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TO STUDY THE IMPACT OF DIGITAL SOLUTIONS IN SUPPLY CHAIN MANAGEMENT WITH SPECIAL REFERENCE TO CEMENT INDUSTRIES IN RAJASTHAN.

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ABSTRACT

The rapid advancements in digital technologies have transformed supply chain management (SCM) across industries, including traditional and asset-intensive sectors such as cement manufacturing. This study examines the impact of digital solutions on supply chain efficiency, responsiveness, and sustainability within cement industries in Rajasthan. Using insights from industry practices, technological adoption patterns, and operational challenges, the research explores how tools such as big data analytics, IoT-enabled monitoring, digital procurement platforms, and automated logistics systems contribute to enhanced visibility, improved coordination, reduced operational costs, and higher service levels. The study also evaluates the readiness and barriers faced by cement firms in adopting digital innovations, including infrastructure limitations, skill gaps, and investment constraints. Findings aim to provide a comprehensive understanding of how digital transformation can strengthen the competitiveness and resilience of the cement supply chain in Rajasthan, offering implications for policymakers, practitioners, and industry stakeholders seeking to optimize supply chain performance in a rapidly evolving digital environment.

Introduction

SCM is a method for developing and optimizing the supply chain's internal and external components, which must be in line with the company's overarching goals. According to Christopher (2000), an efficient SCM is a potent instrument for gaining a competitive edge that may help all supply chain channel partners. According to Tan (1998), SCM aims to improve customer satisfaction by integrating different supply chain channel partners. An outbound supply chain is a network of distribution locations that handles both the acquisition of inventory and the delivery of these final goods to clients. Demand management, inventory sourcing, inventory distribution to all chain channel partners, and final product or service delivery to the client are all

included in this (Alexandria, VA: APICS). It is a process that involves the movement of money, inventory, and information both inside and across supply chain participants (Jain et al., 2009). Building an integrated supply chain framework is one way to get a competitive edge in the supply chain (Sukati et al., 2012).

Alumino silicate glassy spheres found in fly ash, a pozzo lanic byproduct of burning coal in thermal power plants, improve the mechanical, durability, and rheological qualities of concrete. By decreasing internal friction between cement particles and maintaining sufficient flow ability, its spherical shape enhances workability. By interacting with calcium hydroxide (CH) to produce more calcium silicate hydrate (C-S-H) gel, FA also affects the hydration kinetics and eventually contributes to strength development. When FA is used in place of cement in mass concrete applications, the heat of hydration is lowered, which lessens the risk of thermal cracking. FA strengthens resistance to carbonation, sulphate attack, and chloride incursion by enhancing pore structure and reducing permeability. These characteristics make FA a valuable component in the production of durable, eco-friendly concrete. It is characterized by the submicron particle size and high amorphous silica content of silica fume, an ultrafine byproduct of the production of silicon and ferrosilicon alloys. Its tiny particles serve as microfillers, firmly fitting into the cement matrix to reduce porosity and increase densification. The significant pozzolanic reactivity of SF allows for the rapid consumption of CH, creating a refined C-S-H network that strengthens the microstructure. SF is particularly suitable for high-performance concrete applications that require rapid strength progression because it boosts early-age compressive strength. Additionally, by reducing chloride ion permeability, SF significantly boosts durability and improves corrosion resistance in reinforced concrete structures.

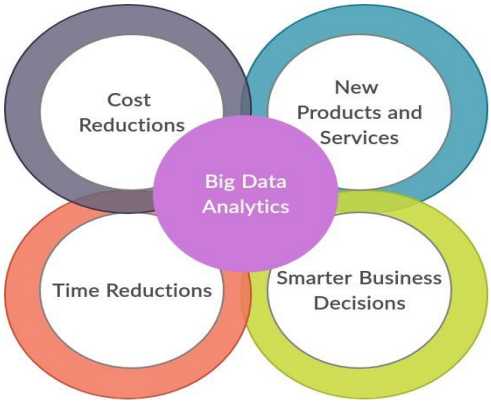

Figure 1: Advantages of BDA

(Source: www.morioh.com)

In actuality, every contemporary gadget, procedure, or activity in our surroundings gathers data. Connecting this data to improve service or streamline industrial processes is the next trend. In recent years, there has been a significant global growth in the volume of data. The phrase "big data" has become very popular recently. The quantity, variety, velocity, quality, and value of the data have all been utilized to describe BD in the current chaotic situation. Current research indicates that analyzing BD is a strong strategy for giving businesses a competitive edge and serves as the main source of accountability and decision-making. In both industrial and service systems, supply chains have made strides toward enhancing performance for improved business execution. Supply chain management, according to Lee & Billingt on (1995), is the organization of activities in a way that promotes better use of raw resources, transforms them into semi-finished inventories and completed goods, and then distributes them to final consumers via a distribution framework. The supply chain includes the procurement, manufacturing, assembly, and distribution of goods and services. According to research, using IT to increase supply chain visibility results in better inventory management execution, which boosts sales and improves demand forecasting (Kaipia & Hartiala, 2006; Kulp, 2002; Lee & Whang, 2000). According to Fawcett et al. (2007), as consumers are an essential component of the framework, their needs should be met by providing information about those demands.

