# ANV Group Ltd. Experience of operation of BelAZ dump trucks in Russian open-pit mines

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ABSTACT: The article deal with the exploitation ANV Group of as the contractor for haulage using BelAZ dump trucks by example of the contract with Tugnuysky coal open pit mine of OAO SUEC. Performance and economical data is presented of Tugnuisky open pit mine BelAZ Haulage.

## 1. Introduction

BelAZ mine dump truck is the main trademark for large dump trucks operating in Russian open-pit mines. They deal for 96% of the whole fleet of mine dump trucks with 40-320 ton truck capacity.

BelAZ is the only truck manufacturer in the territory of CIS, which produces mine dump trucks with 30-320 ton truck capacity (Table 1).

**Table 1: Specification of Dump Trucks by BelAZ**

| **Parameters** | **BELAZ 7513** | **BELAZ 7521** | **BELAZ 7530** | **BELAZ 7560** | **BELAZ 7555** |
|---|---|---|---|---|---|
| Max. payload capacity, tons | 130 | 180-190 | 200 и 220 | 320 | 55 |
| Engine power kW/hp | 1103-1176/ 1500-1600 | 1691/2300 | 1690-1840/ 2300-2500 | 2610/ 3546 | 515-537/ 700-730 |
| Operational weight, tons | 105-107 | 163 | 153 | 240 | 40,5 |
| Gross weight, tons | 235-237 | 343-353 | 353-373 | 560 | 95,5 |
| Transmission type | Electrical | | | Hydro electrical | Hydro me-chanical |
| Max. running speed, km/hr | 45 | 40 | 40 | 64 | 55 |
| Wheel track, mm | 5100 | | 6100 | 6080 | 3650 |
| Base, mm | 5300 | | 6100 | 6800 | 4000 |
| Tires | 33.00-51 | 40.00-57 | 40.00-57 | 41.00-63 | 24.00-35 |
| Body side height, mm | 4850 | | 5600 | 6400 | 3480 |
| Materials-output ratio, kg/kW | 95,2-91 | 96,4 | 90,5-83,1 | 91,95 | 78,6-75,4 |
| Payload ratio | 1,23 | 1,1 | 1,3-1,44 | 1,33 | 1,36 |

Of late, the production structure of mine dump trucks at BelAZ manufacturing site was 42-43% for 30-ton dump trucks, 45-47% for 40-55 ton dump trucks, and 10-13% for 120 ton and over dump trucks.

In 2007 (the best year) BelAZ, truck output was approx. 1800 trucks (Table 2).

**Table 2: BelAZ plant production in 2006-2008, units**

| Payload capacity | 2006 г. | 2007 г. | 2008 г. |
|---|---|---|---|
| 30 ton | 465 | 693 | 618 |
| 40 ton | 564 | 540 | 500 |
| 55 ton | 290 | 228 | 197 |
| 90 ton | 2 | 0 | 4 |
| 120-130 ton | 181 | 214 | 215 |
| 180 ton | 8 | 0 | 0 |
| 220 t | 40 | 67 | 45 |
| Total, ton | **1670** | **1763** | **1711** |

Intensive growth in scope of mining work within the last 5 years (2003 to 2008) determined high demand for mine dump trucks with over 130 ton carrying capacity, since Russian mining companies began to buy excavators with a 18-25 m3 shovel.

However, the main shovel fleet until now consists of excavators with 4-5 m3 и 6-12 m3 shovels, which determines carrying capacity structure of dump trucks.

## 2. Design features of BelAZ dump trucks

30-55 ton dump trucks are equipped with Diesel engines produced by Yaroslavl engine plant (Russia) and Cummins, a foreign manufacturer. Over 120 ton dump trucks use engines from Yekaterinburg Diesel engine plant, Cummins and MTU Detroit Diesel.

Main transmission types are: hydro mechanical transmission for up to 90 ton capacity dump trucks and dynamo electrical transmission for over 120 ton capacity dump trucks. All dump truck types use pneumatic-hydraulic suspension system with single-cavity cylinders.

BelAZ every year improves quality of its products; however, trucks still yield in reliability to world levels, which is compensated low truck prices and, respectively, low prices for spare parts and modules produced by the company. Estimated life of BelAZ dump truck with dynamoelectric transmission does not exceed 40,000 hours, while world level is at least 60,000 hours.

