Keshava in the north, Beyond the bridge. Some are quiet neighborhood ghats, while others are crowded with pilgrims from all over India. Bathing in the Ganga, a river said to have fallen from heaven to earth, is the first act of Banaras pilgrims and a daily rite for Banaras residents. Also along the river are dozens of temples with high spires, most of them dedicated to Lord Shiva, who according to tradition makes this city his permanent earthly home. (Eck, 1982)

Varanasi has a unique association with death in Hinduism. It is believed that dying in Varanasi and being cremated on the banks of the river Ganga grants moksha, or liberation from the cycle of birth and rebirth. This belief makes Varanasi a major destination for Hindus seeking to perform funeral rites and rituals for their deceased loved ones. The Manikarnika Ghat and Raja Harishchandra Ghat are two of the most prominent cremation sites in the city.

Figure 1. Manikarnika Ghat

Figure 2. Wooden Logs on stairs of Manikarnika

Figure 3. Wooden Logs seller on Manikarnika

Figure 4. Wooden Logs on Manikarnika Ghat

Figure 5. Wooden Logs Transported from River Ganga

Figure 6. View of Manikarnika Ghat from River

6. NEED ASSESSMENT AND PROGRAM DEVELOPMENT

Varanasi is one of the oldest cities in India. It is known for its numerous temples, ashrams, Ghats, Kunds, and especially the river Ganga. In Varanasi, the river Ganga flows northwards before merging into the Bay of Bengal in West Bengal, which enhances the city's significance. Varanasi has been renowned for ages for its philosophy of Moksha (Liberation from the cycle of Birth and Rebirth). Since ancient times, people have come here for pilgrimage, cremation of their loved ones, and to perform tarpana (rituals for deceased ancestors).

Death in Kashi is considered to be *mokshada* (Liberating), thus many people come here during their last days to engage in *Bhajans*, Prayers, *Kathas*, and reading scriptures, seeking to understand death. Consequently, hospice centers such as "Kashi Labh Mukti Bhavan" and "Mumukshu Bhavan" established. The increasing popularity of "Manikarnika Ghat" has also attracted explorers and tourists from India and around the world who are interested in Understanding the concept of death.
This rise in tourism has strained the current infrastructure of the Ghats, which do not adequately meet all the requirements. For instance, people who come for cremation have to shave their heads on roads and Ghats as there is no dedicated space for rituals. Similarly, there are no specific spaces for performing other rituals such as Tarpana and Shraddha. To address these issues, a Memorial center is proposed, aiming to provide appropriate facilities and spaces for these important rituals.

- **Addressing Ritualistic Requirements**
Varanasi, with its rich cultural and spiritual heritage, is a major hub for Hindu rituals, particularly those associated with death and the afterlife. The current infrastructure of the Ghats is inadequate to cater to specific needs of various rituals such as head shaving, tarpana (Ancestral rites), and Shraddha (death anniversary rituals). A dedicated Memorial center will provide structured and dignified spaces for these activities, ensuring that they are performed in an appropriate and respectful manner.

- **Alleviating Overcrowding**
The increasing number of pilgrims and tourists visiting Varanasi, particularly for rituals at Manikarnika Ghat, has led to significant overcrowding. This congestion not only hampers the smooth conduct of rituals but also affects the overall experience of the crowd more evenly, reducing pressure on the existing Ghats and enhancing the overall experience for everyone indeed.

- Enhancing the Pilgrimage Experience
The Memorial center also provides the short term stay facilities that support the spiritual journey of pilgrims. By providing amenities such as clean spaces for rituals, accommodation for the elderly and the dying, and areas for prayers and meditation, the center will enhance the overall pilgrimage experience. It will ensure that pilgrims can focus on their spiritual practices without worrying about logistical issues.

