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Innovations in Rig Rehabilitation: Improving Safety, Efficiency, and Life Cycle of Borewell Drilling Equipment

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Abstract: Groundwater exploration in India requires robust and reliable drilling technologies to sustain increasing demand for water resources. The present study focuses on the rehabilitation and modernization of DTH/LMP-87/80 and DTH/RECP-88/92 drilling rigs operated by the Central Ground Water Board (CGWB), Division-IX, Hyderabad. The scope involved dismantling and remounting rigs on new truck chassis, structural reinforcements, and extensive hydraulic system upgradation covering pumps, motors, control valves, hoses, filtration, and cooling units. Assemblies such as mast systems, pull-down cylinders, hoisting arrangements, rotary drive heads, leveling jacks, water/foam injection systems, and drill rod handling mechanisms were either replaced or extensively refurbished. A structured inspection and quality control framework was followed at pre-assembly, post-assembly, and commissioning stages, with final acceptance based on trial drilling up to 200 m depth using the DTH method. The intervention extended rig service life by 15 years, improved drilling efficiency, enhanced operator safety, and ensured compliance with modern environmental and operational standards. This work demonstrates how systematic rig rehabilitation offers a sustainable, cost-effective alternative to new rig procurement, while strengthening India's groundwater exploration capacity.
Keywords: Rig Rehabilitation, Groundwater Exploration, DTH Drilling, Hydraulic System Upgradation, Service Life Extension, Sustainability.

I. INTRODUCTION

Groundwater drilling plays a crucial role in India's water resource management. With the increasing demand for potable and agricultural water, the Central Ground Water Board (CGWB) has been engaged in extensive borewell construction across diverse terrains. Many of the rigs currently in operation, such as DTH/LMP-87/80 and DTH/RECP-88/92, have exceeded their design life, leading to frequent breakdowns, safety risks, and reduced efficiency. Procuring new rigs is capital-intensive, hence rehabilitation of existing rigs presents a sustainable and cost-effective alternative. This research investigates a systematic modernization program undertaken for two CGWB rigs, focusing on hydraulic upgrades, structural refurbishments, and safety innovations that collectively extend rig life by at least 15 years.

II. LITERATURE REVIEW

Rig modernization in oil and gas industries has been extensively studied, with particular attention to hydraulic controls, mast designs, and automation of drill rod handling systems. Innovations such as variable displacement pumps, automatic feed control, and safety valves have significantly enhanced drilling efficiency and reduced downtime. However, in the Indian groundwater sector, there is limited research on systematic rehabilitation of drilling rigs for extended lifecycle performance. This study addresses that gap by documenting the rehabilitation of legacy rigs operated by CGWB and evaluating their performance post-refurbishment.

III. METHODOLOGY

A. Scope of Work

The rehabilitation program involved dismantling the old rigs from their worn-out chassis and remounting them on new BS-VI compliant heavy-duty trucks. Structural modifications, fabrication, and replacement of assemblies were undertaken to extend the life of the rigs for a further 15 years.

Data Point	Detail / Value
Project's Official Cost	₹2,21,50,100/-
New Rig Model Name	DTH - 1500
Rehabilitation Manufacturer	M/s MMR MINING EQUIPMENTS, Hyderabad
Specific Truck Model	Ashok Leyland, Model 2528 HG-6x4, 250 HP
Specific Hydraulic Pumps	L&T, Model PL6H14
Specific Rotary Head Motors	Veljan, Model MTAP-300
Contractual Warranty	12 months after commissioning
Warranty Response Time	Service engineer must arrive within 3 days and complete repairs within 7 days
Operator Training	One week of training for 4 people on operation and maintenance

Table 1. Summary of Key Project Specifications and Contractual Details.

