Introduction to the Digging Operation

Earth moving excavation represents a huge potential and a favourable approach for many earthmoving operations including construction, mining, agricultural, forestry, military applications and especially for cleaning up hazardous areas.

Rapidly growing rate of industry of earth moving machines is assured through the high performance construction machineries with complex mechanism and automation of construction activity. An excavator is an engineering vehicle consisting of a backhoe with cabin for the operator and engine is used for power generation. Hydraulic system is used for operation of the machine while digging or moving the material.

Excavators are used primarily to excavate below the natural surface of the ground on which the machine rests and load it into trucks or tractor pulled wagons or onto convey or belts. They are capable of excavating all classes of earth, except solid rock, without prior loosing. They are adapted to excavating trenches, pits for the basement, and general grading work, which require precious control of depths. Earth moving excavators also called diggers. There are many variations in hydraulic excavators. They may be either crawler or rubber-tire-carrier-mounted, in which the crawler mounted excavators have very low travelling speeds, but the wide treads give low soil pressure, which permit them to operate on soft ground. Rubber-tire mounted excavators, which have higher travelling speeds then the crawler mounted units, are useful for small jobs where considerable travelling is necessary and where the road surfaces and ground are firm.

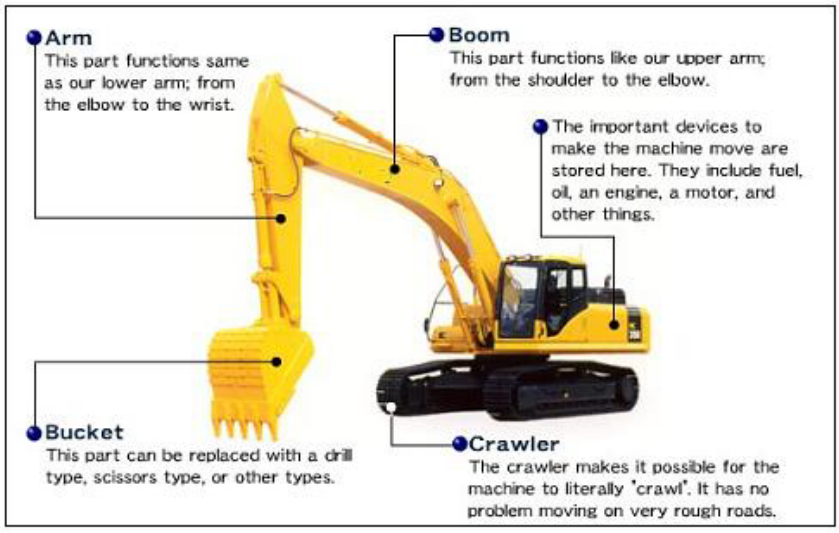


Fig. 1.1 Different parts of Hydraulic Excavator hoe.

There are many different operating attachments available. With the options in types, attachments, and sizes of machines, there are differences in appropriate applications and therefore variations in economical advantages. The hydraulic excavator hoe is shown in following Fig. 1.1.

The main components of the hydraulic excavator back hoe are as follows:

- Boom
- Arm, and
- Bucket

Excavators are used in many roles as follows:

• Digging of trenches, holes, foundations etc.
• Demolition
• General grading/landscaping
• Heavy lift, e.g. lifting and placing of pipes
• River dredging etc.

As per the varying size of the machine they are called as "mini excavators" or "compact excavators". Often the bucket can be replaced with other tools like a breaker or a grapple.
Hydraulic excavators are classified by the digging motion of the hydraulically controlled boom and stick to which the bucket is attached (see Fig. 1.2).

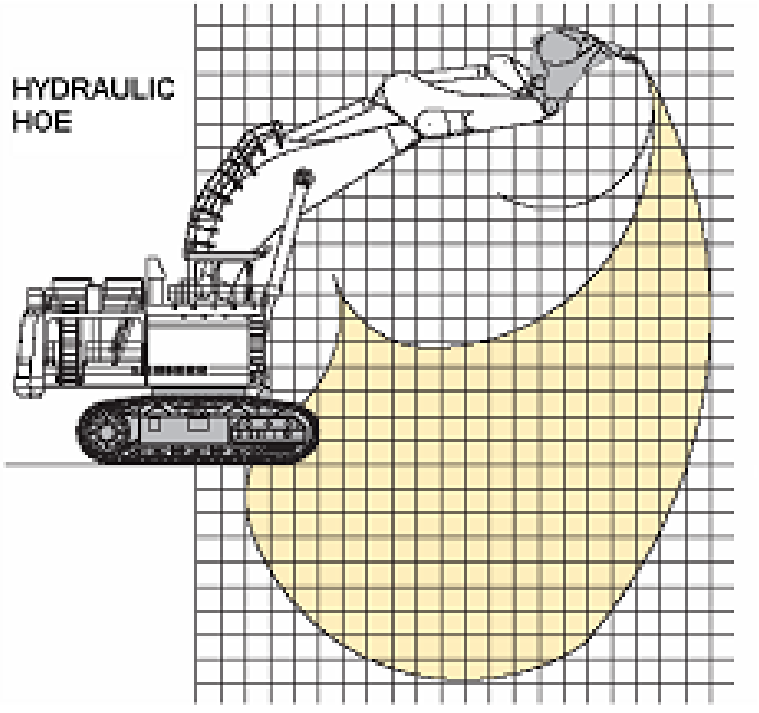


Fig. 1.2 Digging motion of Hydraulic Excavator.