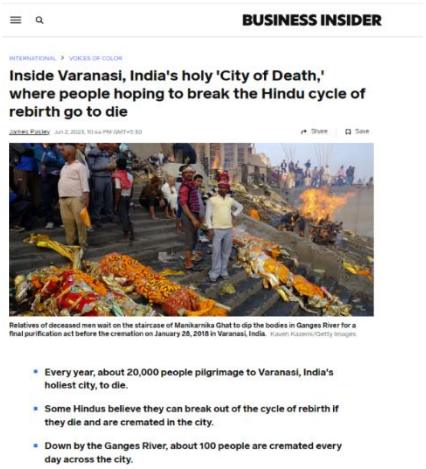
- Providing Hospice Care
Varanasi is home to Several Hospices such as Kashi Labh Mukti Bhavan and Mumukshu Bhavan, which cater to individuals who wish to spend their final days in the city, believing that dying in Varanasi grants moksha (Liberation from the cycle of Birth and Rebirth). These hospices offer basic facilities and peaceful environment for dying, allowing them to spend their last moments in contemplation, prayer, and surrounded by the spiritual ambiance of Varanasi. However, the facilities in these hospices are often limited and cannot accommodate the growing number of individuals seeking such services. The Memorial Center will include modern hospice facilities with better amenities, providing comfort and dignity in their final days.

- Educational and Cultural Significance
The Memorial Center can also function as an educational Hub, Offering insights into the cultural and religious significance of Varanasi. Exhibits and interactive installations can educate visitors about history, rituals, and philosophy of Hinduism, particularly concerning death and afterlife. This will not only deepen the understanding of Indian culture among international tourists but also preserve and promote the rich heritage of Varanasi.

- Preservation of Heritage

With increasing urbanization, there is a risk of losing the traditional practices and spaces associated with Varanasi's spiritual heritage. The Memorial Center will act as a repository and protector of these traditions, ensuring that they are passed down to future generations in their authentic form.

In Conclusion, the need for a Memorial Center in Varanasi arises from the necessity to provide adequate facilities for ritualistic practices, manage the influx of pilgrims and tourists, enhance the spiritual and educational experience, provide hospice care for the dying, mitigate environmental impact, boost the local economy, and preserve the city's rich cultural heritage.

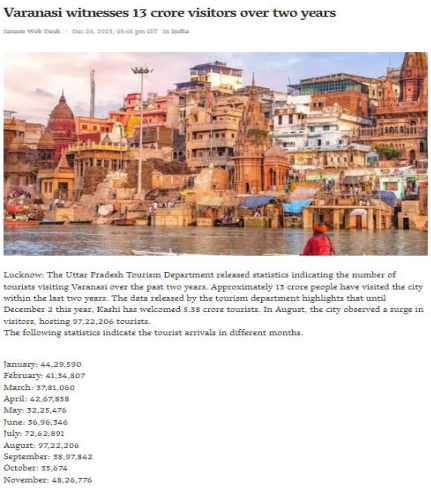

BUSINESS INSIDER

Inside Varanasi, India's holy 'City of Death,' where people hoping to break the Hindu cycle of rebirth go to die

Relatives of deceased men wait on the staircase of Manikarnika Ghat to dip the bodies in Ganges River for a final purification act before the cremation on January 28, 2018 in Varanasi, India.

- Every year, about 20,000 people pilgrimage to Varanasi, India's holiest city, to die.
- Some Hindus believe they can break out of the cycle of rebirth if they die and are cremated in the city.
- Down by the Ganges River, about 100 people are cremated every day across the city.

Figure 1. News of Business Insider, Jun 2023


Varanasi witnesses 13 crore visitors over two years

Lucknow: The Uttar Pradesh Tourism Department released statistics indicating the number of tourists visiting Varanasi over the past two years. Approximately 13 crore people have visited the city within the last two years. The data released by the tourism department highlights that until December 2 this year, Kashi has welcomed 5.38 crore tourists. In August, the city observed a surge in visitors, hosting 97,22,206 tourists.
The following statistics indicate the tourist arrivals in different months.

