

TYPES AND SPECIFICS OF CONSTRUCTION MACHINES USED IN ROAD PAVEMENT DISMANTLING

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Abstract

Road construction is a number of activities including engineering, actual construction of road pavements, as well as maintenance and repair of roads of various purposes. An important area in intensification and acceleration of scientific progress in road construction is a wide use of construction and road machines. Road machines are designed to mechanize road construction works.

Maximum road construction mechanization is reached by using special road equipment including dozens of machine types. Use of special equipment reduces the share of manual labor (used only for patch work) and prime cost of road construction. The article discusses types of road construction machines most frequently used in dismantling of road pavements (road grader, excavator, loader, tractor, bulldozer and recycler), their purpose and specifics.

Keywords

Construction machines, design, equipment, road.

Introduction

Construction machinery consists of an internal combustion engine, a transmission, an undercarriage, and implements. It is equipped with one or several operating elements (implements) and a control system to execute process operations in construction as well as in road construction in accordance with the machine's purpose and area of application. Construction machinery can also be mounted with replaceable implements to expand the application area of special machinery.

The parameters of construction machines include: mass; dimensions; operation and transportation speed; performance characteristics of operating elements. In terms of nature of operation, road construction machines are divided into continuous and cyclic machines. Continuous machines such as compactors operate continuously, and cyclic machines such as excavators have the operating process consisting of repeated cycles that include several different operations.

Road construction machines have two modes: operation and transportation. The operation mode is characterized by higher total resistances and low speeds. In this mode,

pulling properties of road construction machines are used to the fullest extent. Road construction machines are usually classified into groups using a technological principle (by purpose of functions performed).

For instance, they can be classified into preparation machines (for preparatory road construction works: grubbers, rippers, etc.), earth machines for road bed construction (bulldozers, road graders, etc.), machines for construction of artificial structures (hammers, pile-drivers, etc.), machines for base course and wearing course soil compaction.

They also can be classified into other types of road construction machines by purpose of functions performed. It should be noted that there are three types of capacity of road construction machines.

Firstly, it is design capacity characterized by design parameters and properties of the environment.

Secondly, it is technical capacity defined by multiplying the design capacity by a number of coefficients with account for respective losses (power losses, speed losses, etc.). In other words, it is the extent to which implements are used (trip overlap, bucket fill factors, etc.).

Thirdly, it is operational capacity defined by multiplying the technical capacity by the machine use coefficient in time and by the coefficient taking into account the operator's qualification (Dobronravov and Galperin, 1985).

Subject, Objectives and Methods

The subject of the study is represented by types and specifics of construction machines used in road pavement dismantling.

The objectives of the study are the following:

- to review types of construction machines used in road pavement dismantling;
- to analyze specifics of construction machines.

The methods used to achieve these objectives include the study and analysis of characteristics of construction machines used in road pavement dismantling.

Results and Discussion

A roadway is a system of structures designed for comfortable and safe all-year-round traffic of automobile transport at rated speeds and loads. Structurally, a roadway is characterized by transverse and longitudinal profiles (Figure 1).

In accordance with operating requirements, prior to construction (or road construction), a road construction machine shall be selected with respect to machine

purpose. Most practical operation modes of road construction machines are selected. Soil categories at the place of operation shall be taken into account.

A special group of road construction machines is used for road construction, which is divided into groups by functions performed:

1. Equipment for preliminary preparation works:

Grubbers are used for grubbing, removing bushes, tree trunks, and boulders.

Brush cutters are used to remove underwood and bushes.

Rippers are designed for preparation of frozen and packed soil.

2. Digging machines:

Excavators are used for earth moving.

Bulldozers are used for ground surface leveling, digging and earth moving. Nowadays, it is common among many enterprises to rent bulldozers (http://dorstroy.su/arenda_buldozera.php).

Scrapers are used for soil layer cutting and earth moving.

Graders are designed for road bed leveling and grading.

