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Review paper

APPLICATION OF SMALL SELF-PROPELLED DRILL RIGS

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Abstract: Small-diameter drilling is used in many civil and mining engineering applications. In the past, it was mainly performed with hand-held hammer drills. However, the need for safer and more efficient work has led to the development of small self-propelled drilling machines that require fewer workers to achieve the same output while providing significantly safer working conditions.

Small-diameter boreholes are used in specialized blasting methods (e.g., blasting in urban areas, secondary boulder blasting), during the extraction of decorative stone blocks, for installing anchors in slope stabilization, in underground mining, in the application of expansive mortar for the disintegration of solid masses (stone, concrete), for creating protective screens, tunneling, and more.

Several manufacturers produce small self-propelled drill rigs, all equipped with remote controls. This eliminates the need for the operator to stand in potentially hazardous positions, as is required when using hand-held hammer drills. This paper presents the capabilities and application methods of these drill machines under various working conditions.

Keywords: drill rigs, drilling, mining, small diameter boreholes, excavation

1 INTRODUCTION

Boreholes are cylindrical holes drilled into rock for various purposes (Purtić, 1991). Throughout history, the drilling process has significantly evolved, from manual techniques using primitive tools to the fully automated, self-propelled machines used today.

Modern self-propelled drills operate using the principle of percussive-rotary drilling. This technique involves a chisel blade that is impacted by a piston. The blade penetrates the rock, and after each impact, it rotates by a specific angle to shear material at the borehole's bottom, shaping it into an oval. The rock is primarily fractured by the impact,

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so the striking force exceeds the rotational force. The chisel is simultaneously affected by static axial pressure, dynamic piston impact, and rotational torque (Purtić, 1991).

For the chisel blade to penetrate the rock, the specific pressure exerted must exceed the rock's compressive strength. Penetration is possible only when the combined static axial and dynamic impact forces meet or exceed the rock's compressive strength at the point of contact (Purtić, 1991).

A stable suspension system allows these machines to traverse uneven terrain. Their low noise and dust emissions make them ideal for urban environments. Their compact design ensures easy transportation between drilling sites and simplifies servicing, reducing maintenance downtime (Negovanović & Kričak, 2021).

2 CHARACTERISTICS OF SMALL SELF-PROPELLED DRILL RIGS

Several globally recognized manufacturers offer small self-propelled drill rigs that have proven to be reliable and cost-effective. The most notable manufacturers include Epiroc (formerly Atlas Copco) and Sandvik (Negovanović & Kričak, 2021).

Below are examples of specific drill rig models and their key characteristics.

2.1 FlexiROC T15 R surface top hammer drill rig

The FlexiRoc T15 R drill is a machine that has proven itself in demanding locations, providing easy transfer from location to location and excellent stability when moving. It has the possibility of additional anchoring for greater stability on uneven terrain, as well as support in the form of a "leg" when driving on slopes (Epiroc, 2024a). The technical characteristics of the FlexiROC T15 R small rotary drill are given in Table 1.

Figure 1 Small self-propelled drill machine FlexiRoc T15

Table 1 Technical specifications of FlexiRoc T15 R (Epiroc, 2024a)

Hole range					
Rock drill	Threads	Maximum hole length (m)	Drill diameter (mm)	Drill rod length (mm)	
COP 1022	HEX 22x108	9	Ø 27–45 mm	3 660 mm	
COP 1028	R28, SR28, R32, SR32	9	Ø 33–51 mm	3 660 mm	
Hydraulic rock drill					
Rock drill	Impact power	Hydraulic pressure, max	Impact rate	Torque at shank, max	Weight approx
COP 1022	4.5 kW	150 bar	70 Hz	126 Nm	50 kg
COP 1028	5.5 kW	185 bar	50 Hz	205 Nm	51 kg
Compressor- Atlas Copco C55 C106 GD, screw compressor					
Working pressure, max				2.5 bar	

2.2 Surface top hammer drill rig Command DC130Ri

The Commando DC130Ri is a remotely operated drill rig engineered for versatile applications such as road construction, demolition, and foundation work. Its modular design allows for upgradeability, making it a highly adaptable and multi-functional machine. Thanks to its compact dimensions and well-balanced structure, the DC130Ri offers excellent maneuverability, even in confined or uneven terrains. High-torque drive motors enhance mobility, while its lightweight frame facilitates easy transportation between job sites. Additionally, the modular layout simplifies maintenance, reducing downtime and operational costs.

Figure 2 Self-propelled drill for drilling small diameters Sandvik Command DC130Ri (Sandvik, 2024)

The drill's low noise and dust emissions make it ideal for use in urban environments. Its platform is easily adaptable for a range of applications, including secondary blasting, foundation drilling, and trenching.

Table 2 Technical characteristics of the drill machine Command DC130Ri (Sandvik, 2024)

Hole diameter	22–45 mm
Rock tools	H19, H22, H25, R23, R25, R28
Rock drill	RD106, 5.5 kW / 7.4 hp
Engine type	CAT C2.2 Tier 3
Engine output	36.3 kW / 48.7 hp
Flushing air	1.2 m^3/min, up to 8 bar
Control method	Radio remote
Total weight	3,250 kg
Transport length	5.1 m
Transport width	1.85 m
Transport height	2.3m

3 APPLICATION OF DRILLING MACHINES

Drilling small-diameter boreholes is widely used across various applications, making these machines valuable in numerous fields. The most common uses include underground exploitation of solid mineral resources, specialized blasting operations where environmental protection is a priority, the application of expansive mortars, tunnel construction, and slope stabilization through the installation of anchors and protective nets to prevent rockfalls.