January: 44,29,590
February: 41,34,807
March: 37,81,060
April: 42,67,858
May: 32,25,476
June: 36,96,346
July: 72,62,891
August: 97,22,206
September: 38,97,842
October: 55,674
November: 48,26,776

Figure 2. News of Janam Web Desk, Dec 2023

Figure 3. Dark Underlit spaces of Kashi Labh Mukti Bhavan

Table 1. Overall Site Details

Overall program (in Sq. Mt.):	
Total site area (100%)	25,090
Proposed ground coverage (20-60%)	
Proposed FSI	0.33
Proposed built-up area	8375
Proposed number of floors	2

Table 2. Detailed Program breakup in square meters

Detailed program breakup (in sq.mt.):		
Administration	**Total proposed area**	**250 sq.mt.**
	Reception and waiting area	35
	Staff offices	40
	Conference room	40
	Director's office	40
	Manager and curator office	40
	Record area	10
	Staff toilet	45
Center for mourners	**Total proposed area**	**1000 sq.mt.**
	Consulting rooms x 5	50
	Auditorium (150 people capacity)	250
	Psychological healing rooms x 5	100
	Library	200
	Meditation area	150
	Yoga area	200
	Toilets	50
Ritual area	**Total proposed area**	**1010 sq.mt.**
	Head shaving ceremony area	30
	11th day ritual area	350
	Shraddha vidhi	350
	Bathing area	40
	Toilets	40
	Bhajans area + shrine	200
Stay facilities	**Total proposed area**	**1080 sq.mt.**
	Director's residence	150
	Dormitories (50 people)	500
	Staff dormitories	180
	Kitchen + service area	100
	Mess	150
Hospice services	**Total proposed area**	**700 sq.mt.**

	Doctor's consulting room	20
	Pharmacy	30
	Patient's care unit	100
	Waiting area	30
	Toilets and drinking water	30
Narrative spaces	**Total proposed area**	**3150 sq.mt.**
	Av galleries for importance of Antyesti	150
	Narrative spaces	3000
Total area		**6700 sq.mt.**
Total built up	Total area + 25% circulation	**8375 sq.mt**

Table 3. Expected Footfall

Total expected footfall (per day)	450 visitor's / day	Fluctuating user for narrative spaces
Total expected footfall (per year)	164,250 visitor's/day	Fluctuating user for narrative spaces
Total expected employees (with break-up)	35 people / day	Employees
Expected duration of stay (per day) - visitors without stay	In hours	12 hours (9:am to 8:pm)
Expected duration of stay (per day) - visitors with stay	In days	

7. CONCEPTUAL FRAMEWORK

Table 4. Conceptual Framework

Elements of Design	**Grief**	**Shock**	**Guilt**
Form	Cuboidal	Curvilinear which provides shock / surprise at every phase	
Scale and Proportion	Regular Human Height Scale		Huge Volume Space
Material - Color - Texture - Emotion	Bold/ Solid Color + Texture	Direct Change of Material	Bold Material with bold texture

Light	Little Light coming from one end indicates the transition	Proper light quality	Proper Light quality from the top
Ventilation	Little Discomfort able space		
Acoustic	Reflection of noises		Reflected Sounds
Natural Elements - Pathways - Hardscape - Water feature - Plantation		Long Physical Path that encourages physical activity which provide relief against the actual shock happened by death of deceased	
Degree of enclosure	Closed	Closed	Semi open

Table 5. Conceptual Framework

Elements of Design	**Cognitive Dysfunction**	**Anger**	**Loneliness**
Form			
Scale and Proportion			Narrow but volumetric
Material - Color - Texture - Emotion			Warm and Soothing Color and texture
Light	Reflected and soothing Light		Well Lit space
Ventilation			

Acoustic			Reflected Sounds
Natural Elements - Pathways - Hardscape - Water feature	Renewal of Sensory by adding water feature	Distracting Pathways and unorganized Movement causes anger	Visually connected to outside but not physically

From the Above Table and the literature review. Created some experiential schemas which was the base for the architectural journey.

