A STUDY ON FACTORS INFLUENCING COST STRUCTURE AND COST CONTROL IN IRON ORE MINING OPERATIONS

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ABSTRACT

India's steel industry is one of the most important sectors in the country's economy. It supports infrastructure, drives manufacturing, and contributes significantly to national growth. As one of the largest steel producers in the world, India's ability to stay competitive globally depends not just on how much steel it produces, but on how efficiently it manages costs at every stage right from extracting raw materials to delivering the finished product. Among all the stages in this chain, iron ore mining is perhaps the most critical, because what happens at the mine has a direct impact on the financial performance of the entire steel operation. Most large steel companies in India have chosen to operate their own captive iron ore mines rather than rely on outside suppliers. This gives them greater control over supply and protects them from sudden price increases in the open market. However, having a captive mine does not automatically mean costs are under control. Mining iron ore is an expensive and complex activity. It involves drilling, blasting, removing large volumes of overburden, consuming fuel and electricity, maintaining heavy equipment, managing a large workforce, handling transportation, and paying various statutory charges and royalties. Each of these cost elements needs to be carefully monitored and managed. The study uses secondary data collected from cost statements, production records, and financial reports of an integrated steel company for the period 2020–21 to 2024–25. Analytical methods including trend analysis, percentage analysis, common-size analysis, and ratio analysis have been applied to understand how costs have moved over this period, where inefficiencies have crept in, and how well the existing cost control practices have worked. The findings provide a clear picture of the company's current cost performance and offer practical suggestions for improving cost efficiency and ensuring long-term operational sustainability.

Keywords: Cost Structure, Mining Cost, Cost Control Practices, Trend Analysis, Ratio Analysis, Operational Efficiency.

1. INTRODUCTION

Steel is one of those industries that quietly holds everything together. Roads, bridges, railways, factories, buildings none of it happens without steel. In India, the sector carries even greater significance. It is not just a contributor to economic growth; it is one of the primary drivers of it. Among the various types of steel producers, fully integrated companies hold a distinct advantage they control the entire production process from the ground up, beginning at the iron ore mine. These captive mines are not a side operation. They are the starting point of everything, supplying the raw material that keeps the entire plant running.What happens at the mine, therefore, matters enormously. Mining is one of the most cost-heavy stages in steel production, and any disruption or inefficiency here sends ripples through the entire value chain. When fuel prices rise, when equipment breaks down unexpectedly, when labour costs climb, or when regulatory charges increase

the cost of producing every tonne of steel goes up. In an industry that already operates on thin margins and faces intense competition, these pressures are difficult to absorb.

This is why cost control in mining operations is not just an accounting exercise. It is a strategic necessity.This study takes a close look at the cost structure of iron ore mining operations in an integrated steel company, examining how costs have behaved over a five-year period and how effectively the existing systems for managing those costs have actually worked. The aim is to move beyond surface-level observations and offer a grounded, evidence-based understanding of where the real cost pressures lie and what can be done about them.

1.1 Industry Profile

Iron ore mining sits at the very foundation of industrial activity. Without it, there is no steel. And without steel, there is no infrastructure, no construction, no manufacturing at the scale that modern economies demand. In India, this connection runs particularly deep. The country is endowed with substantial mineral wealth, and its mining sector has grown into a significant contributor to economic development — not just as a supplier of raw materials, but as an employer, a revenue generator, and a driver of activity across several linked industriesMining, by its very nature, is a demanding business. It requires heavy capital investment, large-scale equipment, and continuous operational effort. Nothing about it is light or simple.

