Practical Restoration Handbook

Excavators
– Safe Operation in Canal Restoration

by

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1. INTRODUCTION

1.1 Excavators come in different sizes from 1.5 tonnes to 50 tonnes, may be tracked or wheeled, and capable, in the case of a river rig, of a reach of approx. 18 metres (60 feet). They may also be required to lift a load of several tonnes on site. Too small a machine and you will be over-reaching the capacity – dangerous. Too large a machine and a lot of trees on the towpath will have to be removed or they will get damaged. There is no point in having a machine that can reach the other bank if you can't get it into position. It is, therefore, very important that the correct size of machine is selected for the job intended.

JCB JS220 Long Reach

Excavators come in all sizes!

1.2 You are totally in charge of the machine. It doesn't matter who has told you to do something with it, if you are not happy to do it for whatever reason **do not do it**.

1.3 Please note that this chapter is primarily concerned with the safe use of excavators and therefore does not fully cover many of the items associated with **excavations**. The relevant legislation for excavations is the "Construction (Health, Safety and Welfare) Regulations 1996". The relevant regulations are 12 & 13 and these state that steps should be taken to:

- prevent collapse of ground both in and above excavations
- identify and prevent risk from underground cables and services

Additionally,

- from the outset, and as any work progresses, any excavation which has the potential to collapse unless supported, should have suitable equipment immediately available to provide such support.

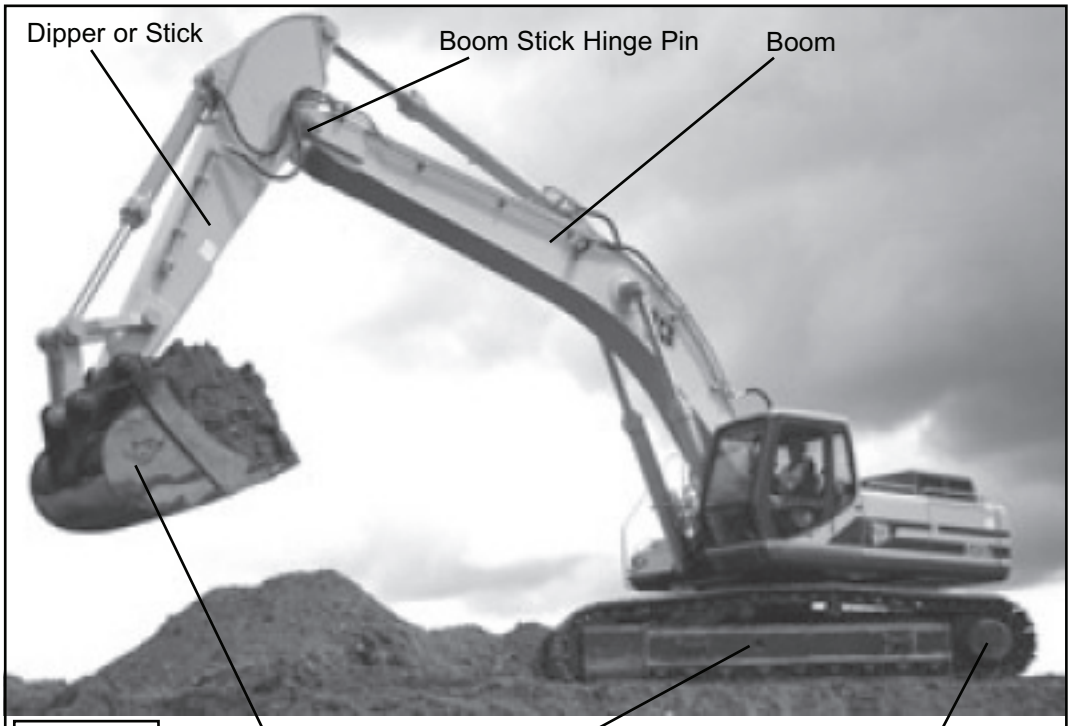
1.4 It is recommended that the reader obtains a copy of the Construction (Health, Safety and Welfare) Regulations 1996 (available from HSE).