Schema-1: Loss of Connection with Physical Body
According to Hindu tradition, life is considered a continuous cycle of birth and rebirth. Thus, when someone in the family dies, there is an immediate loss of connection with the physical body of the deceased. However, while the connection is physically lost, it remains emotionally intact. Therefore, the space is designed to evoke the emotion of grief in the user. As mentioned in the table, grief is evoked through a cuboidal space with light entering from both ends but without any windows. Additionally, scriptures describe the appearance of the god of death as the only source of light in an otherwise dark universe, which this design concept emulates.

Schema-2: Entangled in Maya
The second experience for the user is Maya. As described in the Bhagavad Gita, life is Maya, or illusion. People believe they are in control of their actions, but in reality, it is their Karmas that govern their lives. Everything that happens in this world is a result of Karma. Maya leads humans to think they are superior and that their presence could save a loved one from dying. This loss of control creates feelings of anxiousness, anger, confusion, and sometimes guilt.

To embody this idea, the space created is a maze formed by two architectural elements: the intersection of lines and the subtraction of mass. When the user enters this space, they must find their way through the maze, struggling to move forward. Throughout the maze, there are continuous openings where, at the end of each opening, one can see glimpses of beautiful trees but never the full view. As the person progresses, they may feel they are about to see the full tree, but it never happens.

Here, the tree represents Maya. Metaphorically, this illustrates that humans constantly struggle to escape the maze, seeking the full tree, but it never happens, just as people chase materialistic things throughout their lives, which ultimately prove futile at the end.

Schema-3: Self Discovery
The third experience for the user is self-discovery. After anxiously navigating through Maya, the user moves towards a space where they can gain knowledge of life as prescribed in Hindu scriptures. This space is designed as an exploratory space for life, where one can see exhibits depicting ideal life, samskaras, their importance, and various tales and stories illustrating how to perform good karma.
This exploratory space is built on a curvilinear ramp that gradually leads the user upward and then downward, allowing them to feel the transition. Metaphorically, this indicates that life has its ups and downs, but knowledge and good karma lead to liberation.

The materials used inside the exploratory space are wooden panels, providing psychological warmth to the user. The structure itself is made of metal covered by corrugated sheets from the outside, indicating its temporary and changing nature. The corrugated metal sheets change color over time, symbolizing evolution.

Schema-4: Self-understanding

The experience following self-discovery, where the user learns and gains knowledge from the exploratory space, is the space of self-understanding. This space is essentially a path to liberation. According to scriptures, once you discover yourself, you can see life as an illusion. Self-understanding happens after self-discovery, and once one begins to adopt a soft nature and understands that their time on earth is limited, they realize the need to fulfill their duties towards the world and become grateful individuals.

This space contains temporary exhibitions about individuals who have attained self-understanding and become grateful, such as Saint Valmiki, Goswami Tulsidas, Gautama Buddha, Jain Tirthankara, Sai Baba, and many others who have achieved self-understanding and performed their duties towards society. Even in modern times, there are people who embody these principles, and their achievements and works are showcased here, providing users with motivation to contribute positively and make the world a better place. Architecturally, this space allows the user to see the whole tree, which was previously only glimpsed in the space of Maya. Metaphorically, this indicates that once you attain self-understanding, you can see things more clearly.

Schema-5: Liberation

After self-understanding comes liberation. According to Hinduism, a person who performs good karma and fully fulfills their duties towards the world can attain a place in the world of gods, known as Vaikunth Dham (the Abode of Lord Vishnu). For Hindus, the River Ganga is also considered a guarantor of Moksha (liberation). Even viewing the great River Ganga can inspire and motivate people towards leading a better life. (www.hinduwisdom.info, 2022)

This final space serves as a viewpoint of the River Ganga, from which one can observe the river flowing, bodies being cremated on Manikarnika Ghat, and the historic skyline of Varanasi. Observing these sights encourages deep contemplation in the user. Architecturally, by creating a visual axis, the building expresses gratitude towards the River Ganga and metaphorically indicates that its existence is due to the river. This space prompts the user to reflect on the journey they have experienced while moving through the museum.

