Best Practice

Title: Robotic Demolition
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Introduction

Demolition Robots are precision specialty demolition machines that are used in conjunction with or in place of cutting and coring demolition work, to surgically remove specific items of interest with minimal impact of surrounding structures.

This Best Practice on Robotic Demolition is intended to be an overview of the Demolition Robots as used in concrete renovation work. This BP does not replace any materials that the specific machine manufacturer provides to properly train the operators in the use of the equipment and safety precautions.

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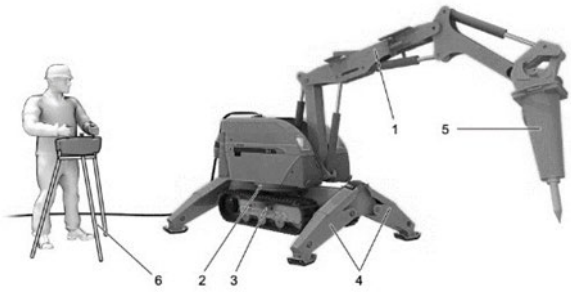
1. Understanding the Equipment

Be certain the operator has been properly trained on the specific machine they are using. Be certain to read and understand the operator's instruction manual and training materials provided by the manufacturer.

The six major components of the robots:

1. Arm System
2. Slew Function / Swing Function
3. Drive
4. Outriggers
5. Attachments
6. Operator Controls (Wired or Remote)



Although the operator is controlling the robot by remote control and not physically in or on the machine, they are still in the work zone, thus are required to use the proper personal protective equipment (PPE) when operating the robot. At a minimum the operator should use:

- Hardhat
- Eye Protection
- Hearing Protection
- Appropriate Footwear (steel or composite toe)

Other PPE to consider:

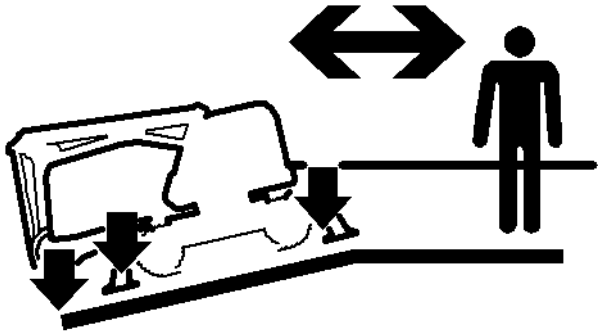
- Reflective Safety Vest
- Thick Overalls
- Work Gloves
- Fall Protection Harness
- Dust Mask or Respirator (depending on the air quality)

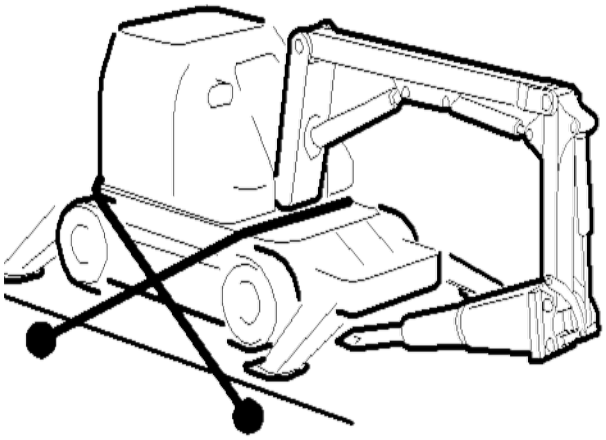
Robotic Demolition machines are designed to use a variety of hydraulic and mechanical attachments for breaking, crushing, digging, drilling, and making openings. They are great for material handling of heavy debris, working in hazardous and/or dangerous environments (the operator is linked by remote control) and working indoors or outdoors. Robotic Demolition machines are not intended for use in environments classified as explosive hazards. They are not intended to be used in areas with high water levels that can damage the machine. They are not intended to transport any passengers. Consult the manufacturer of the machine for details on the specific model to fully understand the capabilities and limitations of that specific machine.