1.5 Equally, work in confined spaces is not covered. See "Safe Work in Confined Spaces" HSE L101.

1.6 Good results when using an excavator can only come with practice. Achieving competent results in trenching, grading and landscaping requires considerable experience and is outside the range of this chapter. Therefore the text concerns itself with safe operation and gives best practice techniques. Regular practice, using these techniques, will result in the ability to excavate regular holes and finish off attractive banks in a safe and efficient manner – practice makes perfect.

2. PARTS OF AN EXCAVATOR

Please note that a wide variety of terms exist for parts of an excavator depending on manufacturer and use. In particular the term "stick", which is the authors preferred term, is frequently referred to as "dipper". Both are acceptable.



Principle Parts of an Excavator

3. BEFORE STARTING WORK

3.1 Do a good site survey in advance checking for:

- Overhead power lines, cables and other height limitations in the working area of the machine or on the route from the storage compound. If lines are present then see later chapter on working near overhead cables

- Underground services such as gas pipes, water pipes, sewer pipes, electric cables, telephone, cable TV, land drains, culverts, ducting and plug holes! All of the utility companies will provide a map of the location of their services if any are on site. Many services are now being laid under towpaths. See later chapter dealing with underground services.

- Ground conditions where the machine could get bogged down or worse. Will they deteriorate significantly if it rains? A common accident is where a machine rolls or falls into the excavation it is digging. Where possible plan the work to avoid poor ground conditions. Perhaps a long carriage machine (LC) or "bogtracks" will be needed.
- Will the excavation reveal or release toxic liquids or gases that will pose a risk to anyone either in the excavation or nearby? Will special arrangements need to be made for disposal of the spoil (see PRH "Health and Safety Section 4 – Control of Substances Hazardous to Health").
- Is the site accessible to the public?
- Consider the room required for manoeuvring the machine. Consider width restrictions and egress and whether there is room to slew and gain access.
- Confirm with the site manager exactly what the job entails.
- Refer to the Site Health and Safety Plan for additional information regarding known site hazards. Should you discover an unknown hazard (either temporary or permanent) it should be reported to the Site Leader for assessment and possible inclusion in the Plan.

3.2 This survey enables you to select the correct type of machine if one is being hired in, to arrange mats for the machine to sit on if soft ground is present and to arrange additional extras such as safety fencing.

3.3 The job should be fully planned out before work starts, right up to and including the excavator leaving site. Access and egress should be considered and the excavations should be in a safe condition at all times.

4. TRACKS VERSUS WHEELS

Tracks	Wheels
Less ground pressure	Mobility and speed (21mph versus 3.4mph)
Traction	No pavement damage
Manoeuvrability	Increased stability with blade and outriggers
Faster repositioning	Levelling of the machine with outriggers
No punctures	Dozing capability on a large machine

4.1 Unless the job requires a lot of travel to, from and around site, a tracked excavator is better for working on canals. A further consideration is whether to have rubber tracks or steel tracks. Generally steel tracks are better for "real" sites, unless you intend to use the machine on tarmac, brick paving, etc. where rubber will leave far less mess.

5. CHECKS

5.1 All the specifications, controls and checks for different makes of machine vary slightly. **Please read and understand the operators manual for that machine**.

5.2 Please note that if you hire in a machine with a driver/operator then you are technically employing him and therefore need employees insurance liability. If you are a participating member of the IWA insurance policy then you may or may not have this cover – it is not automatically included. Make sure you sort this out with the IWA Insurance Officer and the Hire Company before you start work.

5.3 If the machine is owned by the Canal Society or Trust then it is strongly recommended that the overall maintenance and care is delegated to one man, other volunteers may work on it, but it should all be under the control of one person. This means that long term problems can be tracked. Whatever system of maintenance and servicing is employed by an individual, company or society, the operator has the responsibility for ensuring that the equipment is in a safe condition **before** they operate it.