3. Asphalt spreaders distribute and compact asphalt-concrete mixes over the prepared road bed.

4. Soil compacting machines:

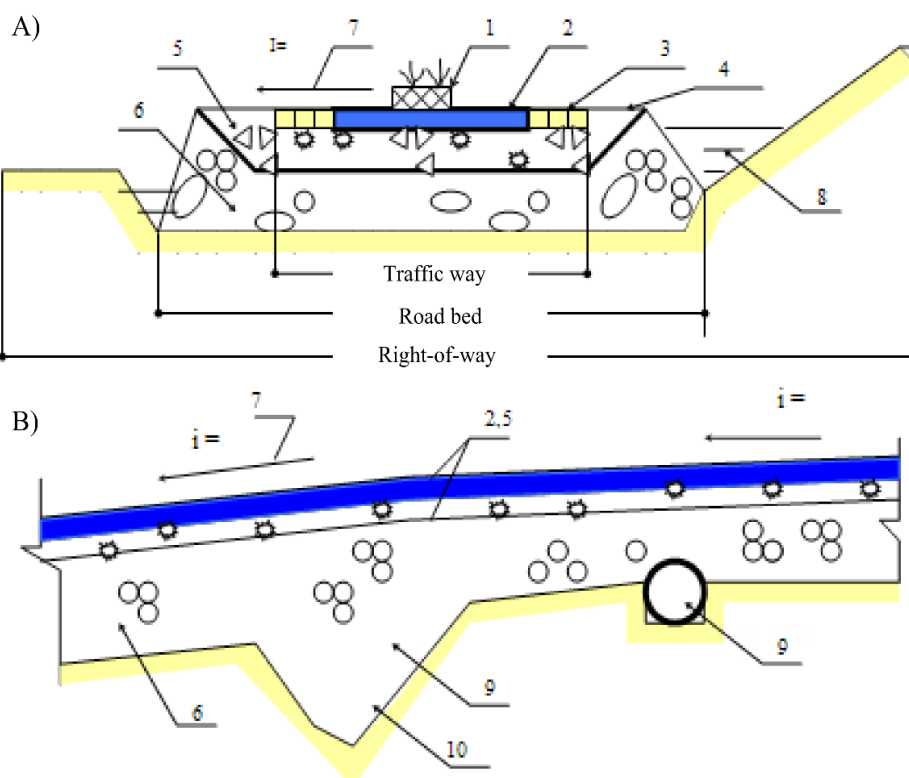


Figure 1. Roadway profiles:

A) transverse profile; B) longitudinal profile; 1 — dividing strip, 2 — road pavement, 3 — margin strip, 4 — shoulder, 5 — road bed, 6 — earth fill, 7 — slopes (transverse and longitudinal), 8 — ditch, 9 — area of concentrated construction works, 10 — natural ground profile

Rollers are machines used for asphalt compaction and tamping.

5. Road construction machines for production and transportation of concrete mixes:

Concrete mixers are used to produce concrete mixes.

Bulk cement trucks transport cement.

Concrete pumps intake concrete mixes and supply them to the concrete placement site (Volkov D., Aleshin N., Krikun V. et al., 1985).

Let us discuss types of road construction machines most frequently used in road pavement dismantling, namely: grader, excavator, loader, tractor, bulldozer, and recycler.

A hydraulic revolving crawler excavator is designed for excavation of non-frozen soils (category I–IV) as well as preliminary loosened rocky and frozen soils with the chunk size of no more than 300 mm.

It is used in developing open pits, digging excavation pits, trenches and channels as well as in other activities.

Such excavator consists of a revolving platform, supported by a crawler truck (undercarriage) through a swivel bearing, and of implements including a boom, a dipper, and a bucket.

The revolving platform accommodates:

- a power unit;
- a hydraulic motor with a swing drive and a braking mechanism;
- a hydraulic pump with a drive;
- a hydraulic tank;
- a fuel tank;
- distribution and valve devices;
- piping and other elements of hydraulic equipment.

A hydraulic lock is usually used as a service brake of the platform swing system, and a multi-disc mechanical brake is used as a retaining (blocking) brake. The revolving platform also accommodates an operator's cabin where controls are located and a counter-weight and implements are secured.

Both the running gear drive of the hydraulic revolving excavator and controls of excavator implements are usually hydraulic. A hydraulic revolving crawler excavator is usually equipped with electrical systems of lighting, ventilation, signaling, heating, diesel engine startup, and power supply.

As a rule, excavators are transported with heavy-duty semi-trailers.

Graders are designed for earth digging and leveling in construction including road construction.

Graders are also designed for works related to urban communal services, repairs, summer and winter maintenance of streets, sidewalks and squares in cities and other localities, and for maintenance of roadways.

Graders are able to level slopes, excavations, earth fills, ditches, clear roads from snow, remove icing from road pavements, move and mix materials with additives and binders on the road pavement, rip asphalt pavements, stone pavements and heavy soils.

A grader is a self-propelled wheeled machine, which usually has three axles and a leveling blade located

between the front and middle axles. It also usually has a bulldozer blade located in front of the machine and a ripper located in the rear of the machine.

The leveling blade can usually rotate in the horizontal plane through 360 degrees. It can be placed vertically to the left or right from the grader, protract to the left or right from the grader, and rotate around its cutting edge.