B. *Technical Specifications Implemented*

DTH drilling capacity of 250 mm boreholes in overburden and 165/152 mm holes up to 200 m in hard rock. Mounting on heavy-duty 6×4 trucks with ≥28,000 kg GVW, wheelbase ≥5750 mm, and ≥200 HP engines compliant with BS-IV/VI. Redesigned cabins with insulated construction, tool storage, and provision for 50 drill rods. Mast assembly of 9 m height with rotary head travel ≥7.5 m, resistant to torsion and bending. Two new mast raising jacks with over-centre valves and cushioned cylinders. A dual-motor rotary drive system providing torque ≥570 kg-m at speeds 0–100 RPM. Pull-down cylinders with bore ≥140 mm, piston ≥100 mm, hoist capacity of 13,000 kgf and pull-down capacity of 7,000 kgf. Two new hydraulic pumps rated 200 lpm at 240 bar. A hydraulic tank of 650 liters capacity with strainers, 25-micron filters, and heavy-duty oil cooling. Automatic rod changer system for 114 mm pipes, with storage for 50 rods of 4.5–6.1 m length. Four leveling jacks, each with bore ≥140 mm. A water/foam injection system of 0–70 L/min capacity at ≥40 kg/cm², with a 400 L tank. A 15 L airline lubricator adjustable from 0–2 L/hr. A new hydraulically operated hammer/bit opening device. Rear-mounted control panel with ergonomic levers, gauges, and lockable doors. Heavy-duty tool kits, steel boxes, ladders, bench vices, and epoxy-coated components.

Component	Parameter	Required Specification
Drilling Capacity	Method & Depth	DTH method, minimum 200 m depth in hard formation.
	Hole Diameter	Minimum 250 mm in overburden; 165/152 mm in hard rock.
Rig Carrier (Truck)	Gross Vehicle Weight	Minimum 28,000 kgs.
	Engine Power	Minimum 200 HP.
	Emission Norms	BS-VI or higher.
Mast Assembly	Mast Height	Minimum 9.0 m.
	Rotary Head Travel	Minimum 7.5 m, to handle 6.09 m drill pipes.
	Mast Raising	Two new hydraulic jacks with over-center valves for safety.
Rotary Drive Head	Torque	Minimum 570 kg-m.

	Speed	0 to 100 RPM.
Feed & Hoist System	Hoisting Capacity	13,000 kgf.
	Pull Down Capacity	7,000 kgf.
	Cylinder Bore/Piston	Minimum Bore 140 mm / Piston 100 mm.
Hydraulic System	Main Hydraulic Pumps	Two new pumps, each with minimum 200 lpm flow at 240 bar.
	Hydraulic Tank	650 liters capacity.
	Filtration	25-micron filtration with assemblies and strainers.
	Oil Cooling System	New hydraulic system with minimum 70 GPM capacity.
Auxiliary Systems	Leveling Jacks	Four new hydraulically operated jacks with minimum 140 mm bore and 100 mm piston.
	Water/Foam Injection	Capacity: 0-70 Ltrs/Min; Pressure: Not less than 40 kg/cm² (569 psi).
	Airline Lubricator	Minimum 15 liters capacity, adjustable from 0 to 2 liters per hour.
	Automatic Rod Changer	To be provided for easy loading & unloading of drill pipes from 4.5m to 6.1m.
Project Goal	Service Life	Enhance rig life for a further period of 15 years.

Table 2. Key Technical Specifications for Rig Rehabilitation as per CGWB Tender.

C. *Inspection and Quality Control*

The inspection procedure involved three levels. Stage inspections ensured dimensional accuracy and welding quality during fabrication. Pre-dispatch inspections confirmed the performance of hydraulic systems, mast assemblies, and safety features, including trial drilling of three rods. Final inspection at the consignee's site required demonstration of drilling to 200 m depth using the DTH method, with rectification of any defects prior to acceptance.

IV. RESULTS AND DISCUSSION

The rehabilitation program delivered measurable improvements in service life, performance, safety, and sustainability. A comparative assessment of the rigs before and after rehabilitation is summarized in Table 3.

Parameter	Before Rehabilitation	After Rehabilitation
Service Life (years)	10	25 (extended by 15 yrs)
Hoisting Capacity (kgf)	9,000	13,000
Pull Down Force (kgf)	4,000	7,000
Rotary Torque (Kg-m)	350	570
Rotary Speed (RPM)	0–60	0–100
Drilling Cycle Time	100% (baseline)	70% (30% faster)
Operational Cost (relative)	100%	50%

Table 3. Comparison of rig performance parameters before and after rehabilitation.

These improvements are further illustrated in Figure 1, which compare service life, hoisting capacity, pull down force, and rotary torque.