5.4 Daily maintenance and checks:

- Tyres, inflation, wear and any damage
- Tracks for correct tension that all the track pins are in and nothing is stuck in the tracks
- Fluid levels, engine oil, coolant, hydraulic oil and fuel – see operator's manual
- Hinge pins in the arm and bucket are in and locked in position
- Teeth on the bucket are tight
- Lubrication of pivot grease nipples and slewing ring as per recommendations in operation manual
- Overall inspection for fluid leaks, damage, cracks and interference from public
- Clean windows and mirrors to aid visibility
- If the machine has strip-down security shields then keep all parts together

5.5 These checks do take time and are tedious but it is much better to find out problems when in the yard than when in a sea of mud on site.

5.6 Be careful when checking over the machine, surfaces can be slippery due to spilt diesel, oil and frost. Always keep your boots and gloves clean.

5.7 Used diesel oil is carcinogenic so never wipe the dipstick on your clothes (this also avoids getting it on the seat). Use a cloth. Do not put it in your pocket, dispose of it.

6. INJECTION INJURIES

6.1 If you suspect a hydraulic line is leaking never run your hand along the hose to find the leak with the engine running. There is sufficient pressure through a small hole (100psi or above) to inject hydraulic fluid into you. Immediate attention must be sought if this occurs. Failure to do so will result in gangrene and blood poisoning after 24 hours.

7. PERSONAL PROTECTIVE EQUIPMENT

7.1 Although the cab of the machine will protect you from most problems it is sensible to wear Steel Toe-capped boots as you will have to get down from the cab and work on site at some time. For this reason you should have your hard hat and gloves with you as well. Depending on the nature of the work it may well be sensible to wear ear defenders and/or goggles (or at least have them available).

8. STARTING UP

8.1 When climbing in and out of the cab always use the steps and grab rails. Never jump down from the cab except in an emergency as you could injure yourself by jumping onto an obscured object such as a sharp reinforcing bar.

8.2 Always start on a fast idle using the cold start (preheat) if necessary and allow the engine to warm up. The warm-up time of the hydraulics (hydrostatic warm up) can take some time, especially in cold weather. The movements of the machine may be slow, sluggish and the rams may not extend to their maximum. Operating the controls working every ram slowly can reduce the warm-up time. This also helps you with familiarisation with the controls. It also checks if everything is working so you don't find a problem after 'hours' of tracking to the site. Find out just what the machine will do – three movements at once, two movements at once, can you track and operate the arm at the same time?

8.3 Check

- Warning indicators e.g. battery charge etc. should all be off
- Gauges read normal
- Check the operation of the controls as they may be "wired" differently from normal
- Adjust the seat for comfort
- Find the engine 'kill' switch and check that it works
- What controls the hydraulic isolation circuit actually isolates (depending on the machine the hydraulics are isolated by the red lever as you enter the cab or by lifting the left arm rest)

9. MANOEUVRING

9.1 Before moving off, check all around and move off slowly to the work site looking out for obstructions and height limitations.

9.2 If the machine is tracked then it should always be set up so that it goes forwards when the levers are pushed forward. This prevents "bunching" of the tracks, reducing wear and keeps the slack of the track on top. The bucket should be close in front of you. Track using your feet on the pedals as this keeps your hands free so you can raise or lower the bucket, the bucket should be kept just above the ground.

9.3 If the machine is tracking around site for any distance then the slew lock pin should be engaged, this stops the machine slewing under its own inertia. On larger machines this will be automatic but on smaller

machines it will be a manual pin probably located in the cab floor. When tracking on the highway this is mandatory.

9.4 To reduce strain on the tracks when turning keep both the tracks moving so the turn is gradual. On no account turn on the spot by pushing one track lever forwards and one back. Be aware of picking up mess, barbed wire, wire rope etc in the tracks. This can lead to a track coming off it's runners ("popping a track") once a track has been lost it can only be repaired where it stands – usually a very muddy job.

