HYDRODEMOLITION

Method, Solutions and Advantages

Content

Foreword

The purpose of this document is to provide comprehensive information about hydrodemolition as a method and its advantages. Additionally, it aims to assist engineers in developing their specifications for hydrodemolition work. This guide covers various aspects of a hydrodemolition project, serving as a valuable resource for engineers seeking to incorporate this method into their construction and repair projects.

It is important to note that while this document offers a comprehensive overview, engineers have the flexibility to tailor and adjust the specifications based on the unique requirements of each project. The information presented here serves as a foundation upon which engineers can build their specific hydrodemolition specifications, ensuring the best approach for successful project execution.

Introduction to hydrodemolition

We rely on concrete for many aspects of life – the roads we drive on, the dams that help produce power or control flooding, and structures that form our cities, to name a few. But like all building materials, it deteriorates over time. This is where hydrodemolition has proven to be the most ideal method of concrete removal.

Hydrodemolition is a specialized technique used in construction and civil engineering to remove deteriorated or damaged concrete using high-pressure water jets. Also known as water jetting or hydroblasting, it is an effective method for selectively removing concrete without damaging the underlying structure or reinforcing steel.

In hydrodemolition, a high-pressure water jet is directed at the concrete surface, effectively eroding and breaking down the concrete. The water is typically pressurized to a range of 1000 to 3000 bar (14,500 to 43,500 psi) and is emitted through a nozzle or lance. The force of the water jet can be adjusted to control the depth and rate of concrete removal.

The process is commonly used to remove deteriorated concrete from bridges, highways, parking garages, tunnels, dams, and other structures. It is especially beneficial in situations where precision is required, such as when removing damaged sections while preserving sound concrete or when creating a roughened surface for repair work or new construction. Hydrodemolition is known for its ability to remove concrete while minimizing vibrations and producing a clean, well-prepared surface for subsequent repairs or applications.

Hydrodemolition offers advantages over traditional mechanical methods of concrete removal, such as jackhammers or saw cutting, as it reduces the risk of structural damage, eliminates vibrations that can affect adjacent areas, and reduces the potential for micro-cracking. It is also considered a safer and more environmentally friendly alternative, as it generates less dust and airborne particles.

Overall, hydrodemolition has become a widely recognized and utilized technique in the construction industry for efficient and precise removal of deteriorated concrete.

History and development

Hydrodemolition has a history that spans several decades. Here is a brief overview of the development and key milestones in the history of hydrodemolition.

In 1983, the Swedish Road Administration, SRA, embarked on groundbreaking research into hydrodemolition technology, recognizing its potential as a game-changing approach to concrete removal. This early research laid the foundation for what would become a widely adopted method in the construction industry.

By mid 1980s, the first operational hydrodemolition machine in the world was successfully deployed in Sweden, marking a pivotal milestone in the technology's development and demonstrating its practical viability.

In 1988, the SRA in Sweden took a decisive step by announcing a decree that established hydrodemolition as a primary alternative for concrete removal. This official recognition solidified hydrodemolition's status as a legitimate and preferred method in the field of construction.

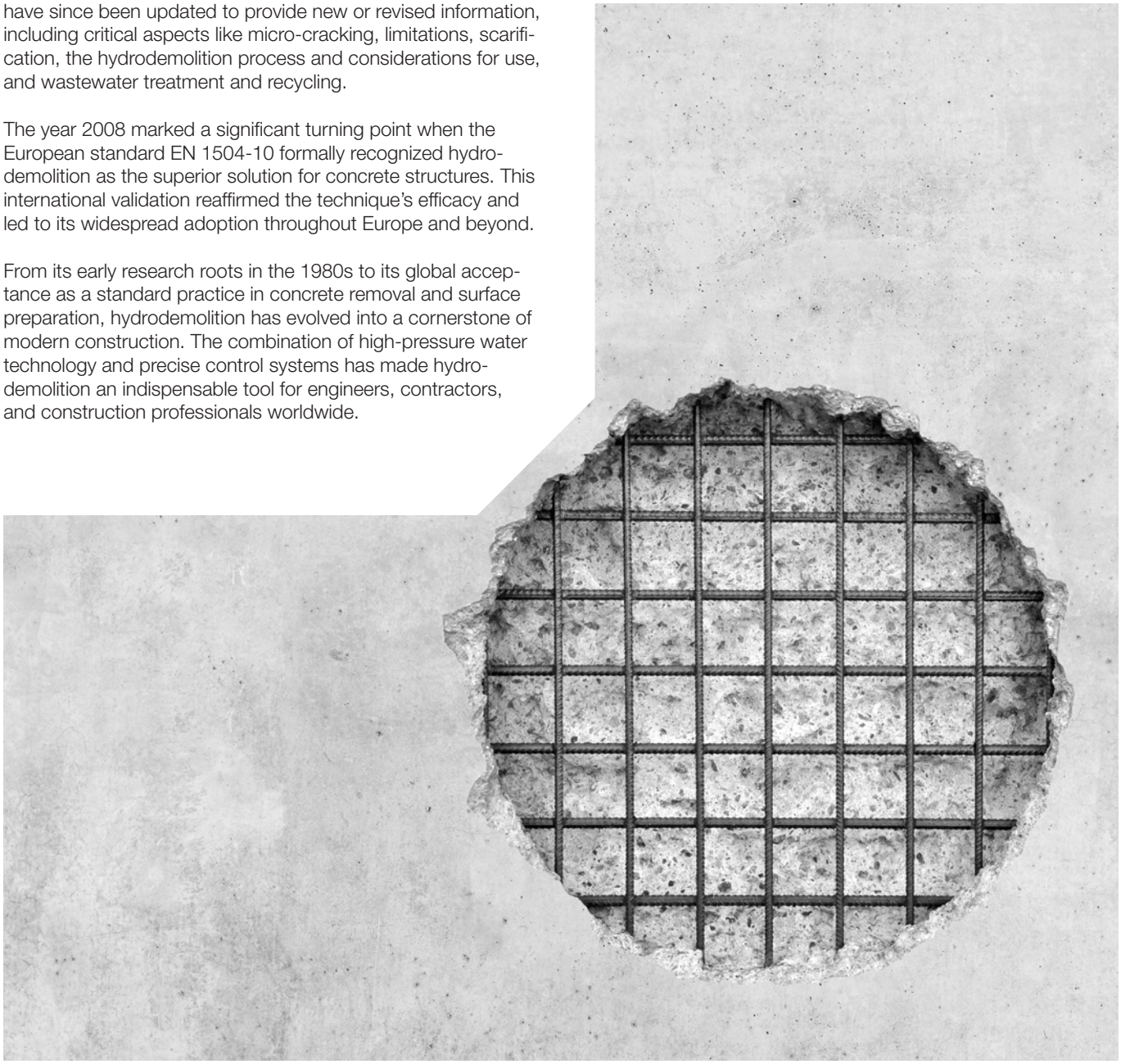
As the years passed, the advantages of hydrodemolition became increasingly evident. In 2004, the technology received official endorsement when it was decreed as a standard in bridge construction in Sweden. This acknowledgment further propelled hydrodemolition into the mainstream of concrete removal practices.