Graders consist of an undercarriage including an articulated (back bone) frame, a wheel travel device including the front axle and balancers, as well as a full revolving leveling blade and rear implements.

The back bone frame accommodates: an engine; a transmission; a hydraulic pump and its drive; hydraulic cylinders (including hydraulic cylinders rotating the grader); hydraulic distribution valves with manual and electromagnetic control; valves and other elements of hydraulic equipment; a cabin with controls.

Bulldozers are designed for earth digging and leveling in construction including road construction.

During the working travel, the bulldozer excavates soil using a blade located in front and pulls the soil wedge forming in front to the backfilling area. At the backfilling area, the bulldozer stops to unload the soil. Its blade raises by approximately 300 mm. Then the bulldozer moves backwards (idling) at a higher speed as compared to the working travel.

The bulldozer ripper located in the rear is designed for layer-by-layer ripping of hard soils, which are difficult to excavate with a blade, for further excavating and moving.

The bulldozer includes a frame, an undercarriage, a front blade and a rear ripper (implements).

The frame usually accommodates: a power unit; a hydraulic gear pump with a drive to control rear and front attachments; a hydraulic vane pump to drive two hydraulic motors each of which drives a side track; distribution and valve devices; piping; a hydraulic tank and other elements of hydraulic equipment; a fuel tank. The frame also accommodates an operator's cabin where controls are located.

Both the undercarriage drive and controls of bulldozer implements are usually hydraulic.

The bulldozer uses electrical systems of lighting, ventilation, signaling, heating, diesel engine startup, and power supply.

A hydraulic revolving wheeled excavator is designed for excavation of non-frozen soils (category I–IV) as well as preliminary loosened rocky and frozen soils with the chunk size of no more than 300 mm.

It is used in developing open pits, digging excavation pits, trenches, channels as well as in other activities (Drozdov N. et al., 1988).

This excavator has an articulated boom. It should be noted that the articulated boom has an additional section and an additional hydraulic cylinder designed to make the additional boom section rotating.

The bulldozer includes a revolving platform, an undercarriage and implements consisting of a monoblock boom, a dipper and a bucket, a blade, and folding supports.

The revolving platform accommodates:

- a power unit;
- a hydraulic motor with a swing drive and a braking mechanism;
- a hydraulic pump with a drive;
- a hydraulic tank;
- a fuel tank;
- pneumatic braking system units;
- distribution and valve devices;
- piping and other elements of hydraulic equipment.

A hydraulic lock is usually used as a service brake of the platform swing system, and a multi-disc mechanical brake is used as a retaining (blocking) brake.

The platform also accommodates an operator's cabin where controls are located and a counter-weight is secured.

Both the running gear drive and control of excavator implements are hydraulic.

The excavator uses electrical systems of lighting, ventilation, signaling, heating, diesel engine startup, and power supply.

In road pavement dismantling, lifting machines are used for handling construction materials, assembling structures, loading/unloading operations, installing and maintaining process equipment during its operation.

These machines are of cyclic action. The main parameter of lifting machines is their lifting capacity which means the maximum permissible load mass including the mass of the removable hoisting gear. The lifting capacity is expressed in mass units (kg, t).

The main classification feature of lifting machines is their similarity in design. Depending on the purpose, area of application and functions performed, loading machines are classified into the following categories: lifting mechanisms; cranes; lifters; industrial robots. Jacks are designed to lift loads to a small height (up to 0.7 m), primarily for assembly and repair.

By design, they are divided into the following categories: rack jacks, screw jacks, hydraulic and pneumatic jacks. Rack jacks are mainly used during installation when it is necessary to handle parts and assemblies of machines or light-weight structures with no accuracy of operations required. Rack jacks with a capacity from 0.5 to 10 tons are the most common.

Screw jacks are used for jacking of machines during preventive maintenance and repair when it is necessary to move parts and assemblies of machines slightly, when placing machines into storage, when lifting and lowering light-weight span structures onto supports, etc. They have a capacity from 2 to 50 tons. Hydraulic jacks are used to lift and lower extra heavy loads. Loads are lifted when pressurized liquid is supplied to the jack's cylinder, and it is lowered when this liquid is discharged through a drain channel. Hydraulic jacks with a capacity from 3 to 200 tons and a lifting height of 0.15–0.4 m, and special jacks with a capacity up to 750 tons are most common.

Hoists are designed to lift loads in confined spaces and applied in construction and installation, repair of machines in the field and in workshops as well as during other activities. Hoists are small lifting machines with

simple design suspended from highly located supports. They can have a manual drive or a geared motor drive. As a rule, manual chain or rope hoists with a worm or gear lifting mechanism are used.