Due to their increased awareness, clients are making sufficient requests these days.

The paper's flow is as follows: The report started with a thorough analysis of the literature on technology and managerial issues in the cement business, including books, articles from journals, conference proceedings, and websites. This covers the extent and procedures of the current outbound supply chain as well as the difficulties channel partners encounter along the way. Following an awareness of the research gap, section 3 outlines the specific goals of the study as well as its methodology. The goal of the mixed method approach was to comprehend the channel partners' perspectives. The article wraps up and concludes in section 5 after going into great length on analysis for each of the objectives in section 4. The deployment of smart devices and technology in the cement industry's outbound supply chain is connected and discussed in this paper. The next part contains a list of research questions that have been developed based on the review.

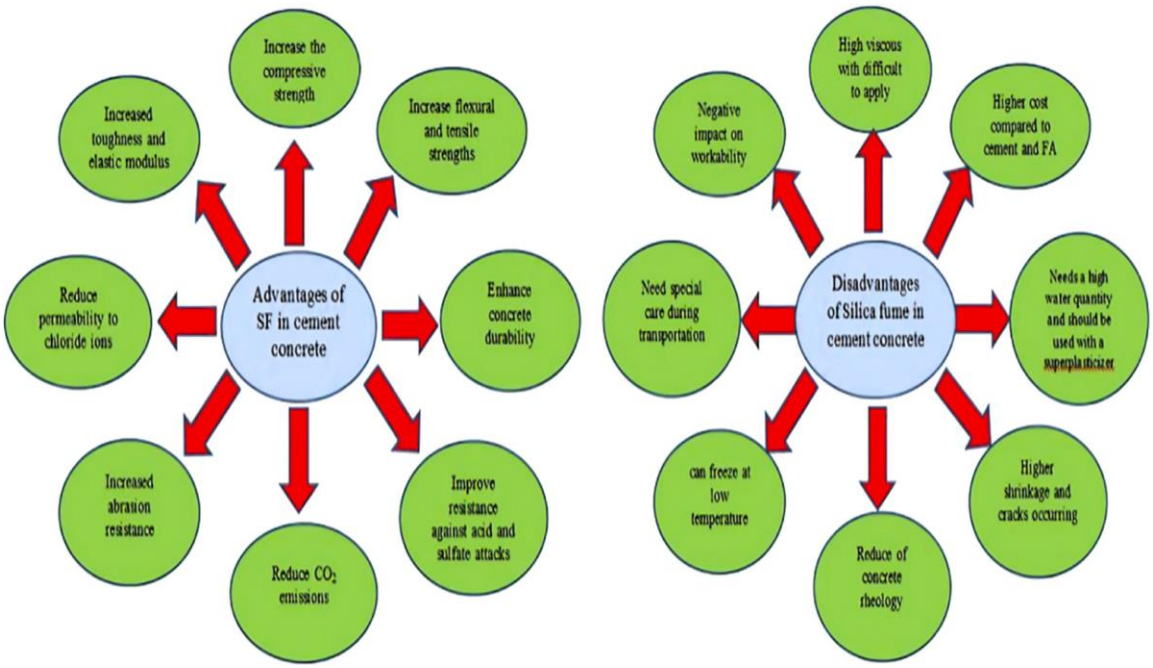

Figure 2: SF's benefits and drawbacks for cement concrete combinations

The present situation and projections for production, consumption, capacity utilization, and installed capacity for 2020 are shown in the study "Indian Cement

Industry Outlook 2020." Configure to Order, Built to Stock, Engineer to Order, and Built to Order are the four types of supply chain systems that are particularly prevalent in the cement business (Reev & Srinivasan, 2005). Build to Order and Engineer to Order may not directly benefit cement companies, according to (Agudelo, 2009). Less than 150 workers are typically needed in a contemporary cement factory (Agudelo, 2009). The foundation of supply chain research is inventory management, buyer-supplier interactions, and IT-enabled supply chains (Jharkharia & Shankar, 2004).