Drilling through rock, blasting, excavating, crushing, screening, and transporting ore across long distances — each of these activities demands fuel, machinery, skilled manpower, and careful coordination. The sheer scale of operations means that even marginal improvements in cost efficiency can translate into significant savings, while inefficiencies, if left unchecked, can quietly erode profitability over time.India's iron ore reserves are concentrated in a handful of mineral-rich states — Odisha, Jharkhand, Chhattisgarh, Karnataka, and Goa being the most prominent among them. Over the years, these regions have developed well-established mining ecosystems, with supporting infrastructure in the form of transportation networks, ore processing facilities, and a trained workforce. Together, they supply the bulk of the iron ore that feeds India's steel plants and keeps the country's production capacity running.Yet the industry does not operate without friction. Mining companies today face a range of pressures that make cost management increasingly difficult. Fuel and energy costs have been rising steadily, adding to the expense of running heavy equipment and processing ore. Environmental regulations have become more stringent, requiring companies to invest in land reclamation, pollution control, and afforestation — all of which add to operational costs without directly contributing to output. Land acquisition remains a sensitive and often time-consuming challenge, while global commodity price swings create uncertainty around revenue even when production stays consistent.Transportation and logistics present another layer of complexity. Iron ore mines are frequently located at considerable distances from steel plants and export ports, meaning that the cost of moving ore from where it is extracted to where it is needed forms a substantial share of total expenditure. On top of this, variations in stripping ratio — the amount of waste material that must be removed to access usable ore — and fluctuations in ore grade and quality directly affect how much it costs to produce each tonne of usable material. Together, these variables make iron ore mining a sector where operational discipline and cost awareness are not optional — they are the difference between a viable operation and one that struggles to survive.

2.Review of Literature

Cost structure and cost efficiency have been studied widely in heavy industries:

Krishna (2000) noted that economies of scale lower unit costs in capital-intensive industries such as iron and steel.

B. N. Goldar (2012) emphasized the importance of technology and energy efficiency in lowering mining and manufacturing costs.

Chopra (2001) highlighted that environmental compliance and statutory payments must be treated as integral components of mining cost.
Ghose (2004) identified labour wages, fuel price increases, and mechanization as major cost drivers in mining.
Sinha (2010) linked productivity with equipment utilization, stripping ratio, and scientific mine planning.
Jain (2008) underscored the importance of budgetary control and variance analysis in public sector companies.
Papola (2005) stressed labour productivity as a key determinant of industrial cost efficiency.

2.1.Research Gap

Most existing studies on cost structure in iron ore mining focus on broad financial trends such as total production cost and profitability, with limited attention to detailed, mine-level analysis. There is a clear gap in micro-level examination of cost components like drilling, blasting, hauling, fuel, labour, and maintenance, which are often aggregated, making it difficult to identify inefficiencies. Additionally, operational causes of cost variation—such as poor equipment utilisation, unplanned downtime, inefficient fuel management, ore quality variability, and inadequate planning—are not sufficiently explored. Although key cost drivers like energy consumption, labour productivity, equipment efficiency, stripping ratio, and transportation are recognised, their dynamic interrelationships are rarely analysed in real operational contexts. Further, factors influencing cost control practices, including technological adoption, management efficiency, workforce skills, and regulatory constraints, are not well integrated into existing research. The effectiveness of cost control techniques such as budgeting and variance analysis also remains under-evaluated. These gaps lead to higher costs, inefficient resource use, reduced profitability, and weaker decision-making in mining operations.