9.5 Keep personnel away from the swing area of the machine. If the machine is working close to a wall or other obstruction and it is closer to it than 600mm, the machine should be fenced off so that people can't walk in between and get crushed if the machine is slewed. The visibility when working is limited so before tracking back slew to improve your vision.

10. TRAVERSING INCLINES

10.1 Before traversing an incline, it may require grading so that it is not too steep and the top and bottom angles are not too sharp. Only go straight up and straight down an incline, with the track drive to the rear (normal tracking). Never try to cross an incline at an angle, as there is a greater risk of toppling the machine.

10.2 When going uphill track with the arm in front of you. Extend it and the bucket to their maximum, keeping it low down as this puts a lot of weight up hill and acts as a counterbalance to prevent the front of the tracks from lifting. If extra counterweight is required fill the bucket. In slippery conditions such as wet clay or with a rubber tracked machine it is also possible to dig the bucket in at the top of the bank and pull yourself up at the same time as you are tracking.

10.3 Going downhill, again, keep the arm in front of you but keep it tucked in as close as possible so that it does not act as a counterbalance. Keep the bucket just above the ground so that if the machine does tip it will only go as far as the bucket.

10.4 Great care must be taken when tracking small sized excavators up and down pavement kerbs for tipping and toppling reasons.

11. WORKING

11.1 The working position should be on stable, level ground (if it is not level then make it level). This is the only way to dig a trench with vertical sides and a flat bottom and makes grading easier. The machine is most stable when working directly over the tracks i.e. the arm is parallel to the tracks. This is not always possible to do especially when dredging along a canal. Additional attention must be given when working at right angles to avoid toppling of the machine:

- Avoid overfilling bucket
- Never slew with a full bucket at maximum reach. Bring the bucket in close first
- Always slew slowly

11.2 Excavators are very stable machines but are capable of digging under themselves. Most accidents occur due to undercutting and the ground collapsing from beneath them. Therefore always check the working face regularly, as it may not be as stable as you think it is!

11.3 Always work within eyesight of someone else. The comfort and security of a large excavator cab can seem impregnable but every year accidents such as roll overs, collapses and drownings occur where the machine operator was injured and help was unavailable.

JCB JS240/260

Bucket reaches full load as the stick reaches vertical, avoiding undercutting

12. BEST DISTANCE FROM THE EDGE

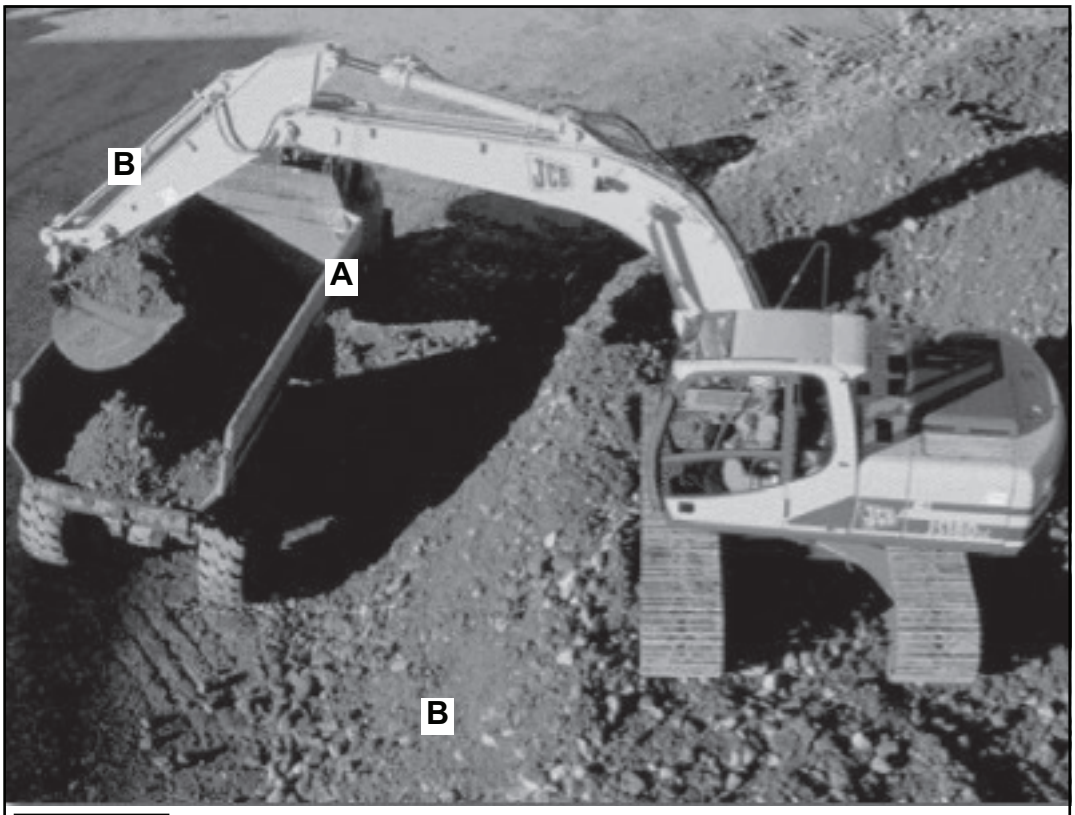
12.1 The machine should be positioned so that the stick is vertical when the bucket reaches full load. This gives maximum breakout forces. If the machine is too close to the edge then undercutting will occur and also time is wasted bringing the stick back out. If the machine is too far from the edge the breakout force is reduced.