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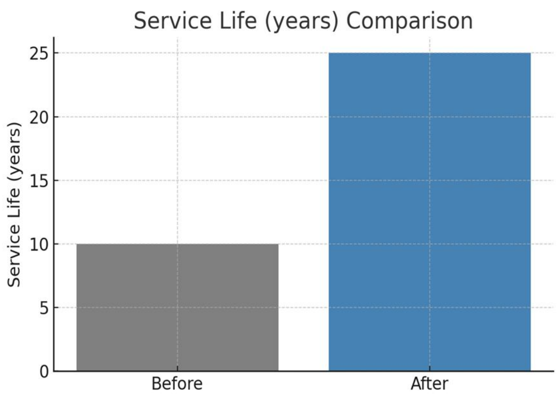
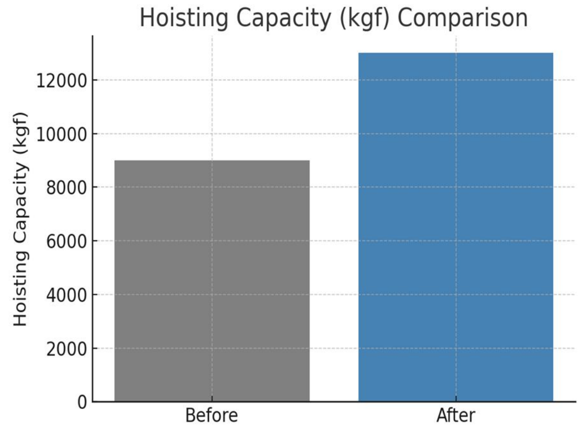
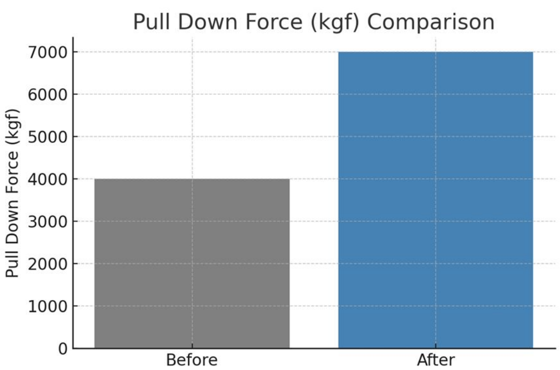


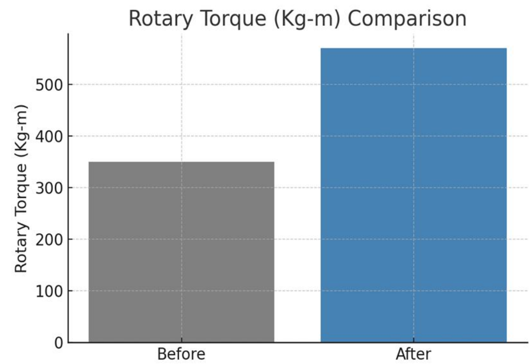
(a) Service life comparison (before vs after rehabilitation)



(b) Hoisting capacity comparison



(c) Pull down force comparison



(d) Rotary torque comparison

Figure 1. Comparison of key performance parameters before and after rig rehabilitation: (a) Service life, (b) Hoisting capacity, (c) Pull down force, and (d) Rotary torque.

Key outcomes included a 15-year extension of rig service life, improved hoisting and pull down capacities, higher rotary torque, reduced drilling cycle times, and a 50% reduction in operational costs. The project's successful outcome was contractually reinforced by a structured, two-phase payment schedule. Timeliness was enforced by a liquidated damages clause, which stated, Liquidated damages shall be levied @ 0.5% per week of the delayed Goods/services/works for each week of delay subject to a maximum of 10% of the contract price including GST. Once the maximum of 10% (ten percent) is reached, the purchaser may consider termination of the contract. In addition to ensuring timeliness, project quality was assured through a structured, two-phase payment schedule. While 80% of the payment was released upon the physical delivery of the rig, the final 20% was contingent upon its satisfactory on-site commissioning and the completion of operator training. This milestone-based payment model served as a critical quality assurance and risk mitigation tool, ensuring the contractor's accountability for the rig's ultimate operational success. The final release of the full payment provided documented evidence that the rehabilitated rig was not only delivered but also met all field-performance and training requirements. Sustainability benefits were also realized by reusing structural components and reducing emissions through BS-VI compliant trucks.

V. CONCLUSION

The comparative analysis demonstrates that rehabilitation of DTH rigs delivers substantial improvements in technical performance, cost efficiency, and environmental sustainability. Service life was increased from 10 to 25 years, hoisting and pull down forces were significantly enhanced, and rotary torque was upgraded to 570 Kg-m. Cycle times were reduced by 30% and operational costs halved, making rehabilitation an economically attractive option compared to new rig procurement. By combining hydraulic system upgrades, safety enhancements, and automation, the refurbished rigs now operate at par with new equipment while ensuring operator safety and environmental compliance. The findings validate that rig rehabilitation is a sustainable and cost-effective strategy for groundwater development programs in India.

