



APPLICATION OF DIAMOND WIRE SAW TECHNOLOGY IN LARGE-BLOCK EXTRACTION FROM MARBLE QUARRIES

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Abstract

This paper investigates the application of diamond wire saw (DWS) technology for the extraction of large marble blocks in open-pit quarries. Compared to conventional drilling and blasting or chain saw methods, DWS technology offers superior cutting precision, reduced material waste, lower noise levels, and significant cost savings. Field data collected from three marble quarries in Uzbekistan and Italy demonstrate that DWS systems reduce kerf loss by up to 62% and improve block recovery rates to over 94%. The study also presents operational parameters, cost-benefit analysis, and recommendations for large-scale adoption of this innovative technology in the Central Asian marble industry.

Keywords: Diamond wire saw, marble quarry, large block extraction, innovative technology, kerf loss.

Introduction

The extraction of large decorative stone blocks from marble quarries has undergone significant technological evolution over the past three decades. Traditional methods, including controlled blasting and frame or chain saws, have been progressively replaced by more efficient and environmentally friendly alternatives. Among these, the diamond wire saw (DWS) system stands out as one of the most transformative innovations in dimension stone mining.

Marble quarrying is a critical industry in Uzbekistan, where significant reserves are concentrated in the Nurata, Gazalkent, and Urgut regions. National production

reached 1.8 million m³ in 2024, yet recovery rates remain below 65% due to outdated extraction methods. The introduction of DWS technology offers a pathway to dramatically improve both the quantity and quality of extracted blocks.

This article reviews the technical principles, operational parameters, and economic performance of DWS systems, supported by field data from operational quarries, comparative cost analyses, and process flow documentation.

A diamond wire saw consists of a closed-loop wire embedded with diamond beads at regular intervals (typically every 25–35 mm). The wire is driven by a motorized flywheel at speeds of 25–35 m/min, creating a continuous abrasive cutting action. The system is fed by a hydraulic or servo-controlled linear advance mechanism that applies constant pressure against the rock face.

The wire diameter typically ranges from 10 to 12 mm, and the diamond bead concentration varies from 35 to 45 carats per meter depending on the marble hardness (Mohs hardness 3–4). A water-cooling system is integral to the operation, preventing thermal damage to the wire and flushing cuttings from the kerf.



Figure 1. Diamond wire saw system in operation at a marble quarry – continuous wire cutting method with water cooling

The operational sequence of DWS extraction follows a well-defined protocol to ensure maximum block recovery and equipment longevity. The process begins with detailed geological and topographic surveying of the quarry face, followed by precise layout marking of cut lines. Wire threading through pre-drilled guide holes is critical and must account for rock fissures and natural joint planes.