2.2Objectives of the Study

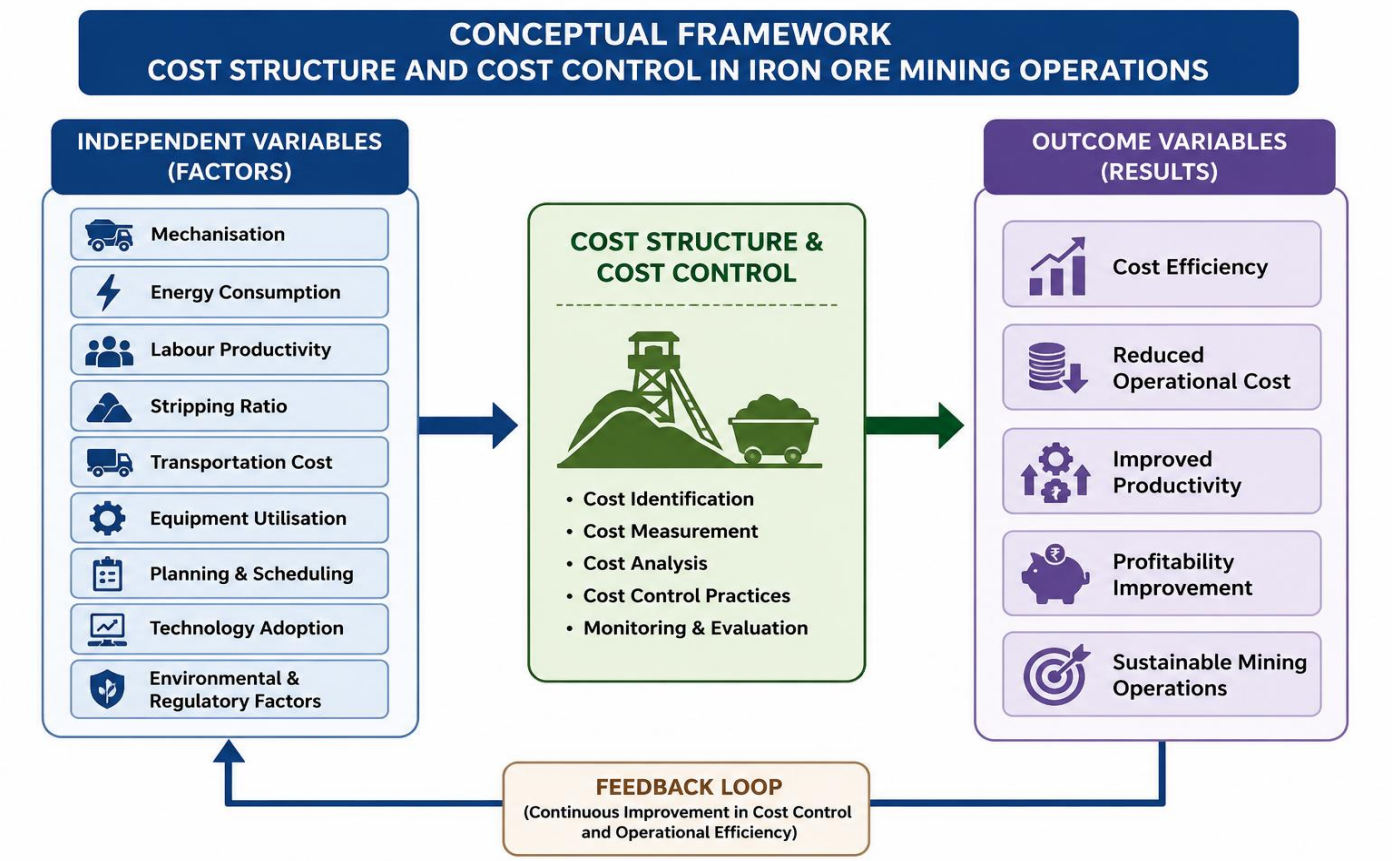
Primary Objective

To analyse the cost structure of iron ore mining operations and evaluate the effectiveness of cost control practices.

Secondary Objectives

- To identify and classify major mining cost components.
- To examine fixed, variable, and semi-variable cost behaviour.
- To calculate and analyse cost per tonne trends.
- To evaluate the role of stripping ratio, fuel price variation, and equipment utilization in cost behaviour.
- To analyse productivity indicators (output per employee, machine utilization, fuel consumption).
- To assess statutory expenses such as royalty, DMF, and environmental compliance.
- To evaluate existing budgeting and cost monitoring systems.
- To suggest strategies for cost reduction and operational efficiency

3.Conceptual Framework



Source: Author's own conceptual Model

4.Research Methodology

4.1.Research Design

The study adopts a descriptive research design to analyze the cost structure and cost control practices in iron ore mining operations. Both primary and secondary data are used to achieve the objectives of the study. Primary data is collected through a structured questionnaire based on a five-point Likert scale from employees and officials involved in mining operations. Secondary data is gathered from annual reports, cost statements, production records, journals, books, and relevant online sources. The study period covers five years from 2020–21 to 2024–25. For data analysis, various statistical and financial tools such as percentage analysis, descriptive statistics, trend analysis, ratio analysis, and comparative statement analysis are applied. In addition, correlation analysis is used to examine the relationship between cost factors and overall cost efficiency. The collected data is analyzed using appropriate software tools to ensure accuracy and reliability. The methodology helps in identifying key cost components and evaluating the effectiveness of cost control practices in mining operations.

4.2.Sampling Technique:

The study adopts a non-probability sampling technique, specifically the purposive sampling method, to analyze the cost structure and cost control practices in iron ore mining. In this approach, the sample is selected based on the relevance and availability of data required for the study. A single iron ore mining unit has been chosen deliberately as it provides adequate and reliable information related to production, cost, and operational activities. The research mainly relies on secondary data sources, including production reports, cost statements, and company records. This method is appropriate as it enables an in-depth understanding of

cost management practices within the selected mining unit and helps in achieving the objectives of the study effectively.