Literature review

Shokouhyar, S., Seddigh, M. R., & Panahifar, F. (2020) [1] examined the role of big data analytics capabilities (BDAC) in enhancing supply chain sustainability, emphasizing how data-driven insights can improve environmental, social, and economic performance across supply networks. Their study, published in the *World Journal of Science, Technology and Sustainable Development*, highlighted that strong analytics capabilities help organizations optimize resource use, reduce waste, and support sustainable decision-making. The authors further argued that BDAC encourages proactive risk management and collaboration among supply chain partners, thereby strengthening resilience and long-term sustainability. Their findings contribute to the growing body of evidence that digital technologies are becoming indispensable in modern sustainable supply chain management.

Ranjan, J., & Foropon, C. (2021) [2] In 2021, Ranjan and Foropon explored how big data analytics (BDA) supports the development of competitive intelligence within organizations. Published in the *International Journal of Information Management*, their work emphasized that by aggregating, processing, and analyzing vast datasets, firms can uncover hidden patterns and generate actionable insights critical for strategic decision-making. The authors asserted that BDA enhances forecast accuracy, customer understanding, and market responsiveness, ultimately enabling firms to build competitive advantages in dynamic environments. Their study situates BDA as a cornerstone of modern knowledge-driven competitiveness, highlighting its role in improving organizational agility and strategic foresight.

Kinra, A., Hald, K. S., & Vatrapu, R. (2020) [3] introduced an innovative unstructured big data approach to assess

country-level logistics performance within global supply chains. Published in the *International Journal of Operations & Production Management*, their work utilized online, text-based, and other nontraditional data sources to complement standard logistics indices. The authors demonstrated that unstructured data can reveal richer, real-time insights into logistics challenges and opportunities, allowing firms and policymakers to better understand cross-country performance variations. Their study significantly advanced the methodological landscape by integrating digital trace data into logistics performance measurement, offering a more holistic and dynamic perspective for global supply chain assessment.

Shokouhyar, S., Safari, S., & Mohsenian, F. (2017) [4] In an earlier work from 2017, Shokouhyar, Safari, and Mohsenian investigated factors influencing competitiveness in the candy industry, focusing on retailers' perceptions of customer satisfaction. Published in the *Journal of Food Products Marketing*, their study highlighted how product quality, packaging, pricing, and service attributes shape satisfaction levels and, consequently, competitive positioning. The authors found that retailers' assessments provide valuable insights for manufacturers seeking to enhance customer loyalty and market share. Their research underscores the critical role of understanding consumer expectations in niche food sectors and provides a practical framework for improving strategic decision-making through stakeholder perception analysis.

Raut, R. D., Yadav, V. S., Cheikhrouhou, N., Narwane, V. S., & B. E. (2021) [5] addressed the implementation challenges of big data analytics in Indian manufacturing supply chains, as published in *Computers in Industry*. The study identified several barriers including technological limitations, high investment costs, lack of skilled personnel, data quality issues, and resistance to organizational change that hinder successful BDA adoption. The authors argued that overcoming these obstacles requires strong managerial commitment, technological readiness, and robust data governance practices. Their findings shed light on the complexities of digital transformation in emerging economies and provide actionable insights for firms striving to leverage big data for supply chain excellence.

Dadhich, M. (2017) [6] conducted an in-depth analysis of the factors that influence customers' online shopping behavior, published in the *ZENITH International Journal of Business Economics & Management Research*. The study explored various determinants—such as convenience, trust, website design, perceived risk, and pricing—that shape consumer decisions in digital purchasing environments. Dadhich emphasized that trust and ease of use play particularly vital roles in encouraging online transactions, while concerns regarding privacy and payment security often hinder adoption. The research contributes to a deeper understanding of evolving consumer habits in the digital era and provides valuable insights for e-commerce platforms aiming to enhance user experience and strengthen purchase intention.

Lamba, K., & Singh, S. P. (2017) [7] explored the role of big data in operations and supply chain management, providing a comprehensive overview of emerging trends and future research directions. Published in *Production Planning & Control*, their work discussed how big data analytics (BDA) facilitates real-time decision-making, demand forecasting, resource optimization, and supply chain visibility. The authors argued that big data not only enhances operational efficiency but also supports strategic competitiveness by enabling predictive insights and automated processes. They also highlighted challenges associated with data integration, technological infrastructure, and analytical capability gaps, suggesting the need for continuous innovation and cross-disciplinary collaboration to fully harness BDA potential in supply chain contexts.

Bag, S., Wood, L. C., Xu, L., Dhamija, P., & Kayikci, Y. (2020) [8] investigated big data analytics as a tool for achieving operational excellence and enhancing sustainable supply chain performance. Their study, published in *Resources, Conservation & Recycling*, demonstrated that effective BDA deployment enables firms to optimize resource usage, reduce waste, and improve environmental and social outcomes. The authors emphasized that data-driven operational excellence initiatives, such as real-time monitoring and predictive maintenance, contribute significantly to long-term sustainability goals. They also highlighted the strategic importance of digital capabilities in integrating sustainability into core supply chain functions, thereby reinforcing the role of

BDA as a transformative enabler of green and resilient supply chains.