A wheeled tractor with excavator and bulldozer implements is designed for the following operations to be performed by excavator implements: digging trenches, channels, excavation pits with soil unloading into the dump pit or transportation vehicles; simple clean-up works; loading/unloading of loose materials and materials with low specific mass.

A wheeled tractor with excavator and bulldozer implements is designed for the following operations to be performed by bulldozer implements:

- trench backfilling;
- cleaning of debris;
- clearing roads from snow.

Use of replaceable equipment makes it multi-functional. The following replaceable implements are usually used:

- a clamp;
- a hydraulic drill;
- hydraulic shears.

Wide wheels facilitate its movement and insignificant pressure on the surface allows it to move over public roads. It consists of a utility tractor, a rotating column with excavator implements, and bulldozer implements.

A utility tractor accommodates:

- a power unit;
- hydraulic pumps;
- a hydraulic tank;
- a fuel tank;
- distribution and valve devices;
- piping and other elements of hydraulic equipment.

It also has a swiveling seat for the operator. The geared hydraulic pump (designed for the implements drive) is driven by the power take-off connected to the tractor transmission. The running gear drive is mechanical and has an external planetary gear unit. The implement controls are hydraulic. The wheeled tractor with excavator and bulldozer implements uses electrical systems of lighting, ventilation, signaling, heating, diesel engine startup, and power supply. It is usually used in construction (including road construction) and loading/unloading operations. They move at a speed of up to 20 km/h. Their capacity is around 900 kg (including the counter-weight).

The tipping load is about two times more than its load capacity.

This is a mini-loader with skid steering (right-side and left-side wheels are driven by individual hydraulic motors). For purposes of operation, wheels on one side are blocked or wheels of opposite sides rotate in opposite directions.

Usually, mini-loaders are all-wheel-driven and wheels of each side are driven by the hydraulic motor shaft (one per side) using chain transmission. There are mini-loaders with a hydrostatic drive; each wheel is driven by its own hydraulic motor, and braking is carried out by hydraulic locks of the hydraulic system.

It should be noted that there are mini-loaders wheels of which rotate together with the rotary link of the articulated

frame when hydraulic fluid is supplied from the power steering to steering hydraulic cylinders.

A wheeled loader is designed for earth moving and loading/unloading operations during construction (including road construction). Usually, single-bucket frontal loaders are used for stacking or loading of loose and lump materials into vehicles, for clean-up and leveling.

These loaders can have boom or telescopic attachments and use the following rotation methods: rotation using two semi-frames; rotation of controlled wheels; full rotation (rotation of front and rear wheels); skid steering (left-side and right-side wheels are driven with individual hydraulic motors and can rotate in opposite directions).

A wheel loader usually consists of a wheel undercarriage, an articulated frame consisting of two links, and implements. The frame usually accommodates a power unit, a transmission, a hydraulic pump with a drive, a hydraulic tank, a fuel tank, distribution and valve devices, piping and other hydraulic equipment elements.

The frame also accommodates an operator's cabin where controls are located. The implements drive and their controls are hydraulic. The wheel undercarriage is driven by an internal combustion engine through a gearbox, axle gear units and wheels. The loader usually rotates using hydraulic cylinders. The wheeled loader uses electrical systems of lighting, ventilation, signaling, heating, diesel engine startup, and power supply (Galperin M., Dombrovskiy N., 1980).

Recyclers are designed for cold recycling or milling of road pavements. During cold recycling, the recycler's cutting system cuts (mills) about 300–350 mm of road pavement (asphalt, concrete, etc.). Then the recycler mixes this milled material with an emulsion (binder, foamed bitumen, cement grout, etc.) and this newly produced mixture (e.g. asphalt and concrete mixture) is placed as a road pavement on the ground or loaded into the asphalt spreader.

The recycler is loaded with a binder (binding emulsion) from a tank truck. The recycler capacity depends on the cutting width which is usually 1.2–3.8 m depending on its dimensions and design. The power unit capacity varies from 300 to 950 hp. The power unit ensures the operation of hydraulic pumps and motors, as well as recycler's hydraulic cylinders. The milling drum is usually driven by a V-belt drive and has a safety coupling.

Recycler implements

The recycler implements usually include the following:

- a power unit;
- a control system;
- a transmission;
- a track undercarriage;
- a milling drum (cutting drum);
- a rod with spray nozzles;
- a conveyor system;
- a vibratory screen;
- a roller breaker;
- a batch
- a weigher;
- a mixer (usually double-shaft);

- a system to supply mixture to the ground for its further tamping.