2. Transporting and Positioning the Robot

2.1 Loading and unloading using a ramp:

- Be certain the ramp is properly sized/rated for the machine.
- Be certain the ramp is properly secured.
- Stand in a safe area of the machine, typically uphill of the machine, and keep a safe distance.
- Position the arm system and outriggers as low as possible to lower the center of gravity (cg).





2.2 Transportation:

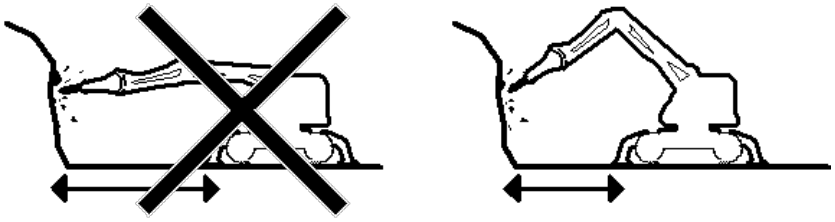
- Be certain not to exceed the Gross Vehicle Weight Rating (GVWR) and/or the Gross Combined Weight Rating (GCWR) if using a trailer.
- Be certain the vehicle bed or trailer is structurally sound for the machines weight loading.
- The control unit must be transported separately from the machine and kept in its carrier box inside the vehicle.
- Position the arm system and outriggers as low as possible.
- Secure the machine with the properly rated and approved straps/chains. Be certain the positioning of the straps will not damage or crush machine components.
- Be certain to secure loose components, tools and attachments.

2.3 Lifting the machine:

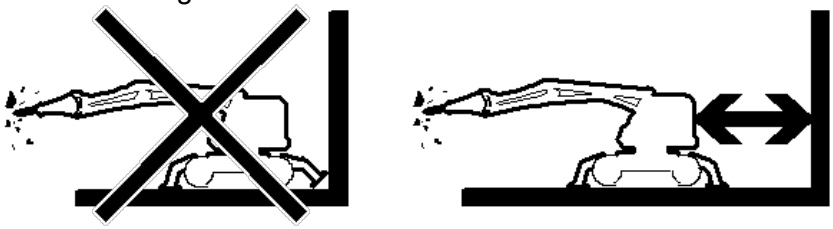
- Never lift overhead, meaning do not lift the machine directly over a person that could be crushed if the machine fell.
- Use the proper rigging equipment and hardware for the size and weight of the machine.
- Inspect proposed rigging prior to use.
- The lifting points on the machine are identified and marked. Only lift from the manufacturer approved lifting points.

2.4 Positioning the machine:

- For maximum stability, perform work in the direction of the machine travel (forward or straight back) with the outriggers deployed.
- For better results, move machine closer to the work so the arm is not fully extended straight to reach the work.



- When the machine's upper section is to be turned to the side, lower the cg by lowering the outriggers and arm as close to the ground as possible.
- Do not brace machine against fixed items to increase the work.



- Let the attachment do the work.

The hydraulic fluid in the cylinders cushion and reduce the shock and vibration transferred to the mechanical components of the machine. It is wise to never operate the cylinders at the stroke limits.

2.5 Changing tools and attachments:

- Use the appropriate tool for the job. Understand the capabilities and limitations of the tool and/or attachment before it is installed. Consult the Manufacturer for training material.
- Ensure that the machine is on a stable surface before changing an attachment or replacing a tool in the hydraulic breaker.
- Be certain the area is properly illuminated to allow for a good visual inspection of the entire machine.
- Follow proper procedures to ensure the machine is not accidentally operated during the tool change.
- Check to be certain the attachment and tool is mounted securely and correctly before using them.