The International Concrete Repair Institute (ICRI) contributed to the field with Technical Guideline No. 310.3R-2014, a comprehensive document produced in 2004. This guideline provides a thorough exploration of the hydrodemolition process, encompassing its advantages and limitations. With a primary focus on utilizing hydrodemolition for concrete removal in preparation for repair work, the guideline covers equipment descriptions, applications, safety protocols, methods for water control and treatment, and debris cleanup. It also addresses surface preparation and coating removal. Various sections of the guideline

have since been updated to provide new or revised information, including critical aspects like micro-cracking, limitations, scarification, the hydrodemolition process and considerations for use, and wastewater treatment and recycling.

The year 2008 marked a significant turning point when the European standard EN 1504-10 formally recognized hydrodemolition as the superior solution for concrete structures. This international validation reaffirmed the technique's efficacy and led to its widespread adoption throughout Europe and beyond.

From its early research roots in the 1980s to its global acceptance as a standard practice in concrete removal and surface preparation, hydrodemolition has evolved into a cornerstone of modern construction. The combination of high-pressure water technology and precise control systems has made hydrodemolition an indispensable tool for engineers, contractors, and construction professionals worldwide.



Methodology

The impact-free process of hydrodemolition eliminates micro-fractures that jeopardize the integrity of a structure while also cleaning and descaling rebar without damaging it. This method leaves behind a rough, craggy surface that provides an optimal bonding surface for new material.

Independent pull-off tests show that the bonding strength achieved through hydrodemolition is much higher than that of jackhammers or other mechanical methods. The Swedish Cement and Concrete Research Institute found that using hydrodemolition for concrete repair leads to a significantly extended life expectancy of 21-35 years, compared to 7-12 years with mechanical chiseling, as determined in a Life Cycle Cost (LCC) Analysis.*

In comparison to alternative methods, like chipping hammers and handheld water jetting equipment, robots used in hydrodemolition reduce labor requirements and minimize the risk of injury. Additionally, these robots operate in consistent cycles 24/7, ensuring uniform speed, performance, and quality throughout the entire project. Also, increased speed of concrete removal reduces the total project time.

The cornerstone of hydrodemolition is water, encompassing its source, wastewater management, and disposal. Fresh water can be drawn from a tank or directly from a natural source like a river or dam. Wastewater can be collected in a containment area and subsequently pumped to a water treatment system. The treated water can either be discharged into the environment or recirculated back into the freshwater tank, creating a closed-loop system. This eliminates the need for a constant fresh water supply or the involvement of a third-party for water collection and removal.

** Life Cycle Assessment of the Different Methods for the Removal of Concrete used for Reparation by Neville Kiwbota and Idris Yasin, Stockholm 2009*

Applications

Hydrodemolition, with its precise and controlled concrete removal capabilities, finds numerous applications in various industries. Some of the common applications of hydrodemolition is presented below.

Infrastructure repair

Hydrodemolition is extensively used in the repair and maintenance of infrastructure, including bridges, highways, tunnels, dams, and parking structures. It allows for the selective removal of deteriorated or damaged concrete, preparing the surface for repairs or rehabilitation.

Surface preparation

Hydrodemolition is used to prepare concrete surfaces for various applications. It can create a roughened profile on the concrete, ensuring better adhesion for overlays, coatings, or new concrete placements. The process effectively removes contaminants, old coatings, and damaged surface layers.

Concrete rehabilitation

Hydrodemolition is employed in concrete rehabilitation projects where damaged or weakened sections of concrete need to be removed. This includes the removal of spalled or cracked concrete, delaminated surfaces, or areas affected by corrosion.

Historical restoration

Hydrodemolition is employed in the restoration of historical buildings and monuments, where careful removal of deteriorated concrete is essential to preserve the architectural integrity while maintaining safety.

Expansion joint removal

Expansion joints in concrete structures can deteriorate over time and require replacement. Hydrodemolition offers an efficient method to remove existing expansion joints without damaging the surrounding concrete, facilitating the installation of new joints.

Industrial facilities

Hydrodemolition is employed in industrial settings for concrete removal, maintenance, and repair tasks. It is used in chemical plants, refineries, manufacturing facilities, and warehouses to address issues like corroded surfaces, damaged floors, or compromised concrete structures.

Retrofitting and upgrades

When retrofitting or upgrading structures, hydrodemolition is employed to selectively remove concrete to accommodate new components, such as reinforcing steel, anchor bolts, or structural attachments.

Nuclear power plants

In nuclear power plants, where precision and minimal vibration are critical, hydrodemolition is utilized for concrete removal in sensitive areas such as containment structures, spent fuel pools, and reactor buildings.

Underwater applications

Hydrodemolition techniques can be adapted for underwater concrete removal, making it valuable for marine construction projects, offshore structures, and underwater repairs.