Schema-6: Gratitude

The next experience for the user after Liberation is the education space, where one learns how to express gratitude. This space exhibits issues such as river pollution, environmental degradation, and rising crime rates in the modern world. However, it also presents solutions to these problems, metaphorically derived from Hindu Scriptures, and emphasizes gratitude towards the elements of nature—sun, earth, air, water, and fire.

This space features small audio-visual galleries where users can watch videos on how to show gratitude towards these elements. Additionally, it includes exhibitions showcasing solutions to contemporary problems developed by researchers for better living. This space aims to provide users with an understanding of the current world's realities and inspire them to contribute positively.

Schema-7: Self -Reflection

After the gratitude space, the next experience for the user is the space of self-reflection. This area is dark, with light entering through slit windows, and it contains a pool of water. The silent, dark space allows users to see their reflection in the water and take a moment to pause before exiting the building.

This space provides a time for contemplation and unconsciously makes users feel that it is time to become grateful and perform their duties towards society for the betterment of the world. Seeing their own reflection helps them realize who they are and who they should strive to be.

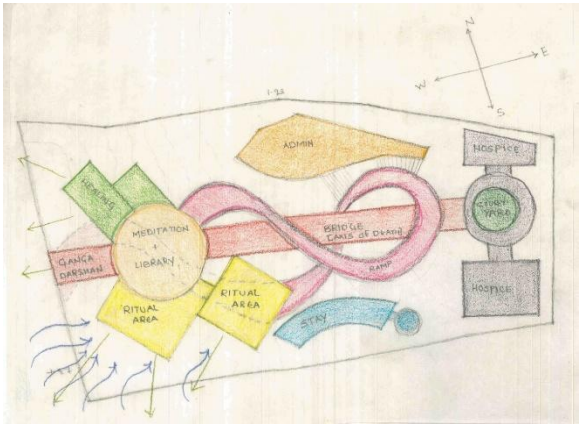


Figure 4. Development of concept on site

7. ARCHITECTURAL DESIGN

The proposed building is constructed with concrete, a material that exudes boldness and strength, symbolizing permanence. The rough texture of the concrete further emphasizes its robustness. In contrast, the exploratory space dedicated to life, which contains various exhibits, is made with a metal structure featuring a façade of corrugated metal sheets painted red. This striking contrast to the grey concrete draws focus, metaphorically highlighting the dichotomy between life and death as shown in Figure 1 and 2. Death, represented by the solid and unchanging nature of concrete, is portrayed as a dark, permanent state. In contrast, life, symbolized by the vibrant, ever-changing red metal, is depicted as temporary and constantly evolving. The metal façade changes color over time, signifying the transient and dynamic nature of life. This conceptual approach is evident from the entrance of the building, where visitors can immediately sense the intended metaphorical meanings. The contrasting materials and colors not only create a visual impact but also convey deeper philosophical insights into the nature of life and death. The design thoughtfully integrates these elements, providing an immersive experience that encourages contemplation and reflection on the impermanence of life and the permanence of death.

8. DESIGN OF VARIOUS CONCEPTUAL SPACES

Schema: 1 Loss of Connection with Physical Body

Figure 5. Schema-1 Dark Underlit spaces Inidcates loss of connection with physical body

As shown in figure 11, The entrance of the building is deliberately designed to be unique, starting from the river side, which leads visitors into the exploratory space. Unlike typical entrances that are welcoming, well-lit, and ventilated, this entrance is dark and low-ceilinged compared to the expansive area it opens into, creating an elongated, cubical space with light only visible at the far end. There are no side openings, reinforcing a sense of enclosure and transition.

This entrance space is a ramp that gradually ascends to the second exploratory space, symbolically named Maya. The dark, confined entrance signifies a loss of connection with the outer, physical world. Moving from the darkness towards the light at the end of the ramp represents a transition from the material world to the ascetic world. This design choice is intended to evoke emotions of grief and fear, akin to the feelings experienced when stepping into an unknown space. However, the natural light at the end of the ramp serves as an encouragement, guiding visitors to proceed towards the next space, offering a sense of hope and direction amidst the initial darkness.

