Construction Equipment

The selection of the appropriate type and size of construction equipment often affects the required amount of time and effort and thus the job-site productivity of a project. It is therefore important for site managers and construction planners to be familiar with the characteristics of the major types of equipment most commonly used in construction. [9]

Excavation and Loading

One family of construction machines used for excavation is broadly classified as a crane-shovel as indicated by the variety of machines in Figure 4-3. The crane-shovel consists of three major components:

- a carrier or mounting which provides mobility and stability for the machine.
- a revolving deck or turntable which contains the power and control units.
- a front end attachment which serves the special functions in an operation.

The type of mounting for all machines in Figure 4-3 is referred to as crawler mounting, which is particularly suitable for crawling over relatively rugged surfaces at a job site. Other types of mounting include truck mounting and wheel mounting which provide greater mobility between job sites, but require better surfaces for their operation. The revolving deck includes a cab to house the person operating the mounting and/or the revolving deck. The types of front end attachments in Figure 4-3 might include a crane with hook, claim shell, dragline, backhoe, shovel and piledriver.

A tractor consists of a crawler mounting and a non-revolving cab. When an earth moving blade is attached to the front end of a tractor, the assembly is called a bulldozer. When a bucket is attached to its front end, the assembly is known as a loader or bucket loader. There are different types of loaders designed to handle most efficiently materials of different weights and moisture contents.

Scrapers are multiple-units of tractor-truck and blade-bucket assemblies with various combinations to facilitate the loading and hauling of earthwork. Major types of scrapers include single engine two-axle or three axle scrapers, twin-engine all-wheel-drive scrapers, elevating scrapers, and push-pull scrapers. Each type has different characteristics of rolling resistance, maneuverability stability, and speed in operation.
Compaction and Grading

The function of compaction equipment is to produce higher density in soil mechanically. The basic forces used in compaction are static weight, kneading, impact and vibration. The degree of compaction that may be achieved depends on the properties of soil, its moisture content, the thickness of the soil layer for compaction and the method of compaction. Some major types of compaction equipment are shown in Figure 4-4, which includes rollers with different operating characteristics.

The function of grading equipment is to bring the earthwork to the desired shape and elevation. Major types of grading equipment include motor graders and grade trimmers. The former is an all-purpose machine for grading and surface finishing, while the latter is used for heavy construction because of its higher operating speed.
Figure 4-4 Some Major Types of Compaction Equipment
**Drilling and Blasting**

Rock excavation is an audacious task requiring special equipment and methods. The degree of difficulty depends on physical characteristics of the rock type to be excavated, such as grain size, planes of weakness, weathering, brittleness and hardness. The task of rock excavation includes loosening, loading, hauling and compacting. The loosening operation is specialized for rock excavation and is performed by drilling, blasting or ripping.

Major types of drilling equipment are percussion drills, rotary drills, and rotary-percussion drills. A percussion drill penetrates and cuts rock by impact while it rotates without cutting on the upstroke. Common types of percussion drills include a jackhammer which is hand-held and others which are mounted on a fixed frame or on a wagon or crawl for mobility. A rotary drill cuts by turning a bit against the rock surface. A rotary-percussion drill combines the two cutting movements to provide a faster penetration in rock.

Blasting requires the use of explosives, the most common of which is dynamite. Generally, electric blasting caps are connected in a circuit with insulated wires. Power sources may be power lines or blasting machines designed for firing electric cap circuits. Also available are non-electrical blasting systems which combine the precise timing and flexibility of electric blasting and the safety of non-electrical detonation.

Tractor-mounted rippers are capable of penetrating and prying loose most rock types. The blade or ripper is connected to an adjustable shank which controls the angle at the tip of the blade as it is raised or lowered. Automated ripper control may be installed to control ripping depth and tip angle.

In rock tunneling, special tunnel machines equipped with multiple cutter heads and capable of excavating full diameter of the tunnel are now available. Their use has increasingly replaced the traditional methods of drilling and blasting.

**Lifting and Erecting**

Derricks are commonly used to lift equipment of materials in industrial or building construction. A derrick consists of a vertical mast and an inclined boom sprouting from the foot of the mast. The mast is held in position by guys or stifflegs connected to a base while a topping lift links the top of the mast and the top of the inclined boom. A hook in the road line hanging from the top of the inclined boom is used to lift loads. Guy derricks may easily be moved from one floor to the next in a building under construction while stiffleg derricks may be mounted on tracks for movement within a work area.

Tower cranes are used to lift loads to great heights and to facilitate the erection of steel building frames. Horizon boom type tower cranes are most common in highrise building construction. Inclined boom type tower cranes are also used for erecting steel structures.
Mixing and Paving

Basic types of equipment for paving include machines for dispensing concrete and bituminous materials for pavement surfaces. Concrete mixers may also be used to mix portland cement, sand, gravel and water in batches for other types of construction other than paving.

A truck mixer refers to a concrete mixer mounted on a truck which is capable of transporting ready mixed concrete from a central batch plant to construction sites. A paving mixer is a self propelled concrete mixer equipped with a boom and a bucket to place concrete at any desired point within a roadway. It can be used as a stationary mixer or used to supply slipform pavers that are capable of spreading, consolidating and finishing a concrete slab without the use of forms.

A bituminous distributor is a truck-mounted plant for generating liquid bituminous materials and applying them to road surfaces through a spray bar connected to the end of the truck. Bituminous materials include both asphalt and tar which have similar properties except that tar is not soluble in petroleum products. While asphalt is most frequently used for road surfacing, tar is used when the pavement is likely to be heavily exposed to petroleum spills.