4.3.Tools Used:

- Trend analysis
- Comparative statements
- Percentage analysis
- Common-size analysis
- Ratio analysis
- Graphical representation

4.4. Data Collection

The study was carried out using both primary and secondary sources of data. Primary data was collected directly from employees and officials involved in mining operations through a structured questionnaire to understand their views on cost structure and cost control practices. Secondary data was obtained from annual reports, cost statements, production records, books, journals, research articles, and relevant online sources to support the study with theoretical and financial information. The collected data was analyzed using statistical and financial tools such as percentage analysis, trend analysis, and ratio analysis with the help of appropriate software to ensure accuracy and reliability of the results.

5.Data Analysis and Interpretation

5.1Trend Analysis

TABLE 1: SHOWING TREND ANALYSIS

PARTICULARS	**2020-21**	**2021-22**	**2022-23**	**2023-24**	**2024-25**	**Abs. Change (₹ Cr)**	%	%	%	%	%
NON-CURRENT ASSETS											
(a) Property, Plant & Equipment	9,124.22	10,155.70	10,473.13	10,500.01	10,492.08	**1,367.86**	100	111.31	114.79	115.08	114.98

(b) Capital Work-in-Progress	2,537.93	1,765.74	1,428.66	1,517.66	1,951.16	**-586.77**	100	69.56	56.29	59.8	76.88
(c) Right of Use Assets	413	698.26	652.7	814.44	1,845.87	**1,432.87**	100	169.07	158.05	197.2	446.93
(d) Inventory (Non-current)		3,098.24	3,136.99	3,155.12	3,112.64		100	232580	260190	262110	143710
(e) Intangible Assets	0.02	465.16	520.38	524.22	287.42	**287.4**	100	120	100	100	100
(f) Investments	0.1	0.12	0.1	0.1	0.1	-	100	167.38	246.33	220.24	1032.63
(g) Other Non-Current Assets	60.36	101.03	148.68	132.94	623.25	**562.89**	100	134.28	134.94	137.31	153.64
Total Non-Current Assets	**12,173.12**	**16,344.76**	**16,424.09**	**16,713.50**	**18,702.01**	**6,528.89**	100	134.28	134.94	137.31	153.64
CURRENT ASSETS											
(a) Inventories	2,154.78	2,714.25	3,975.25	4,677.43	5,745.97	**3,591.19**	100	125.97	184.48	217.06	266.67
(b) Trade Receivables	66.59	51.3	58.56	64.29	88.11	**21.52**	100	77.04	87.93	96.55	132.33
(c) Cash & Cash Equivalents	0.12	0.28	1.11	1.7	8.56	**8.44**	100	233.33	925	1416.67	7133.33
(d) Other Bank Balances	10	12.94	10.17	252.12	400.57	**390.57**	100	129.4	101.7	2521.2	4005.7
(e) Loans	213.1	204.17	258.1	252.12	400.57	**187.47**	100	95.34	121.11	118.33	187.97
(f) Other Current Assets	969.09	1,451.12	1,457.60	1,478.64	1,488.86	**519.77**	100	149.74	150.4	152.57	153.64
Total Current Assets	**3,413.72**	**4,436.97**	**5,762.73**	**6,484.55**	**7,733.31**	**4,319.59**	100	129.94	168.78	189.94	226.47
TOTAL ASSETS	**15,590.03**	**20,785.61**	**22,190.44**	**23,199.09**	**26,435.81**	**10,845.78**	100	133.32	142.34	148.8	169.57
EQUITY &											