13. USE OF A BANKSMAN

13.1 A banksman should be used at times when a wall obscures your vision, or when digging a deep excavation. They can give direction signals, watch for undercutting and look for services, pipes or cables if they are expected to be present. Make sure that all hand signals are agreed – see HSE guidance, "Know your Crane Signals". To avoid confusion only take signals from one person.

14. IDEAL BENCH HEIGHT, TRUCK DISTANCE AND LOADING TRUCKS

14.1 When loading a dumper never load "over" the seat or cab. Always ensure the operator has got off the dumper and turned it off before you start to load. The one exception to this is if it is fitted with a rock cab.



JCB JS180

A. The boom stick hinge pin is over the truck body
B. The bench height is = stick length

14.2 Indicate to the driver of the dumper where you want it to be placed by holding a filled bucket at the required position.

14.3 Excavators work best with the dumper at a lower level than they are. Ideally the truck body should be below the boomstick hinge pin. If the work is being carried out on stable ground the bench height should be equal to the stick length, the bench height should be reduced for unstable materials.

JCB JS130

Truck positioned as close to machine centre line, with work angle kept as small as possible

15. OPTIMUM WORK ZONE AND SWING ANGLE

15.1 For maximum productivity the work angle should

be kept to 15^{o} either side of the centre of the machine or about equal to under carriage width. Trucks should be positioned as close as possible to the machine centre line. This avoids excessive time slewing to load behind you.

16. SPOIL DISCHARGE TO GROUND

16.1 Spoil should be discharged well clear of the excavation to avoid its weight causing the side of the excavation to collapse. If the excavation is 1m deep or less the spoil should be deposited at least 1m away from the edge, 2m deep 2m away and so on. It should be deposited tidily along the line of the trench to make it easier to fill, not in one great big heap.

JCB JS200/220

A. Depositing excavated material

17. ANGLE OF RESPONSE

17.1 All soil types have different abilities to remain stable. They will assume a natural angle of response. This means that when you deposit soil on the ground the pile forms its own angle depending on the material. Excavations cut to this angle are called battered. The table below shows the angles of response for different materials and the effects of water content.

MATERIAL	DEGREES
Drained Clay	45
Wet Clay	16
Gravel and Sand	40
Wet Sand	22

Angle of Response

17.2 There is quite a difference between dry and wet materials and their angle of response. It is important to remove the water from excavations to avoid collapsing.