Hydroelectric power plants

Hydrodemolition is commonly used in hydroelectric power plants for maintaining and repairing dam surfaces, turbine components, spillways, penstocks, and other concrete structures.

How does hydrodemolition work?

To achieve optimal results in hydrodemolition, it's essential to consider the specific objectives of the project. Whether it involves removing a preset depth of concrete, preparing a surface for a new coating, or rust removal, hydrodemolition offers a versatile solution. The key lies in adjusting the pressure and flow of the water.

Pressure and flow

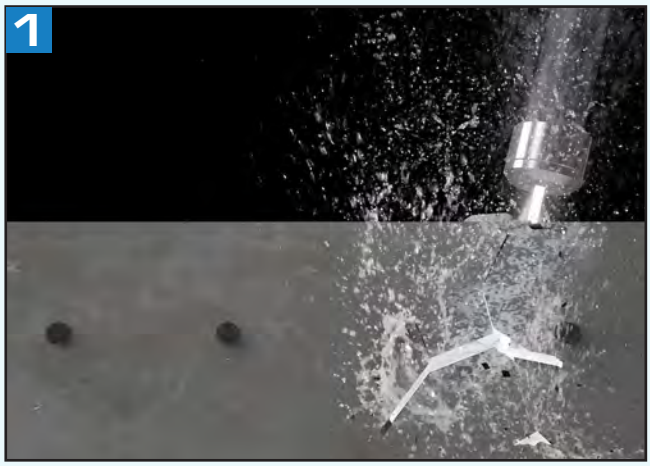
The key element of hydrodemolition is to pressurize and widen existing pores and micro cracks in the weakened concrete structure using high-pressure water penetration. Material is removed as the build-up pressure exceeds the tensile strength of the concrete. The volume of water also plays a crucial role in system efficiency. For instance, the rate of material removal depends not only on water pressure but also on the volume directed towards the concrete surface, ensuring swift and continuous pressurization of the treated areas. This combination of water pressure, flow, and precise robotic control of the water jet nozzle establishes the essential criteria for an effective hydrodemolition process.

In summary, ultrahigh pressure and low flow result in a sharper and more precise cut, while low pressure and high water flow result in selective removal, where only deteriorated concrete is removed, leaving sound concrete intact. By adjusting the pressure and flow, and employing the appropriate equipment, projects can be completed more efficiently and with superior results.

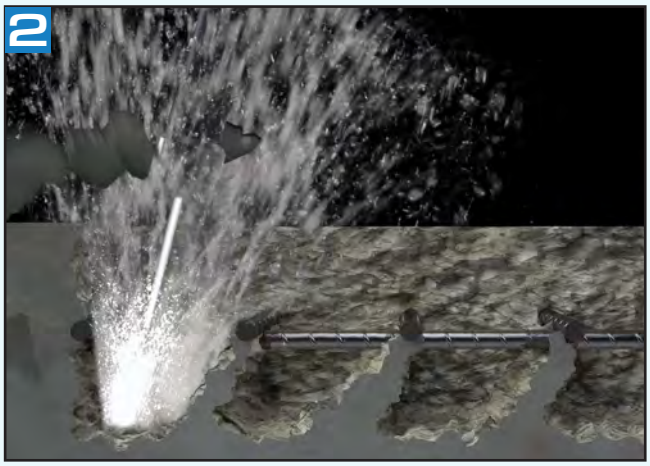
> "Hydrodemolition can be used for horizontal, vertical, and overhead concrete removal and surface preparation on reinforced and non-reinforced structures. It is effective in removing concrete from around embedded metal elements such as reinforcing steel, expansion joints, anchorages, conduits, shear connectors, and shear studs. Hydrodemolition can be used for localized removals where deterioration is confined to small areas and for large area removals in preparation for a bonded overlay. This technology can also be used to remove existing coatings from concrete."
>
> *—International Concrete Repair Technical Guidelines No. 03737*

The process of hydrodemolition illustrated

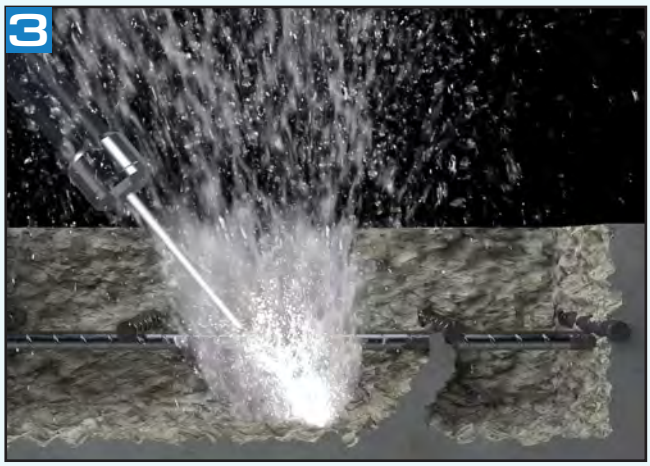
The images below serve purely for theoretical demonstration purposes, illustrating the workings of hydrodemolition technology.



The water jet penetrates existing cavities and cracks.



By exposing the concrete to the water jet for a certain time you reach the desired depth.



By changing the angle of the lance the remaining material under the rebar (the shadows) will be removed.

The remaining area consists of structurally sound concrete and is now prepared for the application of a new layer.

Results depending on pressure and flow

Selective Removal

Selective removal is one of the basic principles of hydrodemolition. By using a lower water pressure (typically 1000 bar / 14 500 psi) the effect on the concrete will be selective, meaning that only the deteriorated or damaged concrete will be removed while the sound concrete will be left intact. As a result, the sides and the bottom of the cut will be a little rough since it follows the quality of the concrete.

Robotic process:

» 1000 – 1400 bar / 14 500 – 20 300 psi

» 180 – 264 lpm / 48 – 70 gpm of water

Controlled Depth Removal/Hydromilling

Controlled depth removal means using higher water pressure (2500 bar/36259 psi), that will result in a more cutting effect on the concrete. The result will be more even along both the sides and the base of the cut. It will remove all concrete specified in the control system, regardless of the quality of the underlying concrete.