Hair, J. F., Hult, G. T. M., Ringle, C., & Sarstedt, M. (2016) [9] In their 2016 book, *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*, Hair, Hult, Ringle, and Sarstedt offered a foundational guide to understanding and applying PLS-SEM in social science research. The authors provided detailed explanations of model specification, measurement validation, and structural assessment, making the methodology accessible to both novice and advanced researchers. Their work emphasized the suitability of PLS-SEM for exploratory studies, complex models, and situations involving small sample sizes or non-normal data. This book has become a seminal reference for scholars, offering clear procedural guidelines and best practices for using PLS-SEM to examine causal relationships in empirical research.

Dadhich, M. (2017) [10] Also in 2017, Dadhich examined the impact of demonetization on the Indian economy in the *International Journal of Research in Social Sciences*. The study analyzed both the short-term disruptions and the long-term structural implications of the policy, which involved the withdrawal of high-denomination currency notes. Dadhich reported that while the immediate effects included liquidity shortages, reduced consumption, and slowed economic activity, the policy also aimed to promote digital payments, curb corruption, and increase transparency. The research provided a balanced perspective, discussing the socio-economic consequences of demonetization and its potential role in fostering a more formal and digitally enabled economy.

Leong, L., Hew, T., Ooi, K., & Wei, J. (2020) [11] investigated consumer resistance toward mobile wallet adoption using a hybrid methodological approach combining structural equation modeling (SEM) and artificial neural networks (ANN). Published in the *International Journal of Information Management*, the study identified key psychological and technological barriers such as perceived risk, lack of trust, and complexity, which significantly hinder user acceptance. Their two-stage modeling approach allowed for a more robust prediction of resistance behaviors, revealing nonlinear relationships among influencing factors. The findings highlight the importance of enhancing trust, usability, and security in digital payment platforms to

improve consumer adoption, offering practical insights for fintech developers and policymakers aiming to accelerate digital financial inclusion.

Butt, A. S. (2020) [12] In 2020, Butt explored strategies for mitigating the impact of the COVID-19 pandemic on supply chain disruptions through a multiple-case study approach involving both buyers and distributors. Published in the *International Journal of Logistics Management*, the research revealed that supply chain resilience during the pandemic relied heavily on agility, digitalization, supplier diversification, and collaborative planning. Butt emphasized that organizations capable of rapidly reconfiguring their processes and leveraging digital tools were better positioned to navigate uncertainties. The study contributes to crisis management literature by offering actionable strategic insights for firms seeking to strengthen supply chain continuity during large-scale disruptions.

Bag, S., Luthra, S., Mangla, S. K., & Kazancoglu, Y. (2021) [13] examined how big data analytics (BDA) capabilities support reverse logistics decision-making and enhance remanufacturing performance. Published in the *International Journal of Logistics Management*, the study demonstrated that BDA facilitates efficient product returns, quality inspection, recovery processes, and inventory management within reverse supply chains. The authors emphasized that advanced analytics help firms identify remanufacturing opportunities, optimize collection networks, and reduce operational inefficiencies. Their findings underscore the critical role of BDA as an enabler of sustainable operations and circular economy initiatives, ultimately improving environmental and economic performance in reverse logistics systems.

Galetsi, P., Katsaliaki, K., & Kumar, S. (2020) [14] provided a comprehensive theoretical framework for understanding the application of big data analytics in the healthcare sector. Published in the *International Journal of Information Management*, their work reviewed various analytical techniques—including predictive modeling, machine learning, and real-time analytics and discussed their potential to enhance diagnosis, treatment accuracy, disease surveillance, and operational efficiency. The authors highlighted both the vast opportunities and significant challenges, such as data privacy issues, integration difficulties, and the need for

advanced analytical skills. Their review positions big data as a transformative force in healthcare, capable of improving clinical outcomes and operational decision-making.

Dadhich, M., Purohit, H., & Bhasker, A. A. (2021) [15] In 2021, Dadhich, Purohit, and Bhasker explored the determinants of green initiatives and their impact on operational performance in manufacturing SMEs, published in *Materials Today: Proceedings*. The study identified several key drivers—such as regulatory pressure, environmental awareness, leadership commitment, and technological readiness—that influence firms' adoption of green practices. The authors demonstrated that the effective implementation of green initiatives leads to improved resource efficiency, waste reduction, and overall operational performance. Their findings highlight the growing importance of sustainability across SMEs and provide practical insights for managers aiming to integrate environmentally responsible practices into their daily operations.