2.6 Service and inspection

- All service to the machine, especially the hydraulic system, must be performed by qualified personnel. Be certain that stored energy either mechanical or hydraulic pressure is relieved and at a safe state before any work including inspections are performed on the machine. Follow the manufacturer's requirements for inspection and service instructions and intervals.
- Hydraulic oil must be kept clean and free of dirt or debris to operate properly. Protect connections and fill caps from allowing them to get dirty and if they do, clean them before exposing the oil to dirt.
- Use the appropriate hydraulic fluid. Many different hydraulic fluids cannot be mixed.
- Inspect the machine daily.
- Inspect the machine after transit for any damage caused during transportation to the jobsite.
- Inspect the control and electrical cables as well as the hydraulic hoses and fittings for damage. Never operate the machine with damaged cables and/or hoses.
- Keep the Robotic Demolition machines clean. Replace any defective, worn, or damaged components immediately.
- Regularly inspect for cracking on the metal or welds of the machine.
- Be certain the machine is positioned horizontally on a flat surface when inspecting the fluid levels. Consult the manufacturers' Operation Manual for inspection intervals and inspection points (some are plugs, dipsticks, sight glass, or indicator lines). Top off fluid levels to the recommended range before using the machine.
- A clean machine will help identify fluid leaks. Fluid leaks must be identified and repaired immediately. They can lead to more damage of the equipment or sometimes even dangerous situations.

2.6.1 Perform function checks before use:

- Brake Functions
- Cylinders
- Slew Function
- Telescopic Arm Function
- Hydraulic Oil Cooler
- Radiator/Coolant Level
- Tool Mounting
- Track Tension
- Attachment/Breaker Function

2.6.2 Be certain the machine is lubricated regularly per manufacturer's recommendations. Keep in mind that the environmental conditions such as temperature, humidity, water, and dust/dirt can impact the service intervals.

2.6.3 Ergonomics of the control unit:

- Vary the working position by adjusting the control unit to maximize comfort and control.
- Take regular breaks.
- Use steady and relaxed movements to operate the controls.

3. Defining the Zones: Work Zone, Risk Zone, Operating Zone, and Debris Field

The work zone is the area of the overall worksite that this selective demolition is being performed. The zones need to be defined well in advance of the start of work with the Robotic Demolition machine. Review the worksite and details of the area/structure to be demolished. Review the plans to be certain the work can be performed following all applicable regulations governing the worksite.

The risk zone is the dangerous areas surrounding the machine. The risk zone must be limited to essential personnel only, typically only the operator. The risk zone varies greatly depending on the worksite conditions, the working materials and methods, the surrounding structure, the ground surface conditions, other work performed in the work zone, the operating style of the operator, etc.

The operating zone is the immediate area that the machine is operating (usually defined by the limitation of the machine's reach). Typically, no one would be in the operating zone except in extreme and carefully planned circumstances.

Plan the work zone for:

- Barriers and signage to identify and restrict access to essential crew members only to the risk zone.
- Entrance, operation and exit of the machine.
- Stability of the machine during operation. Note that the risk of the machine tipping increases with the arm extended to the maximum reach and/or when using heavy attachments.
- Stability of the ground surface for risk of collapse, especially when working on roofs, on platforms, near shafts, holes, or drop-offs.
- Securing of safety harnesses with appropriate tie-off when working on elevated areas near a leading edge.
- Provisions for the operator to stand uphill and behind the machine during operation with a clear visual view of the operating zone.
- Provisions to anchor the machine when work is to be performed near an edge.
- Provisions so the machine does not slip on the ground surface.
- Considerations to reduce risk of tipping/sliding due to height differences and/or inclined surfaces. The risk can be reduced if the machine cg is low and close to the center of the machine.

Define risks within the work zone:

- Survey the work zone and object of the demolition work for electrical, steam, hydraulic, gas, flammable substances, hot fluids, water, telephone or fiber optic cables, and hidden or buried hazards.
- The ground pressure for the tracks and outriggers. Maximum safe floor loads.
- Load bearing items are properly secured. Suspended items are secured. Surrounding structures are protected. The structural integrity is maintained.
- Provisions are made for sorting and removing demolition debris.
- Provisions are made for and clearly identified to the operator for emergency evacuation of personnel.

4. Defining the Work Methods

Demolition can begin only after the machine is in position and fully set up. Start work at an edge or corner. Work small sections at a time. Work methodically. Keep aware of the surroundings and the next upcoming step at all times.