Robotic process:

» 1500 – 3000 bar / 21 800 – 43 500 psi

» 38 – 130 lpm / 10– 34 gpm of water

Scarifying and Surface Preparation

Hydrodemolition can be used to scarify or roughen concrete surfaces in preparation for overlays, coatings, or bonding of new concrete. When the aim is to create an optimal bonding surface while minimizing material removal, employing a rotating tool proves highly effective. This will ensure precise and swift removal of a shallow layer of concrete, resulting in an rough bonding surface for new coating.

Robotic process:

» 1000 – 3000 bar / 14 500 – 43 500 psi

» 38 – 264 lpm / 10 – 70 gpm of water

Rust and Paint Removal

High-pressure water can also be used to remove paint or rust, avoiding use of grid blasting. This means no dust pollution, no contaminated sand to dispose of, just a clean steel surface left after removal. Rubber coatings or rubber on, for example, airplane runways from the tires can also be removed.

Robotic process:

» 1000 – 3000 bar / 14 500 – 43 500 psi

» 38 – 264 lpm / 10 – 70 gpm of water

Industrial Cleaning

Traditional industrial cleaning has historically been carried out by handheld tools. This is a very dangerous operation and something that could be avoided by the use of robotic cleaning. More and more contractors are switching from manual to automated cleaning, increasing both safety and efficiency.

Robotic process:

» 1000 – 3000 bar / 14 500 – 43 500 psi

» 38 – 264 lpm / 10 – 70 gpm of water

Equipment and tools used in hydrodemolition

Hydrodemolition Robots

Hydrodemolition robots are specialized machines engineered for precise and controlled concrete removal. They are capable of performing concrete removal and surface preparation on both reinforced and non-reinforced structures, in various orientations (horizontal, vertical, and overhead). These robots are equipped with highly advanced computerized control systems, enabling accurate manipulation of high-pressure water jets. Additionally, they offer the convenience of remote operation, allowing operators to oversee the process from a safe distance.

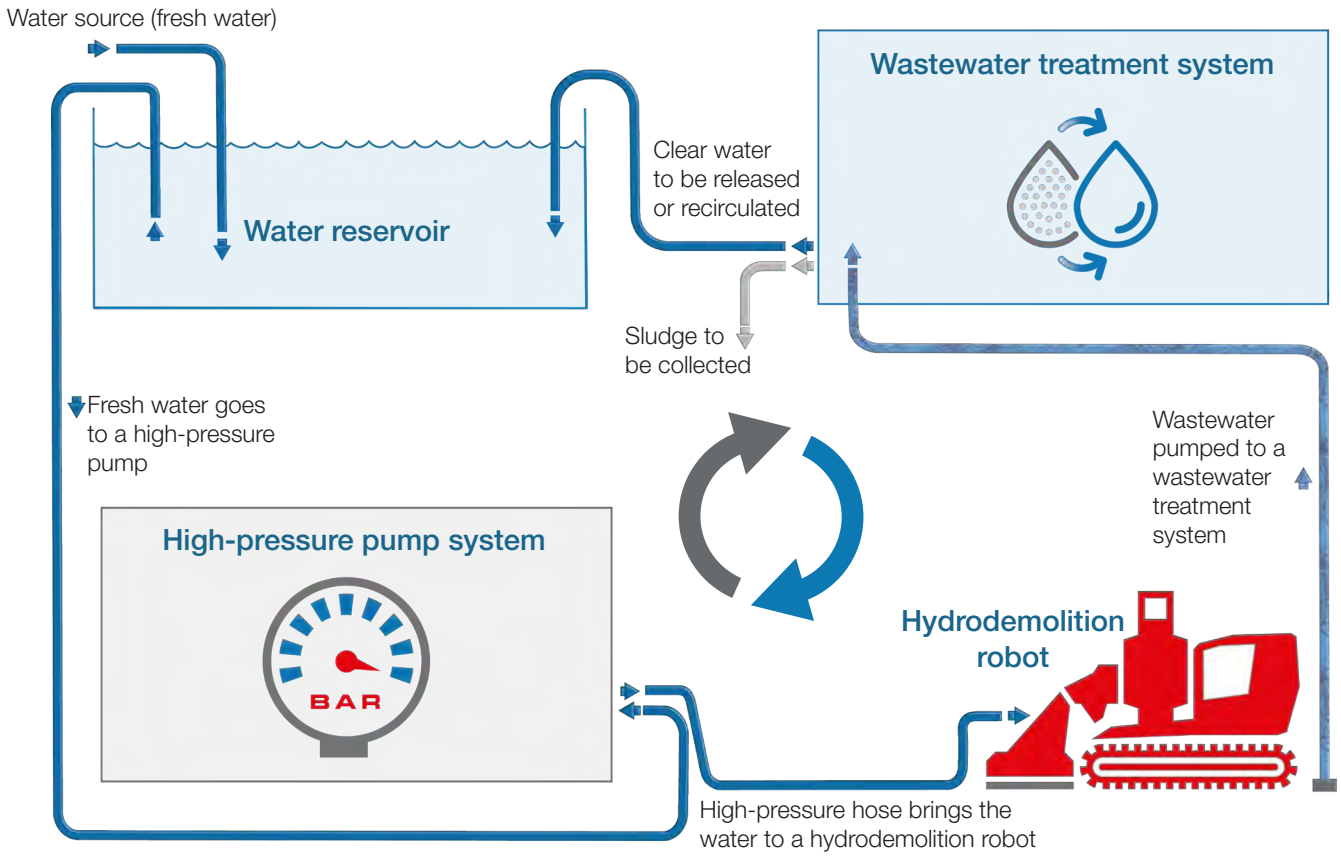
High-Pressure Pumps

High-pressure pumps, with a minimum power rating of 300 hp/ 220 kW, are vital components of hydrodemolition equipment. These pumps generate the high water pressure necessary to propel water jets and effectively dislodge concrete, ensuring efficient concrete removal.

