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Installation of high capacity longwall equipment with diesel vehicles at Adriyala longwall project, SCCL

The Adriyala longwall project is conceived by Singareni Collieries Company Ltd., (SCCL) in the early years of this millennium. This large underground project is a flag ship project not only for SCCL but also for Indian coal mining ndustry as a whole.

Coal is the prime source of energy in India and will remain for decades to come. The growing energy demand can be met only with increasing coal production. India currently produces about 7.8% of the global production with about 9.4% of global coal reserves. This is anticipated to grow rapidly as the country has shortage of other sources of energy. SCCL has produced about 62Mt in the year 2017-18 amounting to about 9% of the Indian coal production. The underground coal production in SCCL is about 13.4% of the total production and in CIL it is about 5.3% for the year 2017-18. Most of the coal exploited so far is up to the depth of 300m only. With depletion of reserves at the shallow depth, the future coal production has to be met from the greater depths only. The longwall technology is the only suitable technology for achieving bulk production from such conditions. Hence the Adriyala project planned for extraction below 350m depth has attained such high significance.

The Adriyala longwall project is a feather in the cap of SCCL and will be a milestone in Indian coal mining industry. This shall drive the coal companies to relook for bulk and profitable underground mining where the conditions are suitable.

For longwall (LW) machinery and connected equipment transport, diesel driven free steered vehicles were used. The floor of the trunk gallery was concreted for 2.0 km to facilitate transport of such heavy equipment with free steered diesel vehicles.

This paper focuses mainly on requirements of diesel vehicles and transport of equipment with diesel vehicles in trunk roadway having 1 in 4.5 gradient and tail gate with undulated floor, uneven sides, water seepage from the floor and other associated problems.

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1. Introduction

The "Adriyala longwall project (ALP)" is located in Kamanpur mandal of Karimnagar district of Telangana State. It is situated due southeast of existing GDK-10AIGDK-10 mine of Adriyala project area of SCCL. It is bounded by northern latitude of 18°39'03" to 18°40'34" and east longitude of 79°34'28" to 79°35'55". The mining block covers an area of 3.4 sq.km. The distances along strike and along dip are 2.75km and 1.25km respectively. The Ramagundam area is the heart of Singareni Collieries Company Ltd. and is also center of industrial activity with a chain of coal mines. This Adriyala longwall project is one of the mines of Ramagundam area, which is well connected by rail and road.

There are four workable seams in the mine with minimum geological disturbances. The total extractable reserves in the project are 78.597Mt. The mine is accessed with four punch entries and one return air shaft of 7.5m dia with 484m depth from surface. Mine development is being done and panels are being prepared with twin bolter mounted roadheaders and bolter miner. Sumps and miscellaneous development is being done by two side dump loaders (SDL) and load haul dumpers (LHD). The layout of ALP mine is as shown in Fig.1.

Keeping in view of interactions with manufacturers and visits to longwall faces being operated in other countries like USA, China and Australia the importance of following were