Estimated lifetime for up to 90-ton capacity dump trucks with hydro mechanical transmission is 350,000-450,000 km, while it is 550,000-600,000 km for 120-200 ton with electromechanical transmission.

## 2. Economics of BelAZ dump truck operation in Russian open-pit mines

In view of great experience in technological transportation and maintenance of mine dump trucks, ANV Group's specialists are regularly employed for feasibility study of mining equipment packages (Kuzbasrazrezugol, OAO Asbest, OAO Magnezit, UGMK, OAO SUEK) as experts.

Our studies for the last 5 years show that transportation costs (using contemporary BelAZ dump truck models in Russian open-pit mines) are 1.4 to 1.6 times as less than using dump truck by CAT, TEREX, and KOMATSU.

Thus, BelAZ, CAT and KOMATSU were considered as truck suppliers were selected (prices 2008) (Table 3).

**Table 3.**

**218-231 Ton Capacity Dump Trucks of Various Manufacturers, Comparison of Performance Figures**

| Performance figures | Units | Komatsu 830E | CAT 793D | BelAZ BelAZ 75306 |
|---|---|---|---|---|
| Price DDP Chelutai RW station per truck | **RUR** | **158,097,896** | **106,945 584** | **50,127,896** |
| Price DDP Chelutai RW station per truck | USD | 4,800,000 | 4,100,000 | 2,000,000 |
| Unloaded truck weight | kg | 158,159 | 165,740 | 151,600 |
| Gross power | kWt/hp. | 1,865/- | 1,743/2,337 | 1,716/2,330 |
| **Payload capacity** | **tons** | **231** | **218** | **220** |
| Max. truck body capacity | m3 | 147 | 147.6 | 129.8 |
| Maximum speed | km/hr | 48.8 | 54.3 | 48 |
| Turning radius | m | 14.2 | 14.2 | 13 |
| ENGINE: | model | KOMATSU SSDA16V160 | Caterpillar 3516B | Cummins QSK 60-C |
| Calculated life | hours | 60,000 | 60,000 | 40,000 |
| DIMENSIONS: | Mm | | | |
| Length | | 13510 | 12862 | 13360 |
| Height | | 6880 | 5584 | 8400 |
| Width | | 7260 | 7605 | 6650 |
| TIRES: | | | | |
| Front tires | | 40.00-57 x 2 | 40.00-57 x 2 | 40.00-57 x 2 |
| Back tires | | 40.00-57 x 4 | 40.00-57 x 4 | 40.00-57 x 4 |

In the first line, this was determined by level of truck purchase expenses and cost of spare pats and assemblies, notwithstanding higher mechanical availability of foreign equivalent trucks.

While mechanical availability of CAT-785 dump trucks in 60,000 hours falls by 10% at the most (fig. 1) - from 93% to 82%, in case of similar by class BelAZ 75131 (130 t) dump truck with Cummins engine this parameter falls by 15% to 17%.

Changes in technical availability and field operating time of dump trucks depend both on structural reliability and on level of organization of maintenance and operation directly in open mines.

## 2. The particularities of organization of maintenance and operation of mine dump trucks in Russian open mines

Beginning from the Soviet era, in Russia large dump truck were maintained by mining enterprises themselves. BelAZ, as a truck producer, only ensured spare parts supplies via its regional offices. Until 2000 Russia had no specialized agencies which could provide complete after sales service of BelAZ dump trucks.

So, level of truck after sales servicing was determined exclusively by attitude top executives of mining enterprises to the issues of investments into truck maintenance service and level of qualification of chief managers and technical specialists in utility vehicle divisions. Such state of affairs is also characteristic at present in the majority of mining enterprises as parts of large mining holdings (SUEC, UGMK, KRY, and EVRAZHOLDING).

Here we need to remember about constant shortage of genuine and quality spare parts, which, in part, can be observed now, too. Indeed, BelAZ have been manufacturing spare parts in volumes insufficient to cover the market demand.

As a rule, the most enterprises adopt a practice when parts and assemblies are replaced only after their failure which results in low mechanical availability of BelAZ trucks after 12,000-15,000 hours (or 2-2.5 year of operation).