Wastewater Treatment System

Hydrodemolition generates a significant amount of wastewater with elevated pH levels, containing concrete particles and debris. To comply with environmental regulations and ensure proper disposal, a wastewater treatment system can be employed. This system corrects the pH, separates and removes suspended solids from the wastewater, allowing for the safe disposal or recycling of the treated water.

Hydrodemolition process



Advantages of hydrodemolition over traditional methods

Hydrodemolition offers several benefits compared to traditional methods of concrete removal, such as jackhammers or saw cutting. Here are some of the advantages of hydrodemolition.

Selective concrete removal

Hydrodemolition allows for precise and selective removal of deteriorated or damaged concrete. The high-pressure water jet can be controlled to target specific areas, ensuring that only the intended concrete is removed while preserving the sound concrete and underlying structure.

Reduced structural damage

Unlike mechanical methods that generate vibrations, hydrodemolition minimizes the risk of structural damage. The water jet effectively break down the concrete without causing micro-cracking or stress to the surrounding areas, ensuring the integrity of the structure remains intact.

Safer working environment

Hydrodemolition provides a safer working environment for operators. Traditional concrete removal methods, such as jackhammering or dry cutting, generate substantial amounts of airborne dust containing silica particles. Silica dust, when inhaled, can cause severe lung damage, including silicosis. In contrast, hydrodemolition's water-based approach minimizes the release of silica dust into the air, reducing the risk of exposure for workers and surrounding personnel. This leads to improved occupational health and safety conditions, protecting workers from the long-term health hazards associated with silica exposure. Hydrodemolition aligns with regulations and guidelines aimed at safeguarding worker health and the environment. Many jurisdictions have established standards for controlling and minimizing silica dust exposure. Employing hydrodemolition can help construction and maintenance projects comply with these regulations, ensuring a healthier and safer work environment.

Increased efficiency and productivity

Hydrodemolition can be a faster and more efficient method of concrete removal, especially for large-scale projects. The high-pressure water jet can cover larger areas quickly, reducing the time required for concrete removal. Automated systems and robotic equipment further enhance productivity by enabling remote operation and precise control.

Improved surface quality

Hydrodemolition creates a roughened surface profile, which is ideal for concrete repair and bonding. The removed concrete typically leaves a clean and well-prepared surface, allowing for better adhesion of new concrete or repair materials.

Environmental friendliness

Hydrodemolition is considered an environmentally friendly method of concrete removal. It generates less noise, dust, and waste compared to mechanical methods, reducing the impact on the surrounding environment. Additionally, water recycling and treatment systems can be employed to minimize water consumption and discharge.

Cost savings

While hydrodemolition equipment and expertise may require an initial investment, the overall cost savings can be significant. The efficiency of the process can reduce labor hours and project timelines, resulting in cost savings. Additionally, the preservation of the underlying structure eliminates the need for extensive repairs or replacements, further reducing long-term costs.

Overall, hydrodemolition offers distinct advantages in terms of precision, safety, efficiency, surface quality, and environmental impact compared to traditional concrete removal methods. Its ability to selectively remove concrete while minimizing structural damage has made it a preferred choice for many construction projects.

Pros and Cons with different methods

When it comes to concrete removal, two primary methods stand out: hydrodemolition and mechanical chiseling (such as jackhammers). Each approach has its distinct advantages and drawbacks, making them suitable for different scenarios. In this comparison, we'll explore the pros and cons of both techniques to help you make an informed decision based on your project's specific requirements and priorities.

Hydrodemolition

Pros

- No micro cracking
- Selective removal
- Superior bonding
- Does not damage the reinforcement
- Good working environment
- Binds concrete dust
- Limited personnel required
- Cleans the reinforcement from corrosion and concrete
- No damage to the steel rebars
- No process-related vibrations
- Longer life span of the repair

Cons

- Management of water
- Removal at freezing temperatures
- Cost of mobilization
- High initial investment costs
- Specialized training of operators

Mechanical chiseling

Pros

- Low initial investment costs
- Easy to use
- Low cost of mobilization
- Well established method

Cons

- Creates micro cracking in surrounding concrete
- Creates poor bonding
- Damages to the reinforcements and the finish
- Does not remove corrosion from rebars
- Poor working environment
- No selective removal
- Creates a lot of Silica dust
- Process related vibrations, white hands

Why specify hydrodemolition in your next project?

Removing concrete for repair work or demolition has been done probably since we started using concrete. In today's world, there are several tools available for contractors to remove concrete. In most projects that require concrete removal for repair work, contractors have been using jack hammers (mechanical impact tools). As we mentioned previously, one of the disadvantages of using a mechanical impact tool is the creation of micro cracks in the concrete structure that will cause premature failure.

Over the years, engineers have incorporated recommendations in their specifications or tender documents to advise contractors on limiting the size and power of mechanical tools used for concrete removal in specific cases. This approach aims to minimize micro cracks in the concrete structure and reduce damage to the reinforcement bars. By including such information in the specifications, contractors are essentially encouraged to utilize jack hammers for concrete removal.

Offer alternatives

By offering alternatives to general contractors, engineers can achieve the following benefits:

- **Quality repair work**
  The provision of alternatives allows contractors to select the most suitable method for concrete removal, potentially leading to higher-quality repair work. By considering hydrodemolition as an option, engineers demonstrate their understanding of the process, its benefits, and their willingness to accept this method.

- **Addressing labor shortage issues**
  The construction industry often faces labor shortage challenges. By specifying hydrodemolition as a viable option, engineers provide contractors with an additional solution that can help mitigate labor constraints. Hydrodemolition, with its precise and efficient concrete removal capabilities, can contribute to overcoming labor shortage issues.