Methodology

Peer-reviewed papers spanning 24 years, from 1995 to 2018, were used to build this conceptual framework. The research objectives (ROs) listed in section 1 are part of the study's scope. In order to accomplish these goals, a gap analysis was initially conducted by compiling secondary data on technology adoption in the cement industry's outbound supply chain from a variety of sources, including case studies, research papers, white papers, websites, blogs, journals, etc. Understanding the current trend of utilizing technology and gadgets in the cement industry's outbound supply chain process is part of the study plan.

It is divided into three sections: the first includes the respondent's demographics; the second shows how much they use devices and technologies, if any, to handle basic inventory management tasks (such as receiving, stock verification, order execution priority, order placement, and shipping). Additionally, the last piece of the questionnaire includes information on how channel partners see the advantages of integrating technology for outbound management. For the purpose of data analysis, the 52 usable forms were distributed. These 52 responders were found in Uttar Pradesh and Rajasthan. We had been working on the interviews for about two months. The scope of the study is that it is self-sufficient to give the as-is situation, thus even if the sample size was limited due

to its complexity, it is still beneficial to provide the inference made for future references. Executives from Cement Company involved in supply chain outbound activities were interviewed. The interviews were conducted either in person or over the phone. This feature was used to collect both quantitative and qualitative data.

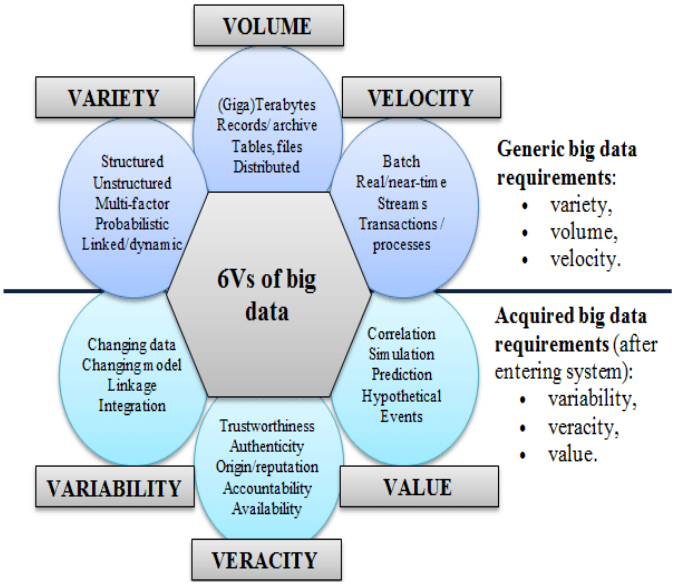

Figure 3: The six Vs of big data

FA serves as a major aluminosilicate precursor in geopolymer concrete, where it undergoes alkali activation to create a long-lasting, low-carbon binder with excellent mechanical qualities. FA-based geopolymers are a good substitute for Portland cement-based systems because they provide better long-term durability, reduced permeability, and increased chemical resistance. Additionally, it has been demonstrated that integrating FA with nano-silica improves geopolymerization rates and refines pore structure, resulting in increased microstructural densification and early-age strength. Tran and Phan demonstrated how this synergy strengthens FA's position in the future generation of sustainable building materials by enabling the production of thinner, higher-strength geopolymer concrete slabs.

Fly ash is a good substitute for cement in a variety of applications because of its strong pozzolanic activity, which is ensured by its chemical composition, which is mostly

SiO_2, AlO_3, and FeO_3 surpassing 70%. By using it in both structural and non-structural components, concrete structures become more impermeable, produce less heat, and last longer. However, there are serious health and environmental dangers associated with untreated fly ash if it is not used. According to Yadav et al., FA must be properly recycled and used because its buildup in exposed regions might cause contamination of the air and water. Papadakis and Poon et al. pointed out that adding more fly ash lengthens the setting time, particularly in mixes with low cement content or low curing temperatures. In warmer regions, where quick setting makes it difficult to properly put and finish concrete, this wait might be helpful. However, delayed setting can impede construction timelines and require changes to mix design or accelerator use in colder areas or time-sensitive projects needing early strength growth.

Because of the slower pozzolanic reaction, fly ash-modified concrete usually has a lower initial strength, but its long-term strength growth is much improved. Malhotra and Ramezanianpour showed that the long-term strength of FA-incorporated concrete can outperform that of ordinary concrete with appropriate curing and mix design. The pozzolanic activity of FA, which gradually interacts with calcium hydroxide to produce more calcium silicate hydrate (C-S-H) gel, is responsible for this improvement. The American Coal Ash Association further stressed that FA's enhanced workability makes it possible to use less water, which leads to lower water-to-cement ratios and ultimately greater strength and durability.