Curves in Figure 1 demonstrate comparative changes in truck availability for various 120-136 ton capacity dump truck models operating at the open-pit mine of OAO Karelsky Okatysh (a company engaged in iron ore mining). OOO Zeppelin Russland provided first three years of complete after sales service of CAT-785 dump trucks with truck availability guarantee at 8,111 hours/yr (Truck availability rate Kt = 93%).

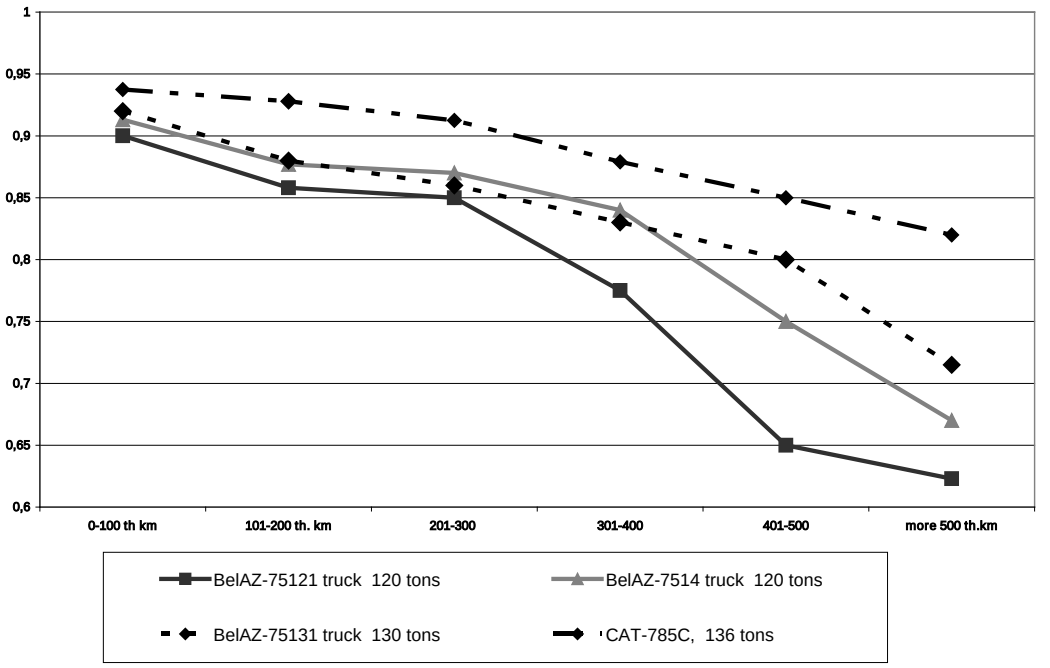

**Fig. 1: Changes in Truck Availability Rate vs. Truck at OAO Karelsky Okatysh in Dependence of Time Life**

The drop in truck availability in case BelAZ-75121 truck against other truck models is very characteristic because of lower reliability of engine in this truck make (engines for BelAZ trucks are manufactured at Yekaterinburg engine plant) and other components.

Operating efficiency of BelAZ dump truck of Russian mining enterprises is also influence by follow factors:

- The salary of a workers responsible for "service" of the mining equipment is half that of dump truck driver.
- Truck drivers take part in truck maintenance and repairs.
- Insufficient qualification of truck drivers resulting in increased truck downtimes for repairs and inefficient truck operation (using retarder brakes, gear switching without lowering engine rpm, riding on sub quality roads at high speed, etc.) which ends up in increased wear and frequent truck breakdowns;
- Insufficient stock of parts and assemblies at the warehouse to provide truck maintenance system in case of scheduled part replacement.
- Inefficient purchase planning system with purchases via holding management companies.
- Use of low quality and non-genuine spare parts during repairs.
- Delays in truck fleet renewal because mining enterprises lack their open-pit machinery retirement regulations based on calculations as to whether further operation of trucks with long service life is economically expedient.
- Generally substandard condition of roads because of currently adopted mining operation planning system, low quality of mining operations, insufficient quantity of excavation equipment and road building materials.

No doubt that the above factors can be referred not to all enterprises, as recently general level of truck maintenance and operation organization growing.

To illustrate general trends as to improvements in organization of maintenance and operation of BelAZ open-pit dump trucks, let us consider ANV Group's experience at Tugnuiysky Open pit (OAO SUEK).