The recycler's conveyor system has a hydrostatic drive (using axial hydraulic motors). The milling (cutting) drum gear unit has a shearing safety coupling. The milling drum is usually driven by a V-belt drive. The milling drum has a planetary gearing. The mill can rotate in both directions. The mill rotation speed during operation is about 20 rpm. The recycler's operation speed is about 50 m/min. The milling depth is controlled by a hydraulic cylinder and is about 300–350 mm of the road pavement depth (asphalt, concrete, etc.). The cutting drum has quick-detachable teeth.

The rod with spray nozzles for binder (binding emulsion) batching and adding to the mixture is usually located next to the crushing plate in the upper part of the drum housing.

Mill cooling is usually carried out with water or binding emulsion. The recycler is loaded with a binder (binding emulsion) from a tank truck. In case the recycler moves forwards, the rear gate located in the drum housing is lowered using the hydraulic cylinder and the front gate is raised, the material can be supplied to the dump truck. The recycler conveyor can usually rotate approximately 60 degrees in both directions, which allows loading dump trucks both on tight curves and when moving along an adjacent lane.

In case the recycler moves backwards, the cutting drum (mill) knives cut the road pavement moving downwards. The mill can crush any hard-surface pavement to the size of crushed stone used in such pavement. Then the milled material is mixed with a binding emulsion (and cement grout, if necessary) and loaded into the asphalt spreader.

It should be noted that the front blade (the gate located in the drum housing) of the recycler, located next to the mill and lowered using the hydraulic cylinder, can be used instead of the asphalt spreader to level the recycled road pavement.

The recycler can also operate as a grader. In this case, the upper conveyors are turned off and the lower conveyor is turned off and raised using hydraulic cylinders to prevent its contact with the milled material. The rear gate is raised and the milled material remains on the ground. Recyclers usually use both contact and non-contact slope control means for leveling, e.g. MOBA Sonic-Ski and automatics (Germany).

A loader with a telescopic boom is a universal soldier of modern small and medium enterprises. Such loaders were invented during the World War II to replace the manual labor of men who went up the line and became a real help for agriculture both in that period and in the following years.

The telescopic loader is equipped not only with forks but with other types of attachments, which makes it an irreplaceable at factories, warehouses and during outdoor work.

Unlike the fork-lift loader, this loader is equipped with a two-section (or sometimes three-section) boom. The first section moves in two planes and serves as the base.

The second section (or sometimes the third section) is flexibly connected with the base and telescopically retracts from the first section using a hydraulic mechanism, though in some options a chain mechanism is used as a more reliable method. At the end of the end section, a fork mechanism is secured along with an excavator clamp bucket, a lifting platform, etc.

It should be admitted that the term "loader" is not completely accurate. It is derived from the original agricultural purpose of such machines. Nowadays, customers have a wide range to select from: a telescopic boom of a small but powerful electric or gasoline loader can be equipped with forks or a fork grip, an excavator bucket, a grab bucket, a lifting platform or a man rider for works at height, a grip for pipes and tanks, as well as other mechanisms.

Depending on the operations area, the telescopic loader can have an electrical motor or an internal combustion engine (depending on indoor or outdoor application). Modern fork-lift loaders as machines used to transport and load small cargoes appeared in the USSR and the USA in the period between World Wars during active industrialization and, therefore, due to the need to replace the manual labor with a more productive system (Dobronravov, 2003).

Types of fork-lift loaders:

1. Classical electric loaders.
2. Narrow-aisle trucks with decreased clearance, side loaders, reach trucks.
3. Stacker trucks designed to place cargo and pallets in stacks.

4. Off-road loaders representing a special type of equipment intended for outdoor operation (for instance, during site improvement), on native soils, including in bad weather (rain, snow, etc.).

It should be taken into account that the fork-lift truck is designed for lifting and moving of pallets with cargo or just cargo of specific dimensions and weight, with a flat bottom.

For other loading operations, either additional attachments (for rolls, drums, tires) or improved lift masts are required. Furthermore, the operations area should be taken into account since a high-capacity loader with diesel or gas power unit is completely unsuitable for warehousing operations. A compact electric loader with small-radius tires can be used outdoors with the same result.

Conclusions

Modern construction of roadways moves onto a new level: at the present time, it is almost completely automated and mechanized. This allows reducing the duration of road construction works to the maximum extent and improving the process using special road equipment.

In accordance with operating requirements, road construction machines and most practical operation modes shall be selected prior to road construction. Soil categories at the place of operation shall be taken into account.

In this study, the classification of road construction machines and their basic types were reviewed. Characteristics, purposes and specifics of road construction equipment were considered.

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