Construction Tools and Other Equipment

Air compressors and pumps are widely used as the power sources for construction tools and equipment. Common pneumatic construction tools include drills, hammers, grinders, saws, wrenches, staple guns, sandblasting guns, and concrete vibrators. Pumps are used to supply water or to dewater at construction sites and to provide water jets for some types of construction.

Automation of Equipment

The introduction of new mechanized equipment in construction has had a profound effect on the cost and productivity of construction as well as the methods used for construction itself. An exciting example of innovation in this regard is the introduction of computer microprocessors on tools and equipment. As a result, the performance and activity of equipment can be continually monitored and adjusted for improvement. In many cases, automation of at least part of the construction process is possible and desirable. For example, wrenches that automatically monitor the elongation of bolts and the applied torque can be programmed to achieve the best bolt tightness. On grading projects, laser controlled scrapers can produce desired cuts faster and more precisely than wholly manual methods. [10] Possibilities for automation and robotics in construction are explored more fully in Chapter 16.

Example 4-8: Tunneling Equipment [11]

In the mid-1980's, some Japanese firms were successful in obtaining construction contracts for tunneling in the United States by using new equipment and methods. For example, the Japanese firm of Ohbayashi won the sewer contract in San Francisco because of its advanced tunneling technology. When a tunnel is dug through soft earth, as in San Francisco, it must be maintained at a few atmospheres of pressure to keep it from caving in. Workers must spend several hours in
a pressure chamber before entering the tunnel and several more in decompression afterwards. They can stay inside for only three or four hours, always at considerable risk from cave-ins and asphyxiation. Ohbayashi used the new Japanese "earth-pressure-balance" method, which eliminates these problems. Whirling blades advance slowly, cutting the tunnel. The loose earth temporarily remains behind to balance the pressure of the compact earth on all sides. Meanwhile, prefabricated concrete segments are inserted and joined with waterproof seals to line the tunnel. Then the loose earth is conveyed away. This new tunneling method enabled Ohbayashi to bid $5 million below the engineer's estimate for a San Francisco sewer. The firm completed the tunnel three months ahead of schedule. In effect, an innovation involving new technology and method led to considerable cost and time savings.

Choice of Equipment and Standard Production Rates

Typically, construction equipment is used to perform essentially repetitive operations, and can be broadly classified according to two basic functions: (1) operators such as cranes, graders, etc. which stay within the confines of the construction site, and (2) haulers such as dump trucks, ready mixed concrete truck, etc. which transport materials to and from the site. In both cases, the cycle of a piece of equipment is a sequence of tasks which is repeated to produce a unit of output. For example, the sequence of tasks for a crane might be to fit and install a wall panel (or a package of eight wall panels) on the side of a building; similarly, the sequence of tasks of a ready mixed concrete truck might be to load, haul and unload two cubic yards (or one truck load) of fresh concrete.

In order to increase job-site productivity, it is beneficial to select equipment with proper characteristics and a size most suitable for the work conditions at a construction site. In excavation for building construction, for examples, factors that could affect the selection of excavators include:

1. **Size of the job:** Larger volumes of excavation will require larger excavators, or smaller excavators in greater number.
2. **Activity time constraints:** Shortage of time for excavation may force contractors to increase the size or numbers of equipment for activities related to excavation.
3. **Availability of equipment:** Productivity of excavation activities will diminish if the equipment used to perform them is available but not the most adequate.
4. **Cost of transportation of equipment:** This cost depends on the size of the job, the distance of transportation, and the means of transportation.
5. **Type of excavation:** Principal types of excavation in building projects are cut and/or fill, excavation massive, and excavation for the elements of foundation. The most adequate equipment to perform one of these activities is not the most adequate to perform the others.
6. **Soil characteristics:** The type and condition of the soil is important when choosing the most adequate equipment since each piece of equipment has different outputs for different soils. Moreover, one excavation pit could have different soils at different strataums.
7. **Geometric characteristics of elements to be excavated:** Functional characteristics of different types of equipment makes such considerations necessary.
8. **Space constraints:** The performance of equipment is influenced by the spatial limitations for the movement of excavators.

9. **Characteristics of haul units:** The size of an excavator will depend on the haul units if there is a constraint on the size and/or number of these units.

10. **Location of dumping areas:** The distance between the construction site and dumping areas could be relevant not only for selecting the type and number of haulers, but also the type of excavators.

11. **Weather and temperature:** Rain, snow and severe temperature conditions affect the job-site productivity of labor and equipment.

By comparing various types of machines for excavation, for example, power shovels are generally found to be the most suitable for excavating from a level surface and for attacking an existing digging surface or one created by the power shovel; furthermore, they have the capability of placing the excavated material directly onto the haulers. Another alternative is to use bulldozers for excavation.

The choice of the type and size of haulers is based on the consideration that the number of haulers selected must be capable of disposing of the excavated materials expeditiously. Factors which affect this selection include:

1. **Output of excavators:** The size and characteristics of the excavators selected will determine the output volume excavated per day.
2. **Distance to dump site:** Sometimes part of the excavated materials may be piled up in a corner at the job-site for use as backfill.
3. **Probable average speed:** The average speed of the haulers to and from the dumping site will determine the cycle time for each hauling trip.
4. **Volume of excavated materials:** The volume of excavated materials including the part to be piled up should be hauled away as soon as possible.
5. **Spatial and weight constraints:** The size and weight of the haulers must be feasible at the job site and over the route from the construction site to the dumping area.

Dump trucks are usually used as haulers for excavated materials as they can move freely with relatively high speeds on city streets as well as on highways.

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