## 3. Analysis of organization of dump trucks maintenance and operation, Tugnuiysky Open pit, years 2007 to 2008

ANV Group have a 10-year practical experience in organization and management of utility transportation, service maintenance and repairs of open-pit machinery both domestic and foreign-manufactured (Liebherr, CAT, Terex, Komatsu, Dressta): open-pit dump trucks, bulldozers, hydraulic excavators, wheel loaders, etc., with a similar record in mining contracts, including at enterprises of Kuznetsk Basin, Urals, Siberia and Transbaikalia.

In 1999 to 2008 the Company performed contractual work for complete service maintenance of BelAZ dump trucks at Zhairemsky ore open pit mine (Kazakhstan) - 60 units of open-pit machinery (BelAZ trucks and earth moving machinery), Pechanga-Nickel integrated works, Kolskaya GMK ore mining and metallurgical company of RAO Norilsk-Nickel - 110 units different mining equipment, Gaysky

GOK (UGMK) - 100 units, contractual work at enterprises UK Prokopievskugol, OAO Mezhurechie, Razrez Raspadsky open pit mines in Kuzbass.

ANV Group research specialists performed technical expertise of the level of organization and management of technical service mining equipment at a number of mining enterprises: OAO Vostsibugol (2002), OAO Primorskugol (2002), OAO Lebedinsky GOK, OAO Mikhailovsky GOK (2003), Severny GOK, CGOK, NKGOK, Volnogorsky GOK (Ukraine, 2003), OAO Mezhdurechie (2004), OAO Karelsky Okatysh (2004), Kovdorsky GOK, OAO Fosforit (2004-2005), OAO Uralasbest, OAO RUDA (2006), Tugnuysky Razrez open pit, Chernogorsky Razrez open pit and other enterprises of OAO SUEK (2007).

Therefore, in 2008 ANV Group began to realize the outsourcing contract of the mined rock utility transportation at Tugnuysky open pit of OAO SUEK

According to SUEK Tugnuysky Open pit mining development program in 2008 mining capacity was 6,7 million ton coal, which was ensured by 12.2 million m3 of overburden rock removed by trucks. As provided in production programs, starting from 2009 output increase up to 8.5 million ton, while scopes of overburden removed will grow to achieve 18.5 million ton after 2011.

## 4. Fleet of open-pit dump trucks of Tugnuysky open pit mine

As of August 2008, open-pit vehicle fleet of Tugnuysky open pit mine consists of 36 dump trucks with 3,554 tons total capacity (Table 4).

New dump trucks - BelAZ-7555 and BelAZ-75145 introduced in 2005-2007, and BelAZ-75131 introduced in 2006-07 substantially changed average operating age of truck fleet, i.e. from 4.6 years in the middle 2006 to about 2 year in early January 2008.

Viewing fleet composition dynamics in terms of carrying capacity, one can observe that in 2005 42-ton dump trucks made up for 50% of the fleet while their total carrying capacity was only 25% of the whole mine fleet.

In 2008 BelAZ dump trucks (13 units) account for one third of the mine fleet and for 50% of total fleet carrying capacity.

**Table 4:** Main Performance Data for the Fleet of Open-pit Dump Trucks, Tugnuysky Open Pit Mine

| BelAZ dump truck model | Number on the balance sheet | Ton capacity | Average years-since-commissioning of a truck in a model group | Lifetime of a average truck model since commencement of operation, 1000 km | Overall capacity, tons | Annual distance of an average truck model, km |
|---|---|---|---|---|---|---|
| BelAZ-7512 | 4 | 120 | 4.65 | 332 | 480 | 71,500 |
| BelAZ-75145 | 2 | 120 | 3 | 234 | 240 | 78,000 |
| BelAZ-75131 | 13 | 130 | 1.7 | 100.2 | 1,690 | 70,000 |

Selected strategy aimed to improve average fleet capacity meets contemporary trends, what with new dump truck models coming to the market. In 2001 average dump truck capacity in the fleet was 42 tons, while by 2006 it reached 78 tons, and 100 tons by early 2008.

Plans provide further increase carrying capacity of open-pit dump truck fleet by purchasing five 220-ton trucks in 2009 because of 41m3 shovels 495 HD Bucyrus purchase by the enterprise. By early March already 4 (four) 220-ton BelAZ 75306 dump trucks operated at the open-pit mine.

Besides, increased output results in more dump trucks engaged in coal transportation. Variants involving purchase and expansion the fleet of BelAZ -7555 dump truck (by other 3-4 trucks).