A downward arc unit is classified as a "hoe." It develops excavation breakout force by pulling the bucket toward the machine and curling the bucket inward. Hoes are used primarily to excavate below the natural surface of the ground on which the machine rests. A hoe is sometimes referred to by other names, such as backhoe or back shovels. Penetration force into the material being excavated is achieved by the stick cylinder and the bucket cylinder. Maximum crowd force is developed when the stick cylinder operates perpendicular to the stick.

The ability to break material loose is best at the bottom of the arc because of the geometry of the boom, stick, and bucket and the fact that at that point, the hydraulic cylinders exert the maximum force drawing the stick in and curling the bucket.

In the selection of a hoe, the following factors must be considered:

- Maximum excavation depth required.
- Maximum working radius required for digging and dumping.
- Maximum dumping height required.

The methodology of operating the machine by operator is very crucial job, otherwise it effect on the performance of operation as well as the failure of mechanical element of the excavator.

The extensive amounts of forces are executed during the digging operation. These forces sometimes adversely affected on the mechanical components of the excavator backhoe and may be damaged during the digging operation. So it is very essential to know the resistive forces developed during the soil-tool interaction. These forces can be predicted by studying the soil-tool interaction models.
Backhoe excavator working under the cyclic motion during the digging operation. The cyclic motion of backhoe link mechanism executes digging forces through actuators. Therefore, it is very important to know the magnitudes of the digging forces and also these forces should be enough to perform the excavation task in soil using bucket teeth as cutting tool.

BUCKETS AND BLADES

Buckets come in many shapes and sizes. Most can be easily replaced or changed quickly ‘‘on the fly.’’ The shape of the bucket and the teeth or penetration edge is greatly influenced by the material that is to be

excavated or moved. A bucket designed for moving loose gravel should not be used to dig into hard material. As the material to be worked becomes harder, typically buckets become slimmer and more elongated. Loaders, backhoes, and excavators typically have standard buckets that can be used for a wide range of material types and uses. Buckets can have jaws or apparatus for grasping irregularly shaped loads such as concrete chunks with rebar protruding or jaws that can be used to cut structural members for demo.

The size of the bucket and ultimate payload must be matched to the power of the equipment. Weight represents the safe operational pounds that the excavating, hauling, or moving unit can accommodate. Placing a large bucket on a piece of equipment with a small capacity engine will not be efficient. This will overburden the equipment and wear the engine out prematurely. Manufacturer's suggestions should be followed for the bucket size selection.

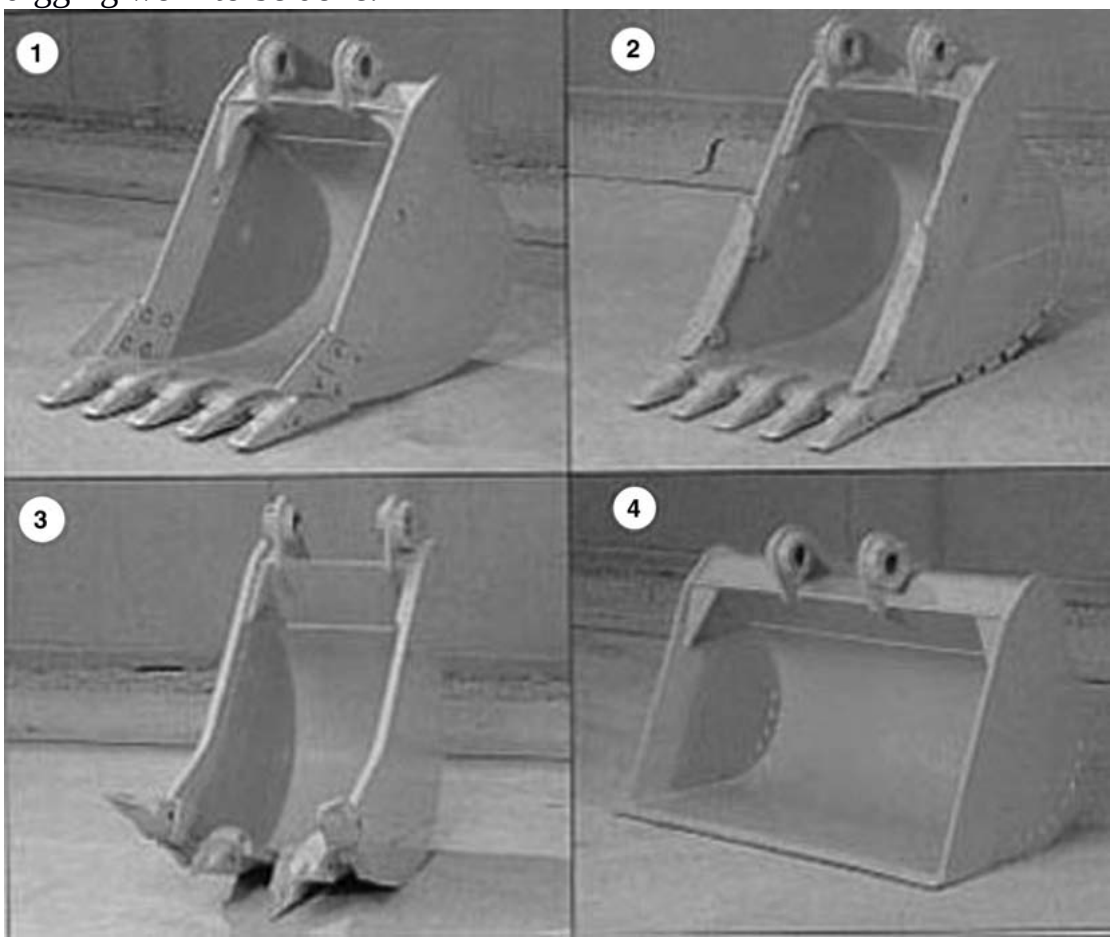
A broad bucket requires more power to push through material than a narrow bucket. However, broad larger buckets are ideal for loose sand or gravel moving. Buckets vary in width, depth, and structure depending on the match to the power of the machine and the type of material that is excavated or moved. Narrow sleek buckets with teeth are designed for penetration of a hard digging surface. The buckets used for moving material are typically wider and may not have teeth. The need for penetration power is dependent upon the density of the digging surface. Most equipment models have a standard bucket or range of types and sizes specified for that machine. The bucket typically is included as part of the purchase price. Most equipments have specially designed bucket and attachment systems so that the bucket can be changed easily and quickly.