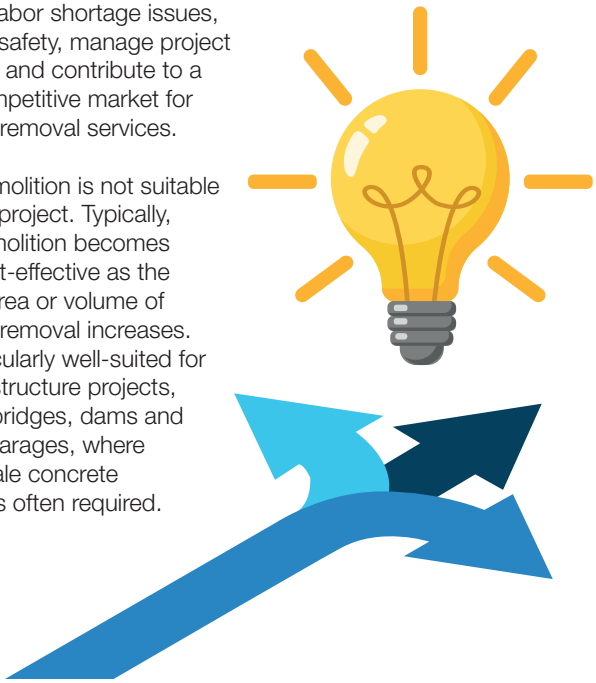
- **Enhancing safety**
  Safety is of paramount importance in construction projects. Hydrodemolition, compared to traditional mechanical tools, offers advantages such as reduced dust generation and enhanced precision, which can contribute to improved safety conditions for workers and surrounding personnel.

- **Project timeline management**
  Hydrodemolition can be a time-efficient method for concrete removal. By allowing contractors to consider hydrodemolition as an alternative, engineers support project timeline management. Contractors can evaluate the feasibility of hydrodemolition in terms of time savings, especially for larger-scale concrete removal tasks.

By specifying hydrodemolition as a viable alternative, engineers not only provide contractors with choices but also contribute to expanding the knowledge and understanding of hydrodemolition in the market. This, in turn, fosters increased competition among providers, leading to a more competitive market and a wider range of options for concrete removal projects.

In summary, by incorporating hydrodemolition as an alternative in their specifications, engineers promote quality repair work, address labor shortage issues, enhance safety, manage project timelines, and contribute to a more competitive market for concrete removal services.

Hydrodemolition is not suitable for every project. Typically, hydrodemolition becomes more cost-effective as the surface area or volume of concrete removal increases. It is particularly well-suited for civil infrastructure projects, such as bridges, dams and parking garages, where larger-scale concrete removal is often required.



Key considerations for hydrodemolition projects

Considering these key factors—surface preparation and assessment, safety measures and precautions, environmental considerations, cost and time efficiency—ensures the successful implementation of hydrodemolition projects. By addressing these considerations proactively, project managers can achieve optimal results while maintaining safety, environmental responsibility, and cost-effectiveness.

Surface preparation and assessment

Proper surface preparation is crucial for successful hydrodemolition projects. The surface should be assessed to determine its condition, strength, and any potential areas of concern. Understanding the concrete's composition, thickness, and reinforcement layout helps in planning the hydrodemolition process effectively. This assessment ensures that the right equipment, tools, and techniques are utilized, leading to precise and controlled concrete removal.

Safety measures and precautions

Hydrodemolition involves high-pressure water jets, which can pose safety risks if not managed properly. Implementing safety measures and precautions is essential to protect workers and other personnel on the site. This includes providing appropriate personal protective equipment (PPE), ensuring proper training for operators, establishing safety zones, and adhering to relevant safety regulations and guidelines. Regular equipment maintenance and inspections are also crucial to minimize the risk of accidents or equipment malfunctions.

Environmental considerations

Environmental considerations are important throughout the hydrodemolition process. Minimizing dust and controlling water runoff are key aspects to mitigate potential environmental impacts. Employing dust suppression techniques, implementing water containment systems, and utilizing proper wastewater treatment and disposal methods help reduce the release of contaminants into the environment. Adhering to local regulations and guidelines regarding water and waste management promotes responsible and sustainable hydrodemolition practices.

Cost and time efficiency

Hydrodemolition can offer cost and time efficiencies compared to traditional concrete removal methods. However, careful project planning and execution are required to maximize these benefits. Factors such as equipment selection, project scheduling, and efficient utilization of resources contribute to cost-effective and time-efficient outcomes. Proper coordination between different project stakeholders, including hydrodemolition specialists, contractors, and engineers, helps streamline the process and optimize project timelines.

Case studies and examples

Case studies and examples of hydrodemolition projects showcase its versatility and effectiveness. From bridge deck rehabilitation to tunnel refurbishment, hydrodemolition has proven invaluable in a range of applications.

Repair of cement plant silo

Location:	Cement plant silo, La Robla, Spain
Material removed:	1,440 linear meters (4,725 ft)
Equipment:	Ergo go (hydrodemolition robot system from Aquajet), high-pressure pump

Spanish contractor Fixen Structural Services used the Hydrodemolition method to successfully repair an aging cement plant silo within a tight deadline. The reinforced concrete lining of the 100-meter tall vessel was crumbling, so the structure needed internal strengthening to correct the problem and allow a higher filling level.

The lower portion had been repaired two years earlier using hand lances and standard scaffolding; however, the aggressive timeline to complete the upper repair called for a faster, more innovative method. That's when Fixen proposed a robotic solution to get the job done during a four week maintenance shutdown. Using the Aquajet Ergo, hanging scaffolding and a hoist, the contractor achieved a production rate of 1 meter per minute, removing two 45-meter vertical sections of concrete each day. After the concrete was removed, they installed new anchored stirrups and filled the section with fluid mortar by form-and-pump means.

"Hydrodemolition with the Ergo Go really exceeded our expectations and allowed us to raise our standard in terms of planning, accuracy and performance optimization," said Jose Rodriguez, COO of Fixen Structural Services. "It took more time to move the scaffolding system than to remove the concrete."

A crew of two removed a total of 1,440 meters of concrete and finished the job with two days to spare.