LIABILITIES											
(a) Equity Share Capital	11,784.45	13,769.22	16,124.77	17,265.16	19,181.38	**7,396.93**	100	116.84	136.83	146.47	162.76
Total Equity	**11,784.45**	**13,769.22**	**16,124.77**	**17,265.16**	**19,181.38**	**7,396.93**	100	116.84	136.83	146.47	162.76
NON-CURRENT LIABILITIES											
(a) Borrowings (NC)	489.22	651.6	628.74	776.38	1,730.24	**1,241.02**	100	133.2	128.53	158.7	353.66
(b) Trade Payables (NC)	50.92	123.38	129.22	139.37	128.85	**77.93**	100	242.3	253.75	273.74	253.12
(c) Other Financial Liabilities	-159.88	689.7	640.88	1,235.91	1,342.15	**1,502.03**	-				
(d) Deferred Tax Liabilities	0	0	9.5	15.41	25.66	**25.66**					
Total Non-Current Liabilities	**384.54**	**1,468.79**	**1,408.34**	**2,167.07**	**3,226.90**	**2,842.36**	100	382.03	366.33	563.53	839.31
CURRENT LIABILITIES											
(a) Borrowings (Current)	702.24	1,573.66	1,451.33	1,179.89	1,200.75	**498.51**	100	224.11	206.67	167.99	170.97
(b) Trade Payables	1,620.90	2,711.50	1,808.34	1,478.06	1,809.41	**188.51**	100	167.32	111.56	91.18	111.63
(c) Other Financial Liabilities	465.88	917.52	841.38	601.93	507.21	**41.33**	100	196.95	180.59	129.22	108.87
(d) Other Current Liabilities	630.09	344.86	556.87	506.84	507.88	**-122.21**	100	54.74	88.38	80.44	80.6
(e) Current Tax Liabilities	1.93	0.06	-0.59	0.14	2.28	**0.35**	100	3.11	-30.57	7.25	118.13

Total Current Liabilities	**3,421.04**	**5,547.60**	**4,657.33**	**3,766.86**	**4,027.53**	**606.49**	100	162.16	136.12	110.11	117.72
TOTAL EQUITY & LIABILITIES	**15,590.03**	**20,785.61**	**22,190.44**	**23,199.09**	**26,435.81**	**10,845.78**	100	133.32	142.34	148.8	169.57
ANALYTICAL RATIOS											
Current Ratio (CA / CL)	0.998	0.8	1.237	1.721	1.92	**0.92**	100	80.16	123.95	172.44	192.38
Equity Ratio (Equity / Assets)	0.76	0.66	0.73	0.74	0.73	**-0.03**	100	86.84	96.05	97.37	96.05
Debt-Equity Ratio	0.1	0.16	0.13	0.11	0.15	**0.05**	100	160	130	110	150
Working Capital (₹ Cr)	**-7.32**	**-1,110.63**	**1,105.40**	**2,717.69**	**3,705.78**	**3,713.10**	100	15165	-15082	-37107	-50576

Source- Secondary Data

Interpretation

The company shows strong financial expansion from 2020–21 to 2024–25, with total assets rising from ₹15,590 Cr to ₹26,435.81 Cr due to increased investment in core assets. Liquidity improved sharply as the current ratio rose to 1.92, and working capital turned strongly positive. Equity remains the primary funding source, keeping capital structure stable, though rising debt levels need careful monitoring to maintain sustainability.

5.2.Common-Size Analysis

TABLE 2 : SHOWING COMMON SIZE ANALYSIS

ASSETS	2020-21 (₹)	(%)	2021-22 (₹)	(%)	2022-23 (₹)	(%)	2023-24 (₹)	(%)	2024-25 (₹)	(%)
Total Assets	15590.03		20785.61		22190.44		23199.09		26435.81	
Non-Curre	12173.12	78.09	16344.76	78.64	16424.09	74.02	16713.5	72.04	18702.01	70.74

nt Assets										
Property, Plant & Equipment	9124.22	58.53	10155.7	48.86	10473.13	47.2	10500.01	45.27	10492.08	39.69
Capital Work-in-Progress	2537.93	16.28	1765.74	8.49	1428.66	6.44	1517.66	6.54	1951.16	7.38
Right of Use Assets	413	2.65	698.26	3.36	652.7	2.94	814.44	3.51	3112.64	11.77
		100		100		100		100		100
Current Assets	3413.72	21.91	4436.97	21.36	5762.73	25.98	6484.55	27.96	7733.31	29.26
Inventories	2154.78	13.82	2714.25	13.06	3975.25	17.91	4677.43	20.16	5745.97	21.73
Trade Receivables	66.59	0.43	51.3	0.25	58.56	0.26	64.29	0.28	88.11	0.33
Cash & Bank Balance	0.04	0.01	0.28	0.01	1.11	0.01	1.7	0.01	8.56	0.03
Other Financial Assets	213.1	1.37	204.17	0.98	258.1	1.16	252.12	1.09	400.57	1.52
Other Current Assets	969.09	6.21	1451.12	6.98	1457.6	6.57	1478.64	6.37	1488.86	5.63
Equity	11784.45	75.58	13769.22	66.27	16124.77	72.67	17265.16	74.43	19181.38	72.56
Total Non-Current Liabilities	384.54	2.47	1468.79	7.07	1408.34	6.34	2167.07	9.34	3226.9	12.21