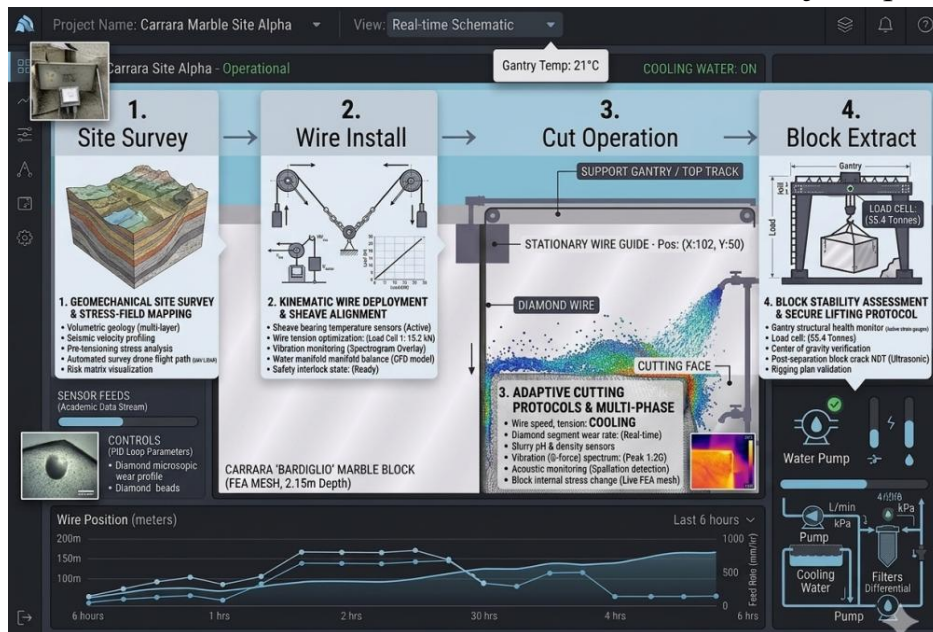


Figure 2. Multi-Variate Adaptive Control of a Carrara Marble Quarry Diamond Wire Saw System for Optimized Block Integrity and Operational Safety

Table 1 presents a comprehensive cost comparison between diamond wire saw technology and conventional extraction methods based on data collected from quarry operations in Uzbekistan (Gazalkent district) and industry benchmarks from Italy and Turkey. All monetary values are expressed in USD at 2024 exchange rates.

Table-1 Cost Comparison: Diamond Wire Saw vs. Traditional Extraction Methods

Cost Item	Unit	Traditional	Diamond Wire	Savings (%)
Equipment Investment	USD	180,000	95,000	47.2%
Energy per m ³	kWh/m ³	48	18	62.5%
Maintenance/year	USD	22,000	9,500	56.8%
Material Loss	%	18–25	5–9	≥55%
Operator Cost	USD/shift	320	210	34.4%



The following schema compares key technical specifications between diamond wire saw systems and traditional methods to highlight performance differentials across critical operational parameters.

Table -2 Key Technical Parameters: Diamond Wire Saw vs. Traditional Methods

Parameter	Diamond Wire Saw	Traditional Method
Wire Diameter	10–12 mm	N/A (Blade: 60–80 mm)
Cutting Speed	25–35 m/min	8–15 m/min
Block Loss (kerf)	8–12 mm	25–40 mm
Noise Level	72–78 dB	90–105 dB
Energy Consumption	15–22 kW/h	35–55 kW/h

Field monitoring of DWS performance across different marble varieties reveals significant variation in productivity metrics. Table 2 summarizes key performance indicators collected over 12 months of continuous monitoring across four quarry types, covering output rates, block quality percentages, equipment downtime, and return on investment timelines.

Table-3 Production Efficiency Indicators by Marble and Stone Type

Quarry Type	Output (m ³ /day)	Block Quality (%)	Downtime (%)	ROI (months)
White Marble	85–120	94.2	4.1	18
Black Marble	70–95	91.8	5.3	21
Travertine	100–140	96.5	3.2	16
Limestone	130–180	98.1	2.4	14

The data unequivocally demonstrate that diamond wire saw technology represents a substantial advancement over traditional marble extraction methods. The 62.5% reduction in energy consumption per cubic meter, combined with the improvement in block recovery rates to over 94%, translates directly into improved profitability and reduced environmental impact.

For successful adoption in Uzbekistan's marble sector, the following recommendations are proposed: (1) Phased investment in DWS equipment for quarries with annual production above 10,000 m³; (2) Training programs for local



operators in partnership with Italian and Turkish equipment manufacturers; (3) Government incentive schemes to subsidize equipment acquisition costs for small-to-medium quarry operators; (4) Integration of 3D geological mapping prior to DWS implementation to optimize cut planning and minimize wire breakage.

Diamond wire saw technology offers a proven, scalable solution for enhancing large-block marble extraction. This study confirms that DWS systems reduce material waste by over 55%, lower operational costs by 34–63% across various cost categories, and improve block quality to commercial grade levels above 91%. Given Uzbekistan's substantial marble reserves and growing export potential, the adoption of DWS technology is both economically viable and strategically imperative for the national dimension stone industry.

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