Parking garage restoration

Location:	Parking garage, Toronto, Ontario, Canada
Material removed:	Estimated 18,581 m^2 (200,000 ft^2)
Water treated:	Estimated 38 million liters (10 million gal)
Equipment:	Aqua Cutter 710V (hydrodemolition robot), Ecoclear (Water treatment system), Ecosilence (high-pressure pump) from Aquajet.

Arguson Projects Inc., with extensive experience in new construction and commercial renovation, faced a unique challenge with a multi-million dollar parking garage renovation in Toronto's East End. Teaming up with RJC Engineers, specialists in parking facility design and restoration, Arguson concluded that hydrodemolition was the most suitable concrete removal method for this complex project. To execute the task, they brought on Conterra Restoration, a Canadian contractor with extensive hydrodemolition experience.

The 39-year-old structure, comprising an open-air parkade with a roof deck, two suspended slabs, and asphalt on grade, needed to remain operational while crews removed 18,581 m^2 (200,000 ft^2) of material from the second and third levels. The project demanded a solution that would minimize dust and environmental impacts while allowing for work during regular business hours. With tenants relying on access to both parking facilities and the roof deck's amenities, maintaining uninterrupted service was crucial.

Tunnel repair

Location:	Tunnel, Zemst, Belgium
Material removed:	42 m^3 (1,483 ft^3)
Equipment:	Aqua Cutter 710V (hydrodemolition robot from Aquajet), high-pressure pump

Hompert-Renes B.V., a Netherlands-based hydrodemolition contractor, was tasked with an urgent tunnel repair in February 2021. The tunnel, which ran under a busy railroad, was becoming a safety hazard because deteriorating concrete was falling into the roadway.

The initial scope of the project was to remove 6-7 cm of concrete across 80% of the tunnel. Once the team started, they learned the amount of weakened concrete was more extensive and it was necessary to remove 100% from the walls and ceiling.

The experienced team from Hompert-Renes B.V. used a hydrodemolition robot to make quick work of the project, removing a total of 42 m^3 (1,483 ft^3) in just two weeks despite frigid temperatures and travel challenges from the global pandemic.

Bridge repair

Location:	I-70, Utah, USA
Material removed:	2523 m^3 (3300 yd^3)
Water treated:	3,8 million liters (1 million gal)
Equipment:	Aqua Cutter 710V (hydrodemolition robot from Aquajet), high-pressure pumps

The project, Utah's largest hydrodemolition endeavor to date, addressed significant wear on multiple I-70 bridge decks between Cove Fort and Sevier. The Utah Department of Transportation (UDOT) embarked on this extensive 20-mile operation to replace the deck concrete on 14 parallel bridges, enhancing their lifespan and improving driving conditions.

Redi Services kicked off the I-70 project in April 2018 with three hydrodemolition robots. Using three robots simultaneously, crews spaced them about 6 m (20 ft) apart to remove the top 10 cm (4 in) of the 20 cm (8 in) bridge deck concrete. They left 2,5 cm (1in) between the remaining concrete and the rebar. Together, the robots removed about 46 m3 (60 yd3) of concrete a day. Each machine jetted about 91,000 l (24,000 gal) of water per 10-hour shift.

"The technique was extremely effective," said Cody Austin, Redi Services Nevada area manager. "With chipping tools there is no way to know whether you are through all of the decomposed concrete. With these robots, the removal depth is always even. Plus, there's almost no risk of damage to the rebar or the structurally sound concrete."

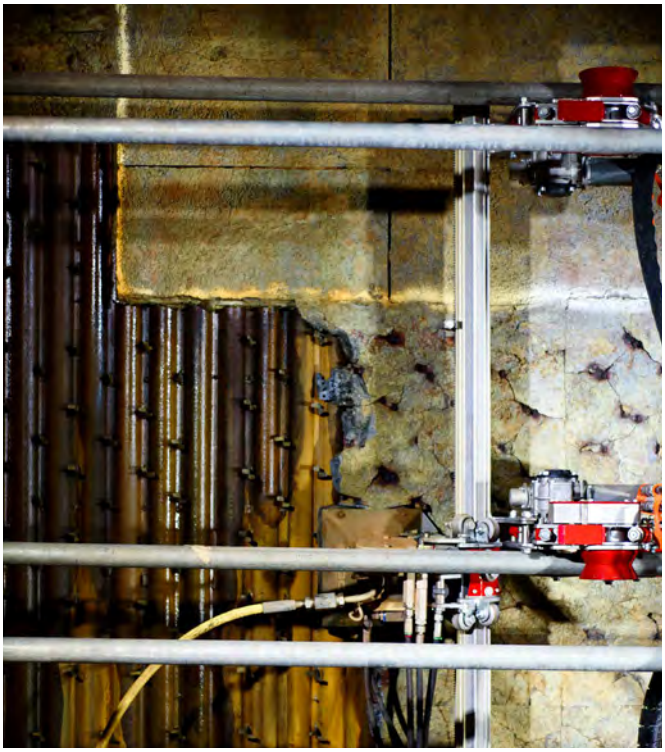
Refractory removal

Location:	Heating plant boiler, Sweden
Material removed:	Heat lining
Equipment:	Ergo go (hydrodemolition robot system from Aquajet), high-pressure pump

At this work site, the task was to replace the heat lining inside a heating plant boiler, done in 5-year intervals. This plant serves a city of 225,000 people with district heating and electricity.

The hydrodemolition robot system used eliminated the need for manual hand lance work. Its components were easily installed within the boiler on existing scaffolding used for re-casting the new heat lining. Two hydrodemolition robot systems, one starting from the top and one from the bottom of the boiler, were powered by high-pressure pumps. The robots controller were positioned outside the boiler, with hydraulic hoses routed through a small manhole. Operators could control and adjust parameters using a radio remote control with a graphic display.

The plant's downtime was significantly reduced thanks to automation and the system's ability to handle higher reaction forces compared to manual methods. The entire project was completed in just one week.