**Fig. 2.** The conditions of haulage in Tugnuisky mine. Belaz 75131 dump truck and EKG-12,5 (12,5 v3) rope shovel.

**BelAZ -75131, 130-ton capacity dump trucks** are used at Tugnuysky open pit mine for transportation of overburden rock by 1.8-2.5 km haul distance with hauling height not more than 90 m. Annual output achieved is 3.7 million ton-km.

In our opinion, 130-ton BelAZ model is the best dump truck ever produced by the plant. At Kovdorsky GOK's open-pit mine, providing over 400 m rock hauling height and 4.5 km haul distance, thee dump trucks achieve over 6 million ton-km annual output, while their line operation time may reach 7.500 hours.

Electro mechanic transmission ensures high reparability of electric machines. Providing sufficient inventory of these assemblies and reducing gears, reliable fleet operation can be ensured at high truck availability rate (85%-93%).

## 4. Results of Fulfillment of the contract for transportations on the Tugnuysky open-pit mine and ANV Group

Main Performance Figures for dump trucks in years 2007-2008 during Contract Fulfillment by ANV Group are presented in table 5.

Costs were reduced per unit by 8% (cost of 1 ton-km) of utility transportation for OAO SUEK at result of release of a measures by ANV Group on the Tugnuysky open-pit mine (Fig. 2).

**Table 5:**
Key Performance Figures for Dump Truck in Years 2007-2008
and Performance Figures During Contract Fulfillment by ANV Group

| Performance | **Belaz-75131** | **Belaz-7555** | **Belaz-7514** | **Belaz-7548** | **BelAZ-7540** |
|---|---|---|---|---|---|
| Annual productivity of dump trucks, thousand ton-km, year 2007 | 3,724.2 | 1,583.4 | 2,428.8 | 956.6 | 625.2 |
| Annual productivity of dump trucks, thousand ton-km, year 2008 | 3,704.0 | 1,796.4 | 2,688.1 | 1,056.9 | 667.7 |
| Annual productivity of dump trucks, thousand ton-km (for ANV Group contract) | 4,127.5 | 1,905.5 | 2,744.0 | 1,128.0 | 714.0 |

Truck availability data for various dump truck models at Tugnuysky open-pit mine are shown on Fig. 3.