Consideration must be made for electrical supply and cord management as well as handling the debris.

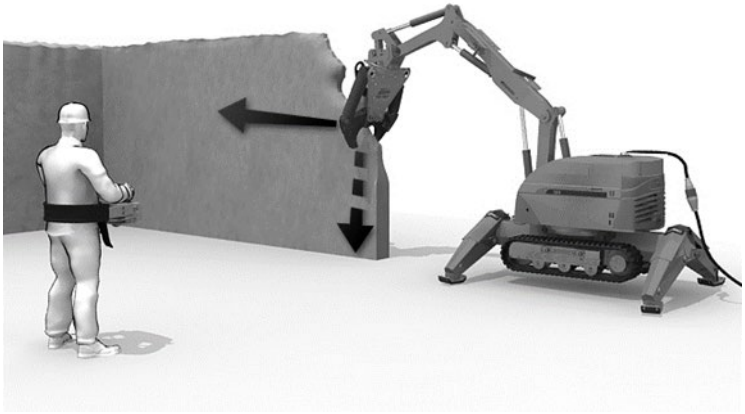
Continual sorting of demolition debris to keep the overall disposal costs down. The materials that have value can be sold to offset the overall costs and the environmentally harmful waste can be minimized and properly disposed.

Hydraulic breaker attachments are good universal tools for demolition. They work in a chipping action and are good for breaking up walls. Various tools fit the hydraulic breakers classified by the shape and the length. Longer tools are more easily damaged but have an extended reach. Never use the tool to pry.

The shapes include: Moil Point, which is used to make holes or general chipping; Narrow Chisel Point for extending cracks; and Wide Chisel for breaking materials along a specified directional line.

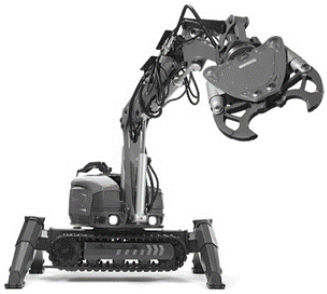
Moil Point Narrow Chisel Point Wide Chisel

Concrete crusher/pulverizer head attachments are good where noise and vibrations are of concern. Good on walls, ceilings, vaults, and stairs. Demolition is by crushing and cutting. Do not use for dragging and bending.



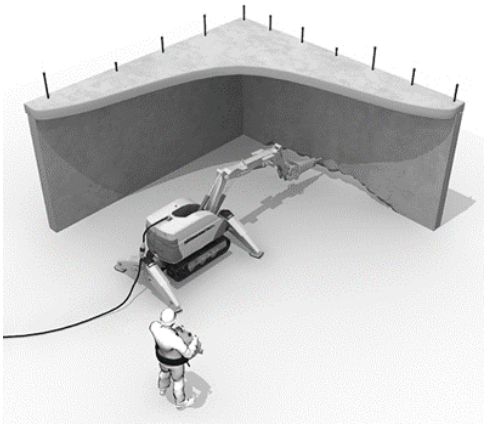
Bucket attachments are good for digging and moving demolition debris. Do not use as a lifting tool. The hydraulic breaker is typically used first to create space. The concrete crusher is then commonly used when sufficiently large holes have been made. Sometimes the crusher can be a more effective tool.

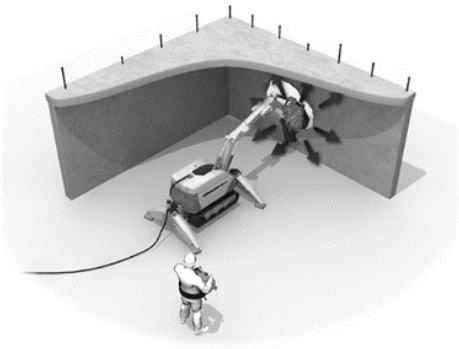




Think about the optimal position of the machine, arm, tool/accessory, and the location of the operator.