Road repair

Location:	Viaduc de Chillon, Lake Geneva, Switzerland
Material removed:	25,000 m^2 (26,9000 ft^2)
Depth:	3-5 mm (0,1181-0,1968 in)
Equipment:	Aqua Cutter 710VE (hydrodemolition robot from Aquajet), Rotolance 2500 (surface preparation tool from Aquajet), high-pressure pump

Walo Hydrodynamik, a specialized hydrodemolition contractor based in Switzerland, successfully removed over 25,000 m^2 (26,900 ft^2) of concrete deck from the Viaduc de Chillon using hydrodemolition. This impressive viaduct, nestled in the foothills of the Swiss Alps and overlooking Lake Geneva, was completed in 1969 and is renowned for its spectacular design. Comprising two 12 m (39,4 ft) wide structures that carry the east and westbound lanes of the Swiss A9 autoroute, the viaduct spans a total of 2150 m (7054 ft) at a height of 100 m (328 ft) above the lake, with staggered heights. The viaduct accommodates peak traffic flows of up to 7300 vehicles and 50,000 annually. In 2013, investigations revealed that the concrete decks were affected by Alkali Aggregate Reaction (AAR), leading to significant corrosion of the alpine aggregates used.

Walo secured the contract to remove a 3-5 mm (0,12-0,2 in) depth of the concrete deck on the eastbound lanes in Phase 1. Subsequently, the deck will be resurfaced with a specially developed, fiber-reinforced ultra-high-performance concrete by Holcim. This new material aims to reinforce the deck and address the issue of AAR. Utilizing a Rotolance mounted on a 4m extension beam, the system is programmed to automatically advance 16 cm (6,29 in) with each cycle as it reaches the beam's end. Besides removing the pavement to a depth of 3 mm (0,12 in), it also prepares five channels, each 2 mm (0,08 in) deep – two of 20 cm (7,9 in) width and three of 25 cm (9,3 in) width – across the deck.

"The unit is operating on-site at 2000 bar (29,000 psi) and 120 l/min (26,4 imperial gal/min) to achieve rates of 100 m^2/h (1076 ft^2/h)", confirmed Bruno Zuberbühler from Walo Hydrodynamik.

Dam repair

Location:	Keeyask Generating Station, Manitoba, Canada
Material removed:	140 m^3 (4944 ft^3)
Water treated:	Estimated 5,016 m^3 (1,325,000 gal)
Equipment:	Aqua Cutter 710V (hydrodemolition robot from Aquajet), Ecoclear (Water treatment system from Aquajet), high-pressure pumps

More than 400 miles north of Winnipeg, the Keeyask Generation Project is being constructed on the lower Nelson River. The 695-megawatt hydroelectric generating station, scheduled for completion in 2021, will be a source of renewable energy, producing an average of 4,400 gigawatt hours of electricity each year. The energy produced will be integrated into Manitoba Hydro's electric system for use in Manitoba and to export to other jurisdictions. Throughout its construction, now in its seventh year, the project has managed a number of location-specific challenges.

One such challenge occurred in 2017 when water in a 61cm (24 in) pipe in the intake froze, damaging an 2,4 m (8 ft) thick concrete pier. To minimize impact to the overall project, Keeyask managers opted to use hydrodemolition to remove the damaged section.

Water Blasting & Vacuum Services Inc., a Canadian industrial cleaning specialist, secured the contract based on a plan that provided not only the efficiency to complete the 140 m^3 (4,944 ft^3) removal work on time, but recycled nearly 80% of the water. With Aquajet's industry-leading technology, combined with years of experience, Water Blasting & Vacuum Services pushed the boundaries of hydrodemolition to work deeper and cleaner than any Canadian project to date.

Conclusion

In conclusion, this document serves as a comprehensive guide to hydrodemolition, providing engineers with valuable insights into its advantages and applications. It empowers engineers to tailor specifications to suit the unique requirements of each project, ensuring the most effective approach.

From its inception in the 1980s to its current status as a global standard in concrete removal, hydrodemolition has revolutionized modern construction. Its combination of high-pressure water technology and precise control systems has made it indispensable for professionals worldwide.

Independent tests have demonstrated that hydrodemolition surpasses traditional methods in bonding strength and significantly extends the life expectancy of repaired concrete structures. This technique finds wide-ranging applications in various industries, including infrastructure repair, surface preparation, and concrete rehabilitation.

When choosing between hydrodemolition and mechanical chiseling, it's crucial to weigh the specific advantages and limitations of each method. While jackhammers have long been a go-to tool, they can introduce micro cracks, potentially leading to premature failure.

By incorporating hydrodemolition as a viable alternative in their specifications, engineers not only provide contractors with choices but also foster competition and innovation in the concrete removal market. This benefits project outcomes, safety, and overall project cost-effectiveness.

While hydrodemolition may not be suitable for every project, it excels in scenarios involving larger-scale concrete removal, particularly in civil infrastructure projects like bridges and parking garages. By carefully considering surface preparation, safety measures, environmental concerns, and cost efficiency, project managers can ensure the successful implementation of hydrodemolition projects. This method stands as a testament to the ongoing advancements in construction technology, offering a more precise, efficient, and sustainable approach to concrete removal.

About the author

This brochure on hydrodemolition has been produced by Aquajet Systems AB in Sweden. Aquajet has, since its start in 1988, been dedicated to a singular mission - crafting the finest hydrodemolition equipment available.

As an international company with global partners, Aquajet offer a comprehensive range of hydrodemolition robots, water treatment systems, and high-pressure pumps.

Aquajet, together with its partners, proudly hold membership in esteemed organizations such as EWJI (European Water Jetting Institute), ACRP (European Association for Construction Repair, Reinforcement, and Protection), ICRI (International Concrete Repair Institute), Rebet (Swedish network for concrete repair), WJTA (WaterJet Technology Association), WJA (The Water Jetting Association), and AUSJET (Australasian High Pressure Water Jetting Association).

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For further details, please visit www.aquajet.se.

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