Borrowings	489.22	3.14	651.6	3.13	628.74	2.83	776.38	3.35	1730.24	6.54
Total Current Liabilities	3421.04	21.95	5547.6	26.69	4657.33	21	3766.86	16.24	4027.53	15.23
Trade Payables	702.24	4.5	1573.66	7.57	1451.33	6.54	1179.89	5.08	1200.75	4.54
Other Financial Liabilities	1620.9	10.4	2711.5	13.33	1808.34	8.15	1478.06	6.37	1809.41	6.84

Source- Secondary Data

Interpretation

The common-size balance sheet shows a gradual shift from non-current to current assets, indicating stronger liquidity and improved working capital. Equity continues to dominate financing, reflecting financial stability, while long-term liabilities have increased, signalling higher future commitments. Although the company's structure is becoming more balanced, rising borrowings and growing inventory levels require close monitoring to maintain financial efficiency.

5.3.Ratio Analysis
5.3.1.Profitability Ratios

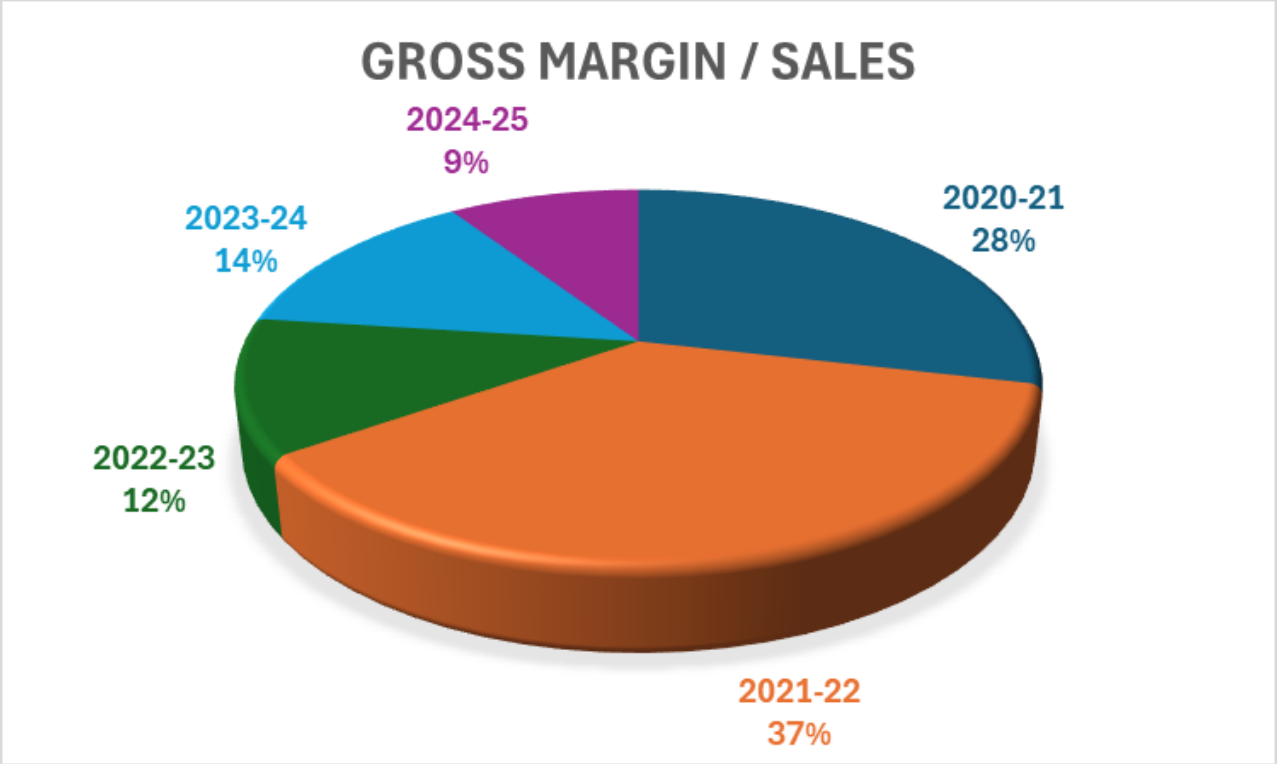
TABLE 3 : SHOWING PROFITABILITY RATIO

Particulars	**2020-21**	**2021-22**	**2022-23**	**2023-24**	**2024-25**
Gross Margin / Sales	2007%	2572%	821%	959%	651%
Net Profit / Sales	1386%	2144%	322%	323%	305%
Return on Net Worth	1675%	4202%	506%	448%	-312%
Gross Margin to Avg. Capital Employed	3192%	6972%	1797%	1882%	1041%
Net Profit to Avg. Capital Employed	2206%	5812%	706%	634%	-444%

TABLE 4 SHOWING WORKING NOTES OF PROFITABILITY RATIO

Year	Net Sales	Net Profit	Net Worth	Total Assets	Current Liabilities	Capital Employed	Avg. Capital Employed	Gross Profit
2020-21	15634.02	2251.5	11784.45	**15590.03**	3421.04	12168.99	12168.99	**3138**
2021-22	27535.31	6064.21	13769.22	**20785.61**	5547.6	15238.01	13703.5	**7083**
2022-23	25295.07	840.84	16124.77	**22190.44**	4657.33	17533.11	16385.56	**2076**
2023-24	24664.24	822.83	17265.16	**23199.09**	3766.86	19432.23	18482.67	**2365**
2024-25	21645.71	-621.12	19181.38	**26435.81**	4027.53	22408.28	20920.25	**1409**

CHART 1 SHOWING GROSS MARGIN SALES



Source: Secondary Data
Interpretation

Net sales and profits peaked in 2021–22 but declined sharply afterward, with net profit turning negative in 2024–25, indicating weakening performance. Although net worth and capital employed have steadily increased, the declining profitability suggests inefficient resource utilization. The drop in gross profit further highlights rising costs or shrinking margins.

6. Findings

- The asset base and capital employed increased significantly during the study period.
- Profitability showed a declining trend, with losses observed in 2024–25.
- Long-term liabilities increased, indicating growing dependence on debt.
- Liquidity improved with higher current assets and positive working capital.
- Inventory buildup reduced overall efficiency.