3.1 Application of small self-propelled drill rigs for blastholes

To exploit solid mineral raw materials underground, small-diameter boreholes were mainly drilled with manual hammer drills. This method required a larger number of workers and made it much more difficult to achieve the desired number of drilled meters. Specialized machines are used for larger mines. These are boomer drilling machines with multiple drilling branches that can simultaneously drill a greater number of boreholes (>1).

Self-propelled drills for drilling small-diameter boreholes are primarily intended to replace manual hammer drills, of course, where possible. Also, in addition to the underground exploitation of solid mineral raw materials, the use of explosives in tunnel construction, special blasting for the excavation of foundation pits during the construction of facilities for various purposes, stabilization of slopes for road construction, secondary blasting of boulders, construction of channels, etc., is included. Figure 3 shows the Atlas Copco FlexiROC T15 self-propelled small-diameter borehole drill drilling a minefield in urban conditions.

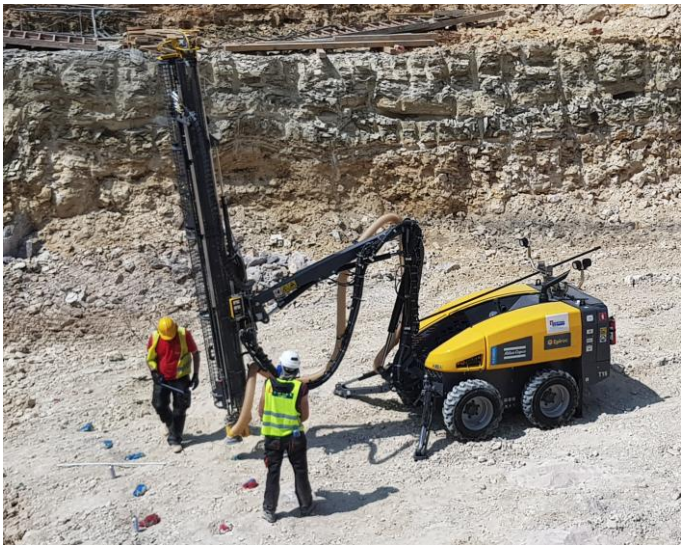

Figure 3 Atlas Copco FlexiRoc T15 self-propelled drill machine on worksite

3.2 Application of small self-propelled drills for expansive mortar

Expansive mortar is increasingly being used; therefore, boreholes with small diameters are being drilled for these purposes. Boreholes for the application of expansive mixtures are made at close distances according to the manufacturer's scheme (Table 3). The application of these mixtures requires a much larger number of boreholes than is the case with the use of explosives, which is logical when comparing the characteristics of explosive and expansive mortars.

Table 3 Characteristics of boreholes depending on the rock in which expansive mortars are applied (Quaryingtools, 2024)

Materials & purpose	Borehole design		
	Diameter（mm）	Borehole spacing	Depth
Soft stone quarrying	28-38	200-300mm	105% of height
Hard stone quarrying	30-40	200-300mm	105% of height
Stone cutting	28-38	200-400mm	90% of height
Plain concrete demolition	30-40	300-500mm	80% of height
Reinforced concrete demolition	35-40	150-300mm	90% of height

The expansion mixture is mixed with water and poured into pre-drilled boreholes in rock or concrete. The resulting mixture swells and exerts considerable expansion pressure on the walls of the borehole, breaking the rock and separating it along the length of the borehole lines (Negovanović et al., 2024).

Drilling boreholes for the use of expansive mixtures is applied in the exploitation of decorative stone and in the creation of protective screens that serve to prevent the propagation of waves behind them (Negovanović et al., 2024).

3.3 Application of small self-propelled drill machines for slope stabilization

Self-propelled drills used for drilling small-diameter boreholes are employed to secure slopes by placing anchors for stabilization. They are also used when installing protective nets that prevent rockfalls.

Figure 4 Construction of boreholes to stabilize the slope (Epiroc, 2024b)

Figure 5 Protective net-protection against the rock fall (Geotech, 2024)

4 CONCLUSION

Small self-propelled drill rigs are equipped with surface hammers and have four-wheel drive, enabling easy movement on uneven terrain. Due to their low noise and dust levels, they have proven to be excellent for working in urban environments. They are also easy to service, reducing maintenance downtime.

These machines have significantly improved the drilling process in many areas, with the most notable advancements in mining and construction. The mobility of these machines and the use of remote control have increased worker safety because the drilling process is indirectly, i.e., passively, controlled through the operator's commands. In contrast, when using hand-held hammers, everything depends on the driller, who relies mostly on physical strength and is directly exposed to dust, water, and the risk of injury.

More and more drilling machine manufacturers are including small self-propelled drill rigs in their product lines as the range of applications expands. The small mass of these machines enables great mobility on construction sites, as they can be moved from one part of the site to another using cranes. These drills can be used for anchoring and slope stabilization, greatly increasing operator safety.

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