Table shows basic work requirements and the preferance of tracks or tires for the work requirement.

Track or Tire Choice

Requirement	Best Choice
High tractive effort required	Tracks
Low tractive effort required	Tires
Stable work surface	Tires
Unstable work surface	Tracks
Short push or travel distance	Tracks
Long push or travel distance	Tires
Muddy work conditions	Tracks
Side sloping	Tracks
Loading heavy unstable loads (dump truck)	Tracks
Maneuverability required	Tires
Speed required	Tires

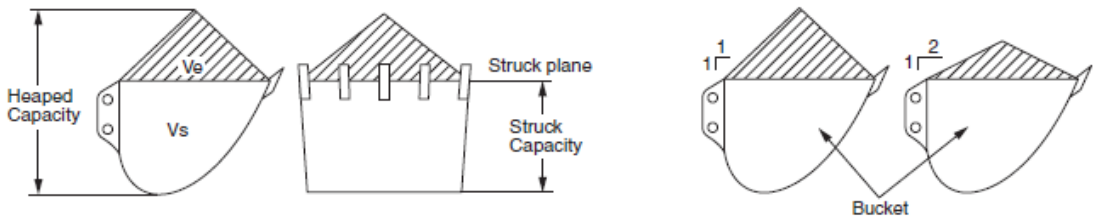
Figure shows basic bucket shapes and teeth designed for the type of digging work to be done.



Bucket 1 is for digging in moderate to hard abrasive materials. Pieces welded on the side near the teeth help penetration and holding the load. Bucket 2 is for digging fragmented rock, frozen ground, and highly abrasive compacted materials. It is taller and thinner than bucket 1. The extra pieces on the front bucket edges protect the bucket sides. Bucket 3 is for digging hard rock and work areas where material is undisturbed or poorly prepared. The thin streamline curved design and sharp irregular teeth configuration make penetration easier. Bucket 4 is for bank forming, ditch cleaning and finishing, and loose material movement. There are no teeth on bucket 4. Along with the bucket, the bucket teeth or tips are very indicative of the type of work that the equipment is set up to do. Teeth might be permanently part of the bucket, attached by bolts, welded or some other means. These teeth might actually have added tips. If teeth are temporarily connected, as their edges wear out they can be replaced easily. Like the bucket, teeth selection is greatly influenced by the density of the material to be excavated or moved.

Bucket capacity calculations

Bucket crowd force or breakout force, arm curl or digging force according to standards of SAE (Society of Automotive Engineers).
Bucket capacity is a measure of the maximum volume of the material that can be accommodated inside the bucket of the backhoe excavator. Bucket capacity can be either measured in struck capacity or heaped capacity as described below:



(a) (b)

Bucket struck and heaped capacities

Struck capacity is defined as: The volume capacity of the bucket after it has been struck at the strike plane. The strike plane passes through the top back edge of the bucket and the cutting edge as shown in Fig. (a).

Heaped capacity is defined as: The sum of the struck capacity plus the volume of excess material heaped on the bucket at a 1:1 angle of repose

(according to SAE) or at a 1:2 angle of repose (according to CECE), as shown in the Fig. (b).