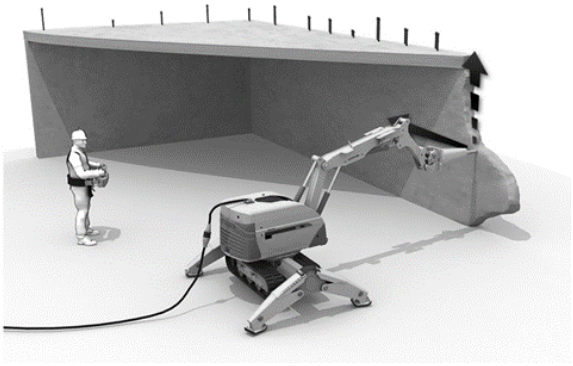
4.1 Short walls with vaults when using breakers:
- Start work at the foot in the center point of one of the walls. In confined spaces, start at a corner.
- Demolish outwards along the floor to expose the wall section.
- Then demolish upwards.

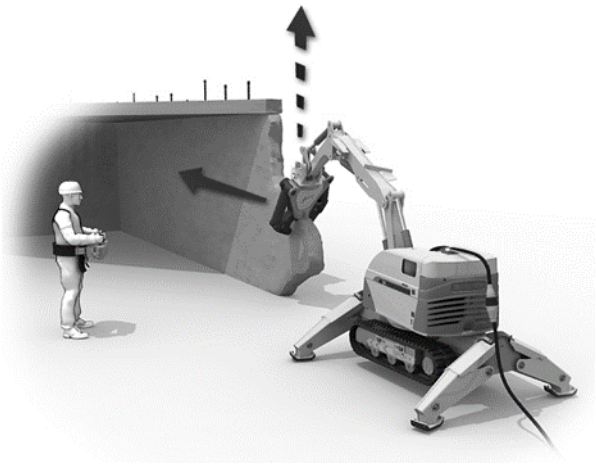




4.2 Short walls with vaults when using crushers:
- Make a hole in the center/middle of one wall using the breaker.
- Change to the crusher tool.
- Demolish outwards from the center of the hole.

4.3 Long walls with vaults using breakers:
- Start at the bottom corner.
- Demolish outwards along the floor in one direction.
- Demolish upwards.
- Demolish in sections. Demolish the entire section within the working zone before moving the machine.
- Orientate the undercarriage along the wall to facilitate moving.



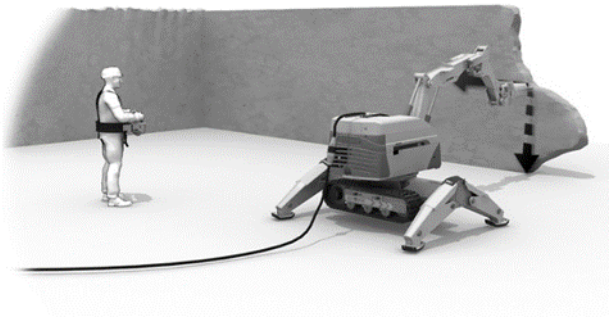


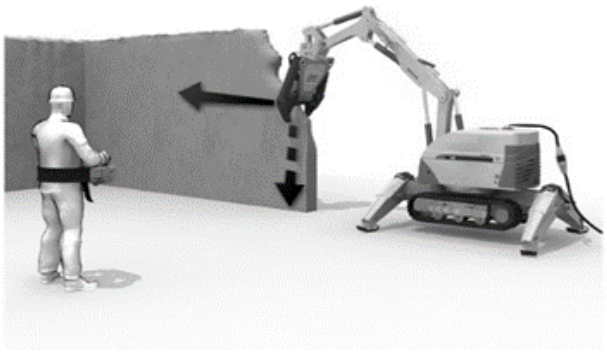
4.4 Long walls with vaults using crushers:

- Make a hole at one end of the wall using the breaker.
- Change to the crusher tool.
- Demolish outwards from the center of the hole.
- Demolish in one direction.
- Start demolishing in the center of the wall.
- Demolish from the bottom up.
- If possible, position the machine in the direction of the wall.