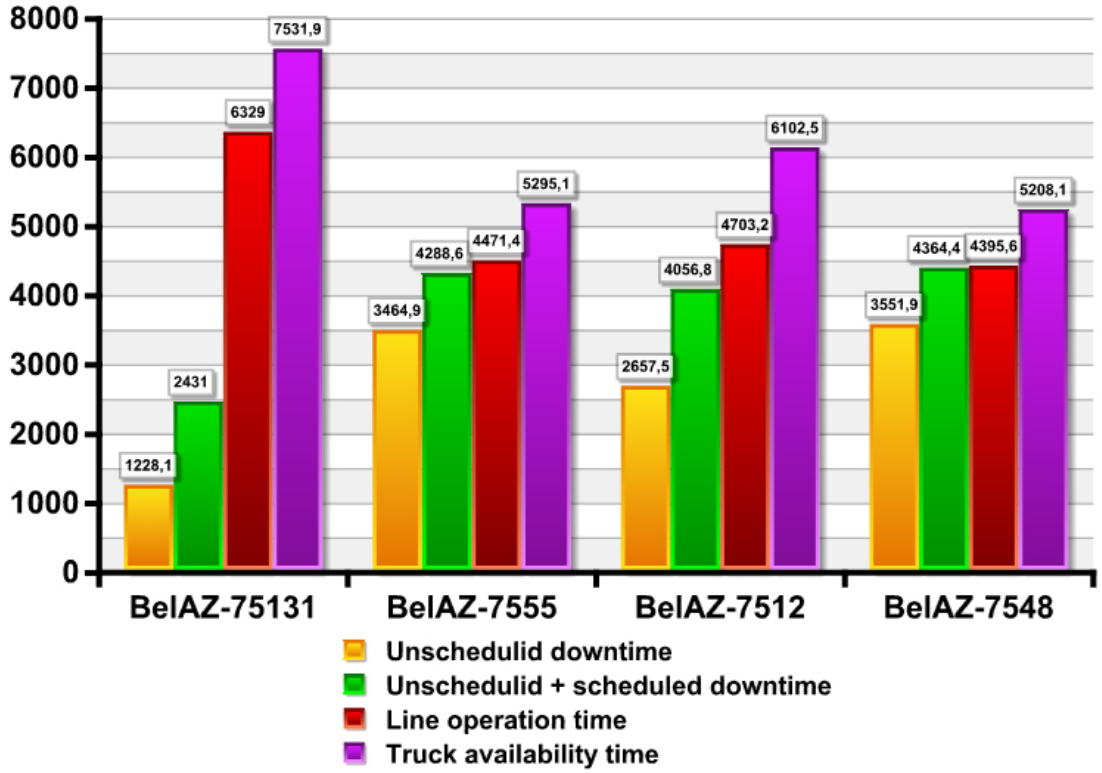


**Fig. 3: Operation Time Structure for Various Dump Truck Models at Tugnuysky Open-pit Mine in 2009.**

Apparently, in years 2007 to 2008 the most efficient operation is shown by Б-75131 models with line operation time $T^{75131}_{oh}$ = 6300 hrs/yr (i.e. operation factor Kat = 72%) which ensure the major portion overburden transportation.

The results of contractual services provided by ANV Group on the Tugnuysky open-pit mine helped to increase line operation time for dump trucks. Operation factor for BelAZ-75131 trucks have risen up to 75.5% (by 6% more as compared to the overall mine operation period) and 65% for BelAZ -75121 trucks (equal to 16.7% increase).

Taking into account that truck operation factor is calculated by summing line operation time, scheduled repairs time and downtime caused by the lack of work available, during work performed by ANV Group truck fleet operation factor increased, too; respectively, this factor rose to 93% BelAZ-75131 trucks (a 5.6% surge as compared to mine operation period) and 86% for BelAZ-75121 truck составил 86% (by 9.2% more than the earlier period).

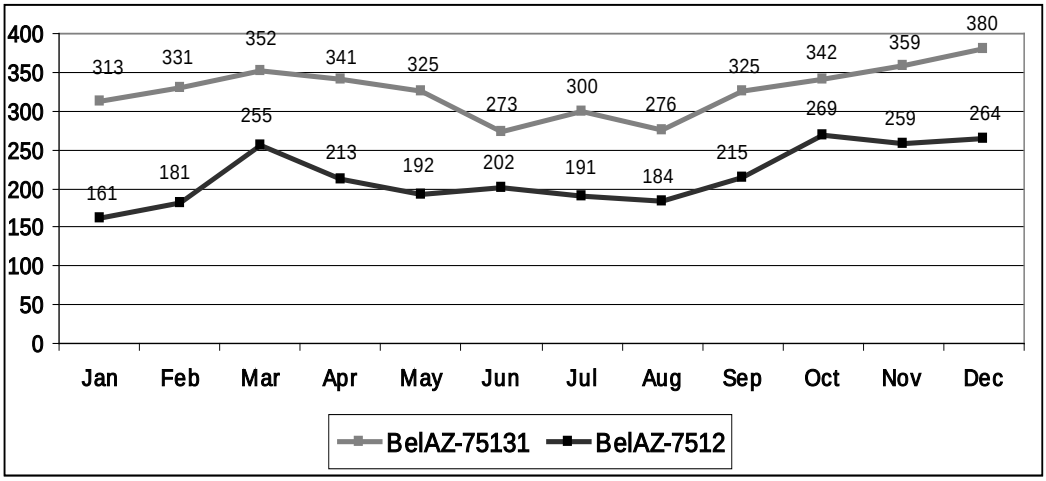


**Fig. 4:** Diagram - Dynamics of Monthly in 2008 productivity (thousand ton-km/month of 120-ton and 130-ton Capacity Dump Trucks

**Conclusion**

ANV Group reached the productivity of BelAZ-75131 of 380,000 ton-km/month ( compared to 314,000 ton-km/month per 13 operating vehicles) which is by 7% more, and 161,000 ton/month as compared to earlier 145,000 (i.e. an 11% increase)";

Productivity 120 ton BelAZ-7514 was raised to 284,000 ton-km/month against 203,000 ton-km/month (18% increase) and 102,000 ton/month per truck (which is by 14% more) as compared to mine operation period with performance of 89,000 ton/month per truck.