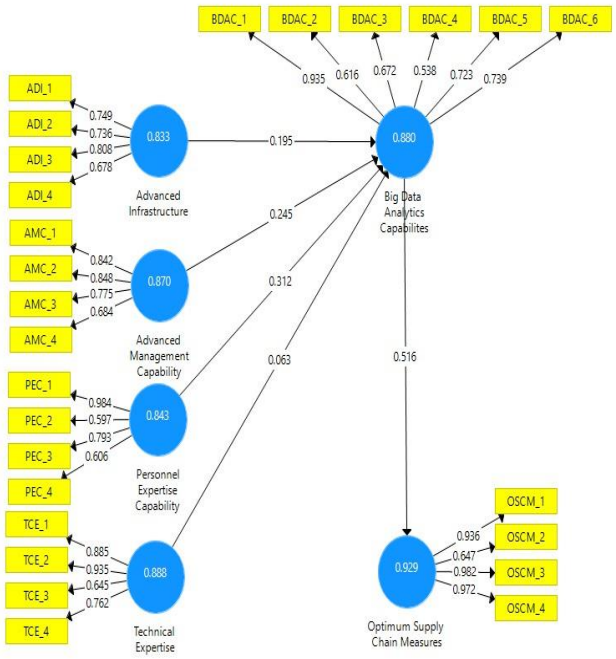

Figure 4: The structural model's mediating effect

Additionally, using fly ash to improve workability lessens the need for chemical admixtures or extra water, which is especially advantageous for producing high-performance and long-lasting concrete. Fly ash-containing mixes improve flowability without sacrificing strength or durability, according to Joshi and Lohtia and Manmohan and Mehta. This makes them suitable for use in large-scale applications like mass concrete placements, where low heat of hydration and long-term performance are crucial. In conclusion, the spherical and smooth particle shape of fly ash greatly alters the fresh qualities of concrete by increasing pumpability, decreasing bleeding and segregation, and improving workability. This impact can be advantageous in some environmental circumstances, even if it slows setup time.

Fly ash's impact on mechanical characteristics

Fly ash's pozzolanic interaction with the calcium hydroxide ($Ca(OH)_2$) produced during cement hydration is the main way that it affects the mechanical qualities of concrete. Over time, this reaction produces more calcium silicate hydrate (C S-H) and calcium aluminate hydrate (C-A-H), which strengthen and prolong the life of concrete. Fly ash provides to significant long-term strength benefits provided appropriate mix design and curing procedures are followed, even though it initially lowers the early-age strength of concrete due to its slower reaction rate. The following is a summary of fly ash's Pozzolanic reaction:

SiO2 + Ca(OH)2 → CaSiO3·H2O (C-S-H) (1)

Ca(OH) + Al2O3 2 → CaAl2O4·H2O (C-A-H) (2)

Calcium hydroxide is created as a byproduct of cement hydration:

C3S + H → C-S-H + Ca(OH) is the cement reaction. 2 (3)

Over time, fly ash and calcium hydroxide undergo pozzolanic reactions to provide additional binding elements that strengthen

concrete:

Pozzolanic Reaction: $Ca(OH)2 + S \rightarrow C\text{-}S\text{-}H$ (4)

shows how cement hydration and fly ash pozzolanic reactions work together to generate more C-S-H and C-A-H gels that improve mechanical characteristics and densify the concrete matrix. Fly ash-based concrete performs better than traditional concrete mixes during longer curing times because of this gradual but delayed strength development.

Result

Since businesses rely on their channel partners, they should take their needs into account and work to satisfy customers. By using supply chain management techniques, a company's channel strategies may enhance its performance and lead to organizational success. Because multiple procedures from different business domains are not integrated with technology, the channel partners are unable to meet consumer needs. The study must uncover every potential obstacle that channel partners in the outbound supply chain may encounter in order to improve customer satisfaction. Responsiveness in handling unpredictable lead times, traceability, geographic dispersion, and sources of disruption that impede execution is the main difficulty inherent in outbound supply chains.

In addition to information, good customer service also hinges on how visible the information is. The research and current practices demonstrate that money, knowledge, and materials or products move across the whole network; none of these resources exist in isolation since they are interconnected (Plenert, 2006).

Table 1: Business area and SCOR mapping in the cement industry's outbound supply chain

SCOR	Business Areas	Integration
PLAN	Demand Forecasting and Planning	• Plan gives an action plan for source, make, deliver and return (Fawcett *et al*, 2007; Marion, 2016). • SC integration optimization can lower the cost of cement supply chain (Isabel, 2009). • Integration on end to end SC includes raw materials, transport

		and information. Cement producers can also use IT solutions (Carmichael *et al*, 2011).
SOURCE	Inventory Planning and Management, Warehouse Management	• Source includes contracts and better supplier relationship management (Cachon *et al*, 2000). • Cement industries is driven by environmental regulations and relate to optimum utilization of raw materials (Galt *et al*, 1991).
MAKE	Inventory Planning and Management, Interface with Channel Partners	• Cement manufacturing process is highly automated continuous production which is capital and energy intensive (Banker *et al*, 2006; Noche *et al*, 2013). • Companies have to minimize logistics costs as cement is a low value density product. The production process is make-to-stock where products can be kept in warehouses and delivered when there is demand (*Choe et al*, 2008).
DELIVERY	Transport Management	• Delivery includes managing the demand, logistics and distribution management (Basolea *et al*, 2016; Stock, 2001).