4.5 Free-standing walls using breakers:

- Start at the bottom corner.
- Demolish outwards along the floor in one direction.
- Demolish upwards.
- Demolish in sections. Demolish the entire section within the working zone before moving the machine.
- Caution- walls without supports at the upper edge can be a safety risk.
- Orientate the undercarriage along the wall to facilitate moving.



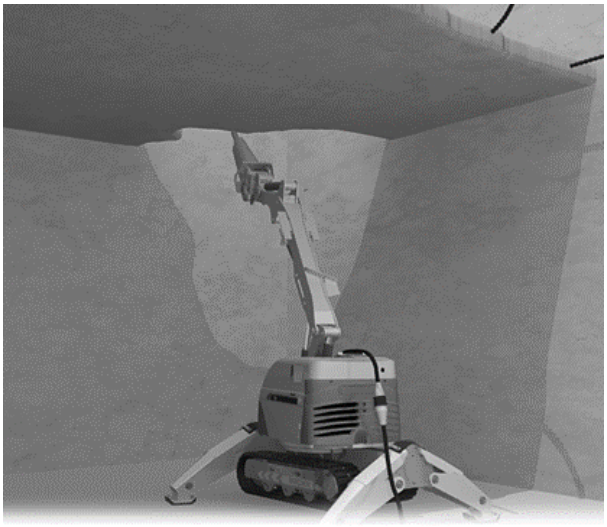


4.6 Free-Standing walls using crushers:

- Start at the top of one end of the wall.
- Demolish in one direction.
- Demolish from the top down.
- Caution- walls without supports at the upper edge can be a safety risk.
- Orientate the undercarriage along the wall to facilitate moving.

4.7 Demolishing with breaker:

- Start at a corner.
- Cut section if a fine edge is required.
- Demolish in one direction and in sections.
- Demolish the entire section within the working zone before moving the machine.
- Move backwards.
- If possible, position the machine in the direction of the wall.

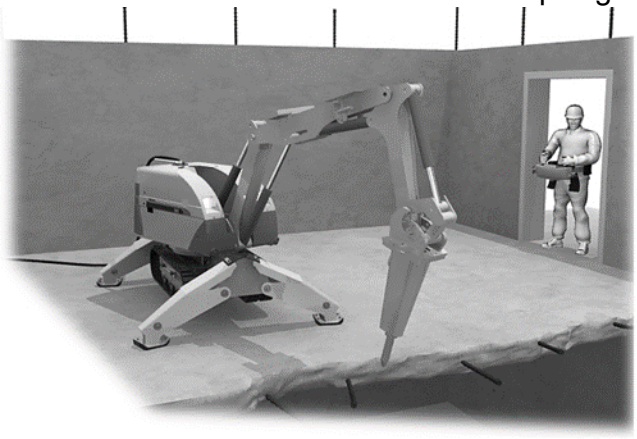


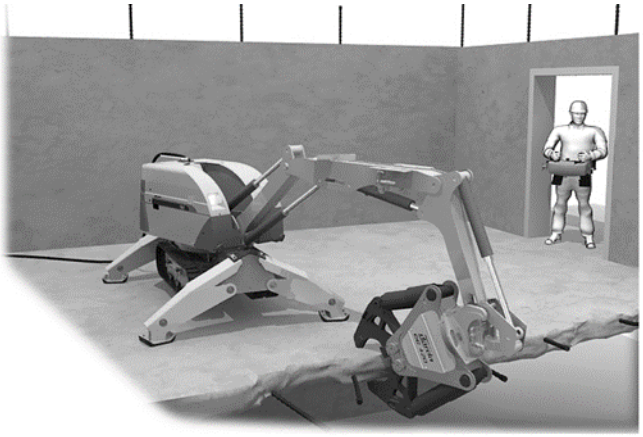
4.8 Demolishing with a crusher:

- Saw sections if fine edges are required.
- Make a hole as close to the wall as possible using the breaker.
- Change to the crusher accessory.
- Demolish outwards from the center of the hole.
- Demolish in one direction and in sections.
- Demolish the entire section within the working zone before moving the machine.
- If possible, position the machine in the direction of the wall.