Schema: 2 Entangled in Maya

Figure 6. Schema-2 Glimpses of tree

The space of Maya, or illusion, is designed as a maze with a series of openings. Through these openings, visitors catch glimpses of a tree, and beneath each opening, a message or quote from the Bhagavad Gita, spoken by Lord Krishna to Arjuna, is inscribed. As users navigate the maze, they may either follow the

correct path or reach a dead end. Each dead end also contains a message about Maya and the illusory nature of life.

When on the correct path, visitors feel as though they are drawing closer to the tree. This progression symbolizes the pursuit of understanding amidst the illusion. The maze is filled with messages about life as an illusion, as described in the Bhagavad Gita. These messages provide knowledge about the transient nature of materialistic pursuits and how to live a life of deeper, more meaningful fulfillment. The design aims to teach users about the concept of Maya, encouraging them to reflect on life's illusions and to seek a more spiritually oriented way of living.

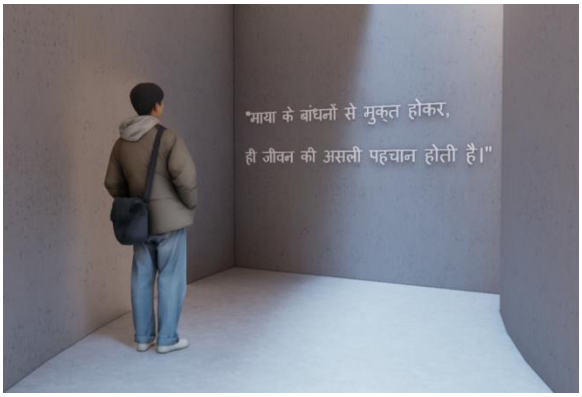


Figure 7. Schema-2 Dead End

Figure 8. Schema-2 Ramp to Schema-3

Figure 9. Schema-2 Entrance of Schema-3

Schema-3: Self-Discovery

Figure 10. Schema-3 Self-discovery space

As shown in figure 16, The Self-discovery space is an exploratory space for Life and Hindu Beliefs and samskaras, the curved path as shown in Plan which indicates the life as a journey

Schema-4 Self-Understanding

The experience following self-discovery, where the user learns and gains knowledge from the exploratory space, is the space of self-understanding. This space is essentially a path to liberation. According to scriptures, once you discover yourself, you can see life as an illusion. Self-understanding happens after self-discovery, and once one begins to adopt a soft nature and understands that their time on earth is limited, they realize the need to fulfill their duties towards the world and become grateful individuals.

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Schema-5 Liberation

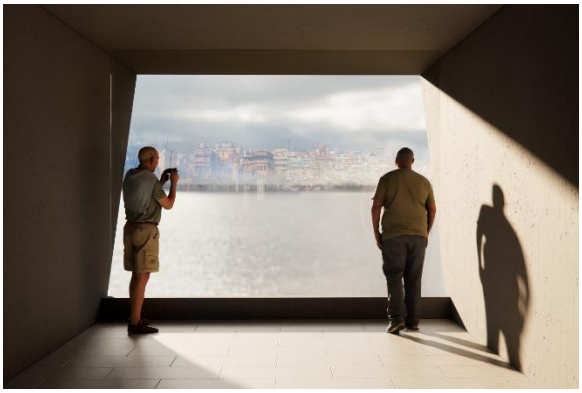

Figure 11. Schema-5 Liberation Space (Viewing Deck)

As shown in figure 17, The Liberation space is the View point of River Ganga, one can watch the river flowing from the View Point.