Collaboration has been shown to enable businesses to respond proactively to client demand (Botta-Genoulaz et al., 2010). Conflicts are reduced when channel partners in a supply chain communicate effectively (Oxford College of Procurement & Supply, 2017). Businesses can improve their supply chain performance by optimizing their resources (Plenert, 2006). However, these difficulties also present chances for businesses with sophisticated logistical systems, knowledgeable staff, and competent management to expand their market (Okeudo, 2012). According to studies, incorporating technology solutions into the supply chain may assist address some of these issues, which will enhance supply chain agility, shorten cycle times, increase efficiency, and guarantee timely delivery to clients.

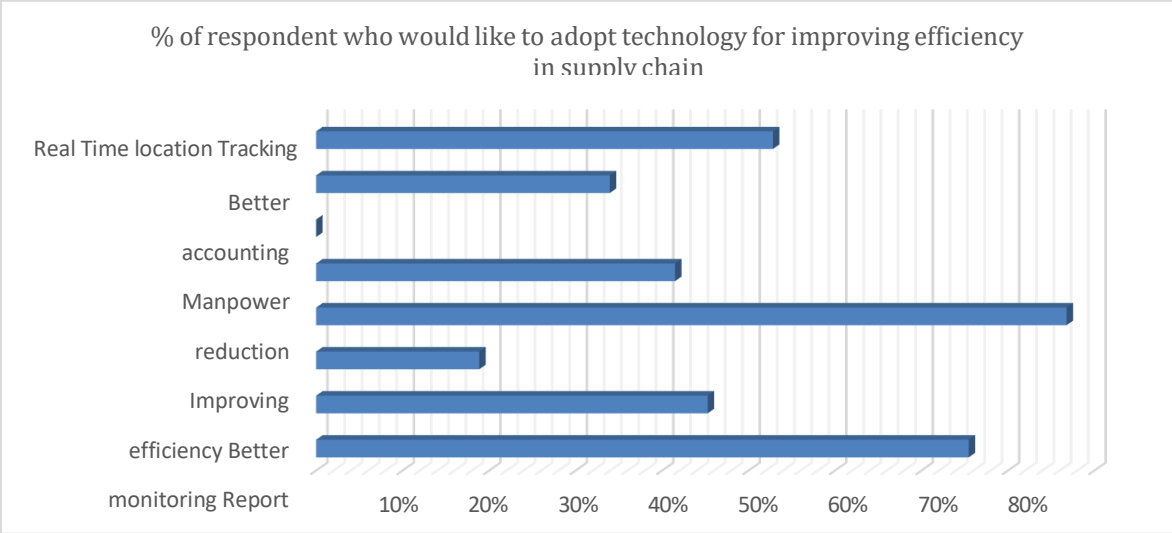

Figure 5: Channel partners' preferred areas for technology adoption in the cement sector

Determining the function of current gadgets and technologies utilized by channel partners

The literature review demonstrated that business imperatives are evolving for every industry worldwide. Here, the emphasis is on how technology is now used in the cement industry's outbound supply chain. Delivery and return are the two key areas of the outbound supply chain. Delivery manages the procedures that produce completed items in accordance with demand or prearranged plans. The topic of "usage of existing set of devices and technologies which are used by channel partners to manage operations in outbound supply chain" was the focus of a questionnaire employed in an empirical study in this area. The study methods section included information on the questionnaire's basis. According to the empirical survey's demographic data, 96% of respondents had less than five workers working for them. According to the report, 77% of the total have just one warehouse, while the remainder have several. Of the total, 58% maintain supplies of many brands of cement. It is discovered that manual procedures are employed for stock computations. When it comes to doing operational tasks on a daily basis, people are hesitant to use any kind of smart gadget or technology. It has been noted that the most popular method used by all responders to determine the stock's availability at the company's warehouse is

the phone. Only a small percentage of them (27% of the total) utilize computers, smartphones, webcams, and the Internet to manage inventory at their warehouses.