4.9 Demolishing the working floor surface:

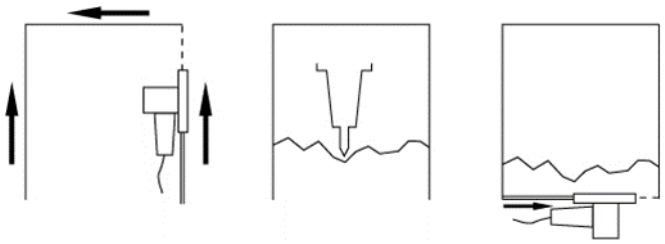
- The breaker is the most effective tool. The crusher can be used when noise or vibration need to be minimized.
- Position the machine above joists. Do not position the machine to close to an edge. Exercise caution for risks of collapsing.

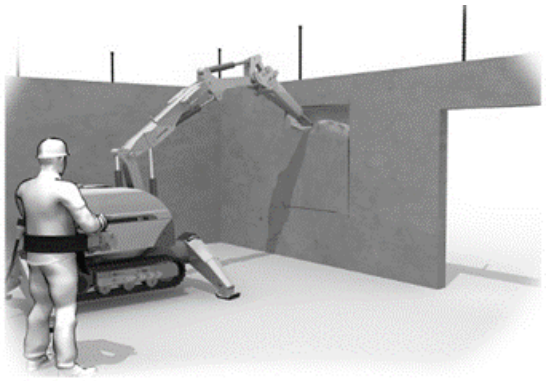




4.10 Demolishing a window or door opening:

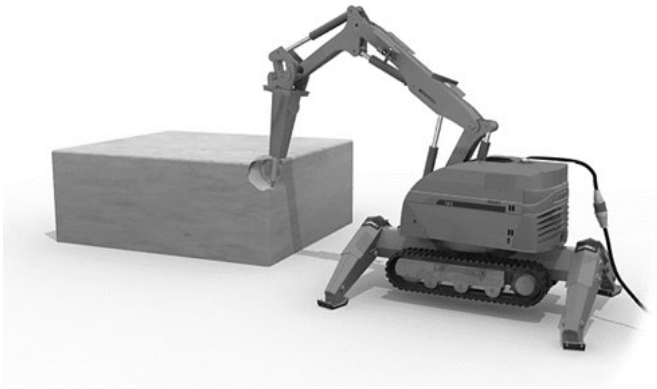
- Saw cut three sides leaving the bottom uncut.
- Start at the top corner using the breaker and demolish downwards.

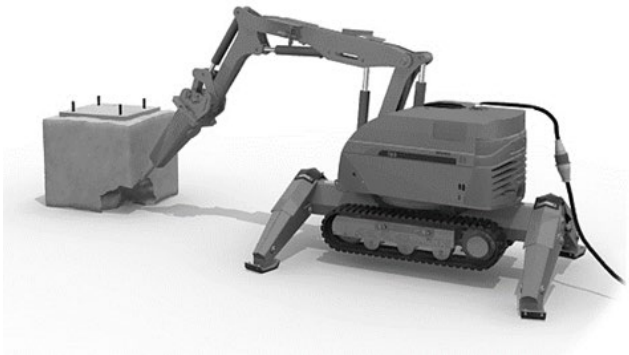




4.11 Large foundations:

- Break from above at the edges.
- Consider the quality to the chipping point to maximize the demolition speed.





4.12 Small foundations:

- Use a flat chisel and try breaking the foundations at the root.
- Break from below and around.
- Never use the tool to pry.

4.13 Demolishing tiles:

- Start in the center of the wall.
- Remove an entire strip of the wall.
- Strip the tiles downwards and upwards.
- Adjust the impact force and frequency to minimize damage to the substructure and surrounding areas/items.