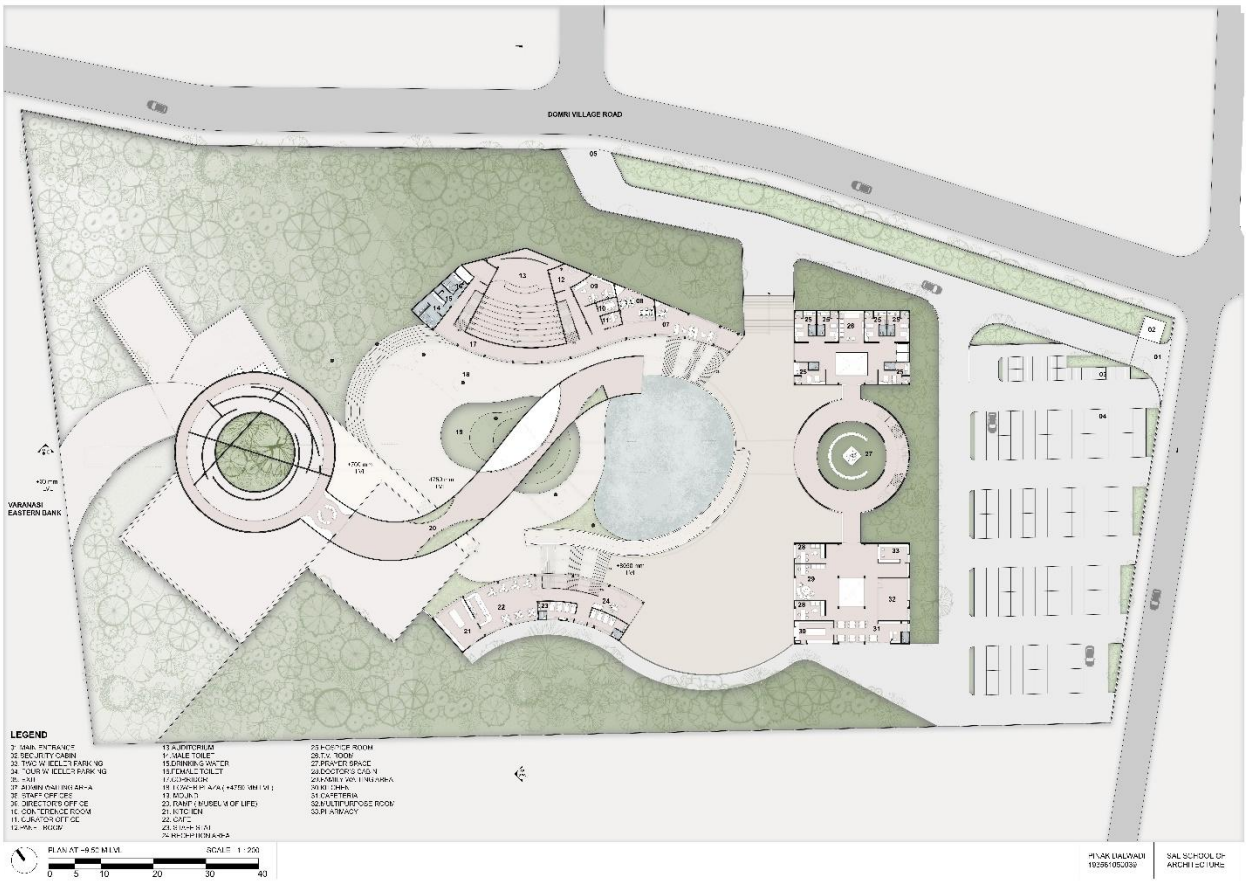

Figure 12. Floor Plan of proposed Center

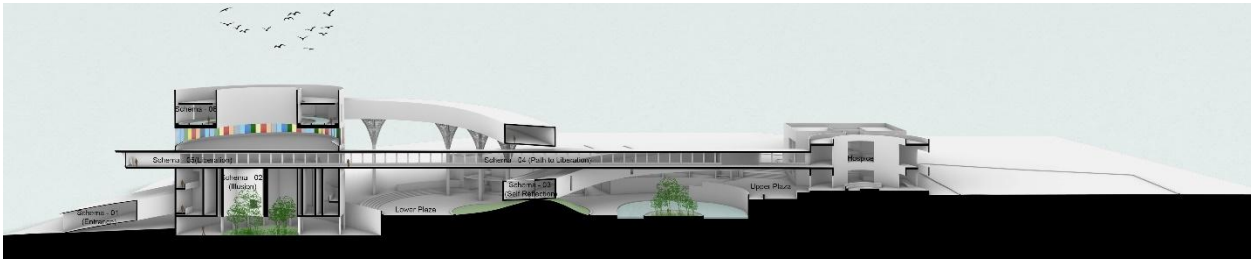

Figure 13. Section of proposed center

9. CONCLUSION

The study explores the profound interplay between architecture and human emotions, specifically in the context of death and the process of mourning. By examining various elements and principles of architectural design, the study demonstrates how spaces can evoke and facilitate a range of emotional responses, guiding individuals through a journey of grief, reflection, and ultimately, healing. In the case of the proposed memorial in Varanasi, the design concept is deeply rooted in Hindu philosophy and traditions. Each space within the memorial is meticulously crafted to reflect different stages of emotional experience, from grief and confusion to self-discovery and gratitude. The architectural journey mirrors the spiritual journey described in Hindu scriptures, offering a path from the immediate impact of loss to a place of contemplation and understanding. The educational and reflective spaces within the memorial not only honor the deceased but also provide the living with a deeper understanding of life, death, and their duties towards society and the environment. By incorporating elements that address modern issues such as pollution and environmental degradation, the memorial serves as a bridge between ancient wisdom and contemporary challenges, encouraging visitors to live more mindful and responsible lives. The inclusion of hospice and psychological healing centers underscores the memorial's commitment to holistic care, addressing not only the physical and emotional needs of those facing the end of life but also providing support for their families. These facilities ensure that the memorial is not just a place of remembrance but also a sanctuary for the living, offering comfort and guidance during times of profound loss. The study highlights the importance of designing spaces that are not only functional but also deeply meaningful. Through careful consideration of form, light, materials, and symbolism, architects can create