Table 2: Coefficient of Path

S N	Structural Path	Original Sample (O)	Sample Mean (M)	95% Confi. Interval (LB, UB)	T Stat.	P-val.
H 1	Advanced Infrastructure → BDAC	0.173	0.175	(0.115, 0.234)	5.791	0.001 *
H 2	Advanced Management Capability → BDAC	0.232	0.230	(0.125, 0.329)	4.442	0.002 *
H 3	Personnel Expertise Capability → BDAC	0.286	0.286	(0.377, 0.552)	6.228	0.004 *

It has been noted that the majority of the information is obtained over the phone. When material is acquired directly from a plant or manufacturing facility, many businesses send the consignee an SMS with information based on data that has already been recorded in the customer master. As soon as the invoice is completed, the communication is sent. In this manner, the consignee receives notification that his item has been loaded and that the invoicing has been completed, but he is unaware of when his goods will arrive. Similar techniques are also applied when materials are sent from warehouses; however, many warehouses do not bill in real time, therefore the usage of SMS for billing confirmation is still restricted.

The effective incorporation of MSP into concrete addresses environmental issues and promotes the circular economy, which is in line with global sustainability objectives. When FA, SF, and MSP are directly compared, their complementary roles in tangible performance are highlighted. While SF greatly increases early-age strength and decreases porosity because of its ultrafine particle size, FA primarily improves long-

term strength, durability, and workability. Despite not being pozzolanic, MSP reduces the need for clinker, which improves particle packing, lowers costs, and promotes sustainability. Workability, strength, durability, and environmental effect should all be balanced when choosing these SCMs in accordance with project-specific criteria.

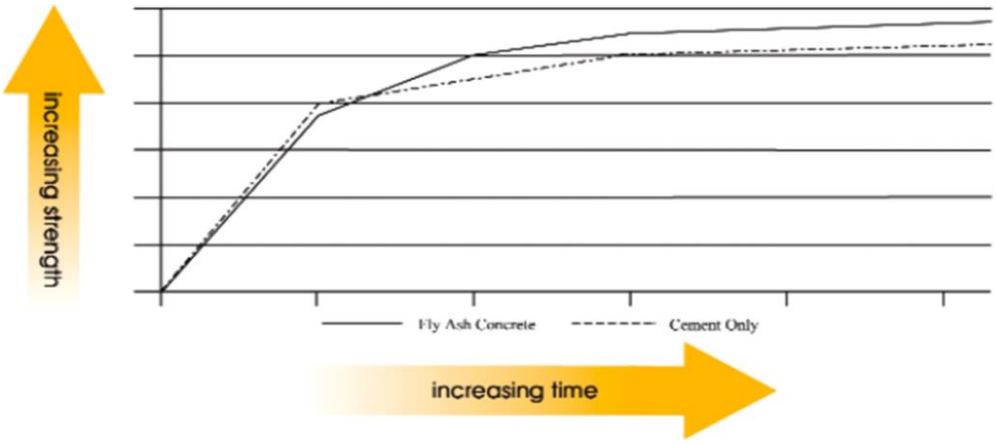

Figure 6: Fly ash concrete's typical strength gain

Determining the ideal replacement amounts to provide high mechanical strength, durability, and sustainability under various environmental circumstances is a substantial gap. Pre-treatment techniques for industrial wastes, such acid treatments, NaOH washing, and nano-coatings, have not been thoroughly quantitatively evaluated. Standardized methods are needed to evaluate and compare the impact of various treatments on strength, durability, and interfacial transition zone parameters. Few studies assess whether employing these minerals in concrete is economically and environmentally sustainable. Particularly for integrated SCM systems, comprehensive life cycle assessments that quantify CO2 emissions, energy savings, and economic advantages are absent.

Conclusion

The study on the impact of digital solutions in supply chain management, with special reference to cement industries in Rajasthan, reveals that digital transformation has become a critical driver of operational efficiency, cost reduction, and strategic competitiveness. The cement sector, characterized by high logistics intensity and complex process flows, benefits

significantly from technologies such as IoT-based monitoring systems, big data analytics, digital procurement platforms, GPS-enabled fleet management, and automated inventory tracking. These digital tools enhance real-time visibility, improve demand forecasting, streamline transportation, and reduce bottlenecks across the value chain. Despite these advantages, the research also highlights persistent challenges—such as limited technology awareness, inadequate digital infrastructure in remote production areas, workforce skill gaps, and high upfront investment requirements—that restrict the pace of digital adoption. However, companies that have embraced digital solutions report improved supply reliability, reduced lead times, better resource utilization, and stronger customer satisfaction.

Overall, the study concludes that while digital integration in Rajasthan's cement supply chains is still evolving, it holds immense potential to transform traditional operations into highly efficient, resilient, and data-driven systems. To fully realize these benefits, cement firms must invest in digital capabilities, employee training, and collaborative partnerships, supported by state-level policies that encourage industrial digitalization. Strengthening digital adoption will not only enhance supply chain performance but also position the cement industry of Rajasthan for sustained growth in an increasingly competitive and technology-driven marketplace.

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