18. TRENCH EXCAVATIONS

18.1 Narrow trenches are dug to take foundations, for buried services and the most common waterway restoration job – bywash pipes.

18.2 Vertical or straight-faced trenches may require additional temporary support but have the advantage that the minimum amount of soil is removed and therefore requires less work in the excavation and back filling.

18.3 Conversely battered trenches do not require any additional temporary support but take extra time to dig and backfill.

19. TRENCH SUPPORT

19.1 No personnel should enter a vertical faced trench excavation if the sides are unsupported.

19.2 A dragbox is used in stable ground. This consists of two metal plates, 3m long by 2m high, which are braced apart. The excavator lifts this into the trench allowing personnel to work below ground without risk of the excavation collapsing in on them. It is very convenient for laying pipework as, when the pipe is laid, it can be pulled along the trench to the next position.

19.3 Other types of support are timber planks with bracing and sheet metal piles with waling, but these tend to be costly and time consuming to install.

20. WORKING *NEAR* OVERHEAD CABLES

20.1 Always assume that overhead cables are live. You do not have to make contact with them to get electrocuted. Electric arcs can jump considerable distances if the right conditions are present e.g. very dry air. The Electrical (Overhead Lines) Regulations 1970 give minimum distances of conductors from the ground. Often the voltage is marked on the pylon.

400KV	7.3m
275KV	7.0m
132KV	6.7m
33-66KV	6.0m
11-33KV	5.2m

Minimum height of overhead cables

20.2 Do not compromise these distances by tipping, landscaping or storing equipment beneath them.

20.3 The local area Electricity Company should be consulted in advance of work commencing to allow them to advise on heights, safe distances and to establish whether the work requires the line to be made dead or what suitable precautions need to be taken to avoid an accident. These precautions are outlined below.

20.4 If the line can only be accessed from one side then a barrier need only be erected on this side. A barrier is required on both sides when access can be gained from both sides. The barrier can take the form of:

- A post and rail fence
- A tension wired fence (earthed at both ends)
- Large steel drums filled with rubble and placed at intervals
- An earth bank not less than 1m high marked with posts to stop vehicles
- 12x12 timber (old balance beams)

20.5 Barriers should be as distinctive as possible, painted in red and white stripes, or red and white hazard tape or bunting can be used on wire fencing. The barrier should be placed a minimum of 6m, plus the maximum reach of the largest machine away, from the line. The Electricity Company may specify a greater distance than this.

21. WORKING *UNDER* OVERHEAD CABLES

21.1 Where it is necessary to work inside the safety zone outlined above then additional precautions are required:

- Specific advice should again be sought from the Electricity Company
- Use a smaller machine whose maximum reach won't go above the safety zone around the cables
- If a larger machine is to be used then welding chains on the boom and stick should mechanically limit it so that it can't reach into the unsafe zone around the cables

21.2 If an accident occurs with an electric cable then don't climb down from the machine but jump as far away from the machine and conductor as you can and roll away. Never assume that the electric conductor is now dead as it may be automatically re-energised at the sub station several times, depending on its importance. Call the Electricity Company for assistance.

22. DEALING WITH UNDERGROUND SERVICES

22.1 The utility companies should be consulted as to the location of their services on site. They will often provide a map of their position; also look out for marker posts that indicate a service is below, what it is and how deep it is. Never rely on the plan being 100% correct.

22.2 Before starting work look for manholes or service ducts and then use a cable finder to mark out the locations. When digging in this area run the teeth through the ground taking away a small amount of material at a time. Most pipe work is laid on gravel or sand to help level it. It is then covered with the bedding material before it is back-filled and compacted. Electric and gas pipes also have a yellow plastic tape laid into the trench above the cable before they are back-filled, to warn you of what's below so you and your banksman should be looking for these as an indicator that you are getting close. Always dig the last bit by hand until you are sure of the depth of the utility.