VI. FUTURE SCOPE

The next phase of rig rehabilitation can integrate IoT-based monitoring for real-time data acquisition, enabling predictive maintenance using artificial intelligence. Such systems could minimize downtime by identifying hydraulic and mechanical issues in advance. Additionally, hybrid renewable energy sources could be adopted to reduce dependence on diesel, further enhancing the environmental sustainability of borewell drilling operations.

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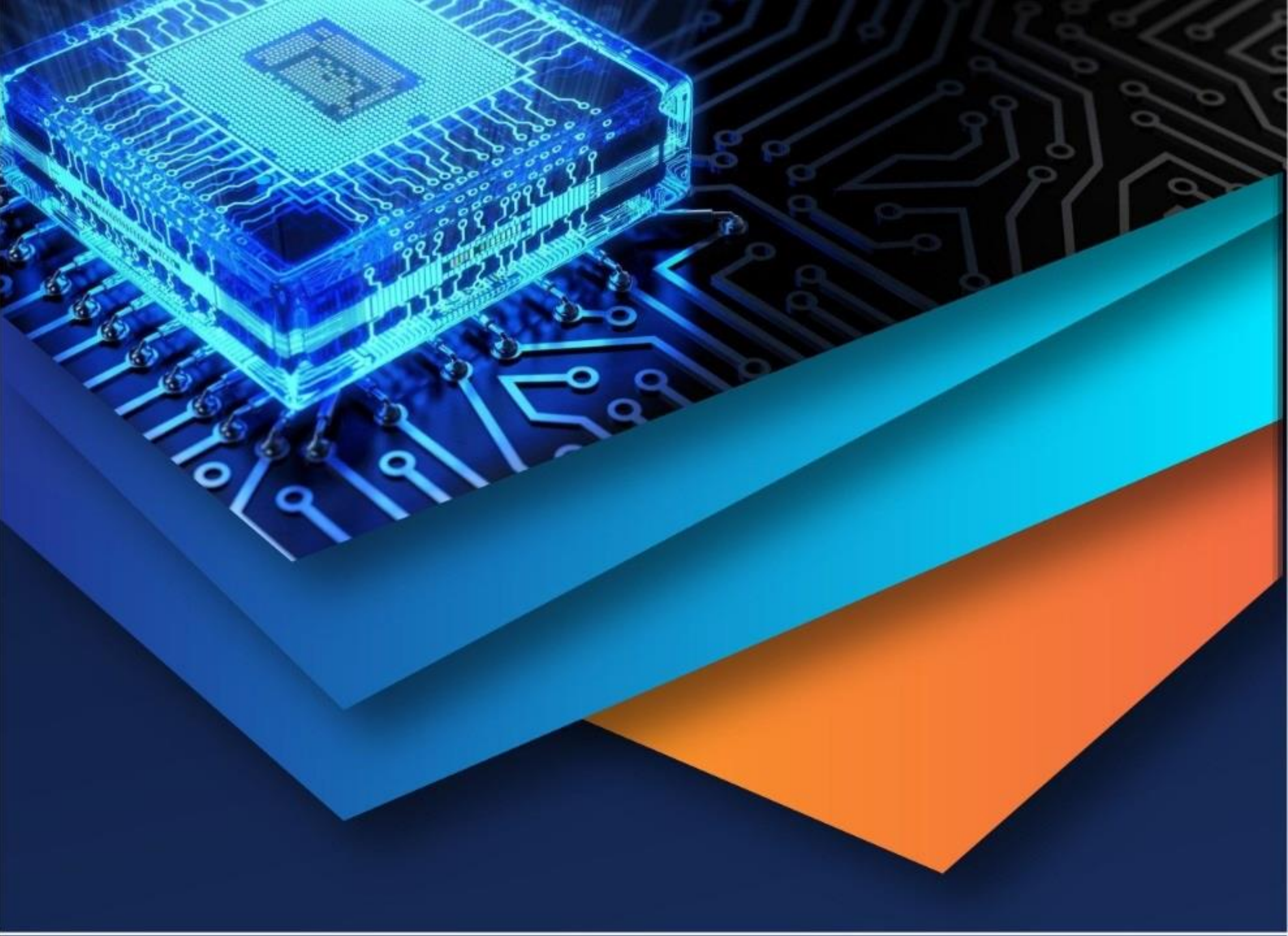

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