environments that resonate with the human spirit, providing solace and inspiration. The proposed memorial in Varanasi stands as a testament to the power of architecture to shape our experiences and emotions, transforming the way we understand and cope with death. In conclusion, this study affirms that architecture, when thoughtfully designed, can play a crucial role in the emotional and spiritual well-being of individuals and communities. The Varanasi memorial serves as a model for how spaces can be designed to honor the deceased, support the living, and promote a deeper connection to our cultural and spiritual heritage. By integrating ancient philosophies with contemporary needs, the memorial offers a timeless space for reflection, learning, and healing, embodying the enduring significance of Varanasi and the sacred river Ganga in Hindu tradition.

REFERENCES

1. Asher, C. B. (1992). *Indian Islamic Architecture: The Delhi Sultanate.* New York City: Oxford University Press.
2. Becker, E. (1973). *The Denial of Death.* US: Free Press.
3. Budge, E. W. (n.d.). *The chapters of coming forth by day.* Kegan Paul, Trench, trubner and co, ltd.
4. Eck, D. L. (1982). *Banaras: City of Light.*

5. Editors, C. R. (2015). *The Mausoleum at Halicarnassus: The History, Architecture, and Legacy of the Ancient Greek Wonder.* New York City: Charles River Editors.
6. Jodidio, P. (2021). An Exploration of the Role of Architecture in Dealing with Mortality. In P. Jodidio, *Architecture and Death.* London: Thames & Hudson.
7. Michael H. Fox, B. P. (2017). "Death and Architecture: A Study of the Relationship Between Architecture and the Concept of Death". *Architectural Theory Review*, 55-70.
8. Poo, A.-j. (2016). *The Age of Dignity: Preparing for the Elder Boom in a Changing America.* US: The New Press.
9. Schneider, B. (2007). *Jewish Museum Berlin: Between the Lines.* prestel.
10. varanasi-tourism.net. (2024, Jan). *varanasi-tourism.net*. Retrieved from varanasi-tourism.net.
11. www.hinduwisdom.info. (2022, December). *www.hinduwisdom.info*. Retrieved from www.hinduwisdom.info.

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