- Equipment utilization and cost behaviour suggest operational inefficiencies. Interest coverage dropped due to declining profits.
- Turnover ratios weakened, showing poor use of capital and working capital. Cost control tools exist but are not effectively implemented.

7. Suggestions

1. Strengthen cost control through stricter budgeting, variance analysis, and monitoring.
2. Improve inventory management to free working capital and reduce holding costs.
3. Enhance equipment utilization and reduce downtime through predictive maintenance.
4. Implement digital monitoring systems for fuel efficiency and machine performance.
5. Optimize labour productivity through training and workforce planning.
6. Regularly review statutory expenses and negotiate logistics and transportation costs.
7. Adopt modern mining technology to reduce fuel and energy consumption.
8. Improve profitability by aligning production planning with market demand.
9. Reduce reliance on borrowings through better internal cost control.

8. Practical Applications

The study has several practical uses that can directly help improve how mining operations are managed. It helps managers clearly understand where most of the money is being spent, such as on fuel, labour, transportation, and equipment maintenance. With this understanding, they can take better decisions to control unnecessary expenses and use resources more efficiently. The study also highlights the importance of using machines effectively and reducing idle time, which can improve productivity and lower costs. It encourages the adoption of modern technology and energy-saving practices to avoid wastage. In addition, the findings support better planning, budgeting, and monitoring of daily operations. Overall, the study helps organizations make smarter decisions, reduce costs, and improve their overall performance in a practical and realistic way.

9.Conclusion

Cost analysis and cost control are essential for maintaining competitiveness in the steel and mining industry. This study shows that while the organization has a strong asset base, a stable capital structure, and improving liquidity, its profitability and operational efficiency have declined in recent years. Rising costs, inefficient resource utilization, and increased liabilities have contributed to financial pressure.

For long-term sustainability, there is a need to strengthen operational efficiency, optimize mining costs, improve equipment utilization, and enhance cost control mechanisms. With strategic improvements and the adoption of modern technologies, the organization can improve cost competitiveness and sustain its position in the industry.

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