23. USE AS A CRANE

23.1 An excavator can only be used as a crane if it is equipped to do so. Check that the load does not exceed the object handling capacity of the machine. An excavator lifting capacity depends on its weight, centre of gravity, its hydraulic capacity and the lift point position (lift to the front or side and at what reach). The lifting capacity also varies with the load position i.e. below ground and above ground. The lifting chains should be shackled to the lifting eye at the bottom of the stick, not wrapped around the bucket.

23.2 If a suspended load of over 1000Kg is to be lifted then Hose Burst Check valves must be fitted to the boom rams and an Overload Warning Device fitted. A suspended load of under 1000Kg only needs a notification prominently displayed i.e. SWL (safe working load) 1000Kg.

24. TYPES OF BUCKETS AND DIFFERENT TYPES OF TEETH

24.1 A machine is provided with a set of buckets that are suitable for it. As a general rule, wide buckets are used in easily dug soils and narrow buckets for harder, more compact materials. On harder materials the teeth play an important part too. There are many types of teeth, with different profiles and lengths all for different materials.

24.2 For digging into a hard material use a narrow bucket fitted with short teeth.

24.3 It is possible to catch the teeth of the bucket on the track and dozer blade so care should be taken to avoid this.

24.4 In dredging and profiling, a ditching bucket is used. These have no teeth and holes in it to allow water to drain out. Because the material being moved is soft the buckets can be quite wide.

24.5 Some machines are fitted with a quick coupler attachment where buckets can be interchanged without leaving the cab. These attachments can add extra length onto the stick so care must be taken with these and with large buckets not to drive them into the cab.

24.6 A clamshell bucket can also be fitted to an excavator. Here the bucket ram is disconnected and the clamshell is hung by a universal coupling from the end of the stick. It is connected to the auxiliary lines and is opened and closed by the auxiliary pedal in the cab. It is particularly useful for emptying dredgings from mud barges. The rules for working at right angles to the tracks should be observed here, as the bucket is free to swing and at full reach it could swing out and topple the machine.

24.7 Most machines can also take a breaker attachment, which is also controlled by the auxiliary pedal in the cab.

24.8 When digging foundations, choosing a bucket with the same width as the required foundation can save a lot of time. There is no need to install any shuttering, since the foundation is dug to the required depth and the concrete can be poured straight in.

25. SHUT DOWN PROCEDURE

25.1 When operations are finished, park the machine on firm level ground away from any excavations and:

- Lower the arm so the bucket is on the ground with the teeth or blade of the bucket flat to the ground (this avoids injury to passers-by). The stick should be vertical (to save space) unless the machine is to be parked for a long time in which case retract all rams as much as possible to avoid rusting.
- Lower dozer blade to ground (if fitted)
- Shut down engine after having slowly reduced the engine rpm
- Waggle all control levers to release pressure
- Clean out the cab
- Climb down from the cab using steps and handrails
- Remove key and lock windows and cab
- Refuel the machine at the end of the working day to prevent air spaces in the tank and therefore avoid condensation building up in the tank overnight
- Fit security shields
- Remove accumulations of soil, paying particular attention to track assemblies

25.2 In severe weather conditions it will be advisable to park the machine on timber to prevent the tracks freezing to the ground.

26. TRANSPORTATION OF EXCAVATORS

26.1 Excavators are relatively slow moving machines, and because of this they tend to be moved from job to job by a road vehicle, either a transporter or a van and trailer. This saves a lot of time and also saves wear on the machine.

26.2 Check on police authority notification (usually via your haulage contractor) when planning transportation.

26.3 Before loading or unloading an excavator from its road transport, check that:

- The transporter is capable of taking the weight of the machine and all its attachments
- Ground surface at the load/off-load point is stable and capable of taking the weight of the combined load of the transporter and excavator and that the wheels of the transporter will not sink in to the ground causing instability
- There are no overhead obstructions
- All of the transporters components are parked in a straight line and the park brake is applied
- When the excavator positioned on the transporter the slew lock pin should be fitted, all attachments lowered and the machine secured

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