AJEMA GLOBAL RESEARCH NETWORK

AMERICAN Journal of Engineering, Mechanics and Architecture
Volume 4, Issue 04, 2026 ISSN (E): 2993-2637

The Role of Buldozers in the Construction of Roads

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Abstract: This article analyzes the role, importance, and effectiveness of bulldozers in road construction. The widespread use of bulldozers in road construction for earthworks, soil compaction, leveling, and preparing road foundations is highlighted. The technical capabilities of modern bulldozers and their role in increasing road construction productivity will also be considered. The article provides an analysis of the effectiveness of using bulldozers in various operating conditions. The research results show that the rational use of bulldozers in the construction of highways serves to improve the quality of the construction process and save time.

Keywords: Buldozer, scraper, blade (scraper), wheel, tracks, engine, soil, working cycle, power, speed, coefficient, capacity.

Introduction

Based on the Resolution of the President of the Republic of Uzbekistan dated 10.10.2023 No. PP-330 "On Measures for Further Improvement of the Road Management Sector," several tasks were defined for the creation and digitalization of a modern road management system, strengthening quality control in the industry and preventing conflicts of interest, creating conditions for the wide involvement of private sector enterprises, and increasing the efficiency of the use of budget funds [1,2,3].

The Committee for Roads under the Ministry of Transport is the single customer for the design, construction, reconstruction, repair of roads and artificial structures, as well as the maintenance of public roads and the prevention of natural disasters, the elimination of their consequences, carries out work on the repair, maintenance and equipping of public roads, the development of roadside infrastructure, and the introduction of modern technologies into the road sector. Therefore, improving the quality of construction by introducing a new generation of modern machines and mechanisms is one of the urgent tasks in the construction of highways.

Main Part

Buldozers are self-propelled earthmoving and transporting machines designed primarily for cutting, leveling, and moving soil and other road construction materials up to 150 meters away.

A bulldozer consists of a base tractor or tractor, in the front part of which a working tool - a blade - is installed in a transverse plane. Bulldozers belong to the category of machines that operate cyclically[4,5].

The bulldozer's operating cycle consists of: excavating the soil, forming a trailing prism, transporting it to the storage (assembly) site, changing gears and stopping to lift the blade (dump), reverse movement of the machine, starting forward movement, and stopping again to lower the blade to the working surface.

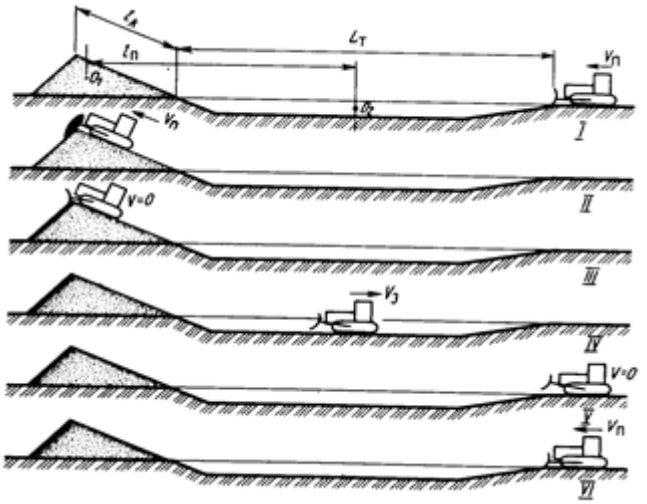

Figure 1. Operating cycle of the bulldozer and bulldozer-loader during trench digging

The working cycle of the bulldozer and bulldozer-loader (Fig. 1) begins at the moment of the first movement of the machine (I). Then comes the working stroke (II), during which the spoil header cuts through the soil at the head of the trench (indicated by a thick line), carries it to the cavaler (soil accumulation point) at a speed vp until a trailing prism is formed. In the process of moving the material, the operator continues to fill the prism with soil, as part of it will inevitably fall onto the side rollers. After this, the machine stops (III) - to lower the soil, raise the moldboard to a height of 200...300 mm from the bottom of the trench, and turn on the rear gear. The bulldozer's idle run (IV) is carried out at a speed v_x[6]. The final operation of the cycle is the machine's stop (V), which is performed to turn on the forward drive and lower the moldboard. Experienced machinists perform gear changes simultaneously with the movements of the working equipment[7,8,9].

After this, the work cycle is repeated (VI). During its movement, the bulldozer traveled the length of the trench $L_т$ and the distance along the cavalier $l_к$. Average transportation distance $l_п$ is the distance between the center of gravity of the trench cross-section (point O_2) and the center of gravity of the cavalier (point O_1).

When a cultivator is installed in the rear of the tractor, a bulldozer cultivator is formed. The bulldozer-loosener, after preliminary loosening, processes soils of high strength and frozen materials.

Bulldozers are classified according to:

1. by function;
2. by type of carriageway;
3. according to the design of the working equipment;
4. by the shape and function of the working body;
5. by the type of drive of the working device;

6. according to the traction class (engine power) of the base machine[4].

By purpose, bulldozers are divided into general-purpose and special types.

General-purpose bulldozers are used in various soils and under the following conditions for the performance of main mining and transportation and auxiliary works:

- in temperate climatic zones, with ambient temperatures up to ±40°C;
- cold climate, air temperature up to -60°C;
- in tropical conditions, temperature up to 50°C.

Special bulldozers are designed for carrying out targeted work in specific soil or technological conditions. They are subdivided into the following types:

- road-opening bulldozers used in the construction of roads and highways;
- pushing (throwing) bulldozers for working with scrapers;
- embankment bulldozers for collecting materials and minerals in ship embankments;
- underground bulldozers for working in mines and shafts;
- Underwater bulldozers for working in water.

Depending on the type of chassis, bulldozers are classified as chain and wheeled.

Chain bulldozers are the most widespread and can be used in heavy ground conditions. Wheeled bulldozers are used in lighter road conditions and when frequent movement between objects is required[10,11,12].

According to the design of the working equipment, bulldozers are subdivided into:

- Bulldozers with non-turning dumps;
- Bulldozers with a planned turnover, universal bulldozers, and bulldozer-loaders.

According to the shape of the working part, straight, hemispherical, and spherical dumps are distinguished. Bulldozers are often equipped with non-straight turning (Fig. 2.1) and turning (Fig. 2.4) dump trucks.

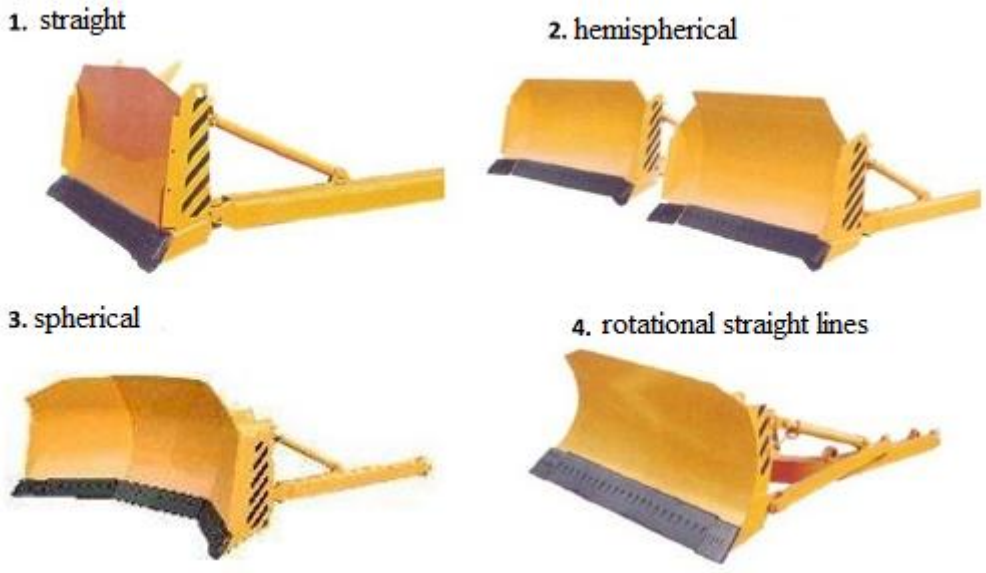

Figure 2. Types of bulldozer working equipment by shape

According to the class, which represents the nominal tractive effort of the main tractor, bulldozers are subdivided into the following types:

a) small-sized (class up to 0.9, power 18.5...37 kW),
b) light (class 1.4...4, power 37...96 kW),
c) medium (class 6...15, power 103...154 kW),
d) heavy (class 25...35, power 220...405 kW),
e) Extremely heavy (class 50...100, power 510...880 kW).

Currently, in the process of earthworks, bulldozers are used to reduce the total volume of work. Performs 30-40%.

The productivity of the bulldozer in cutting and moving soil is determined by the volume of soil being moved and the duration of the working cycle[13].

Bulldozer Technical Capacity (in m^3/hour)

$$П_c = 3600 \cdot V \cdot K_{np} /(T_ц \cdot K_p),$$

here:
V -volume of the traction prism (conventional capacity of the dump), m^3;
K_{pr} - correction coefficient to the volume of the traction prism, depending on the ratio of the width B and height H of the embankment, as well as the physical and mechanical properties of the working soil;
T_s - cycle duration, s;
K_r - softening coefficient.

Soil cutting (collection) is carried out in gear 1. The length of the assembly line is 6...10 m. The movement of soil over short distances and in areas with uplift is carried out on the 1st drive, and over long distances on the 2nd drive[14,15].

The transfer process is often carried out with continuous additional cutting of the soil to a depth of 5...10 cm, which serves to compensate for losses from the traction prism. When significant soil losses occur from the traction prism, intermediate rollers are formed; in this case, as the soil accumulates, the roller is transferred to the pump or to the next intermediate roller.

Conclusion

Powerful bulldozers have higher productivity and better specific performance indicators, but they can fully demonstrate their advantages only at facilities with a large volume of work. As the displacement distance increases, the areas of rational use of more powerful bulldozers expand. The chain drive provides greater traction force at the same engine power than the wheeled one, but wheeled cars develop higher speeds.

Soil harvesting is carried out on tracked bulldozers at a speed of 2.5...3.5 km/h, and on wheeled bulldozers at a speed of 3.5...5 km/h; soil displacement is carried out at a speed of 2.5...5 and 5...8 km/h, respectively, and backward (idle) movement is carried out at a speed of 5...10 and 10...20 km/h. High operating speeds of wheeled bulldozers make them economically efficient at greater displacement distances - up to 120 m. Chain bulldozers show the highest efficiency when moving soil at distances of 20...40 m, while wheeled bulldozers are more efficient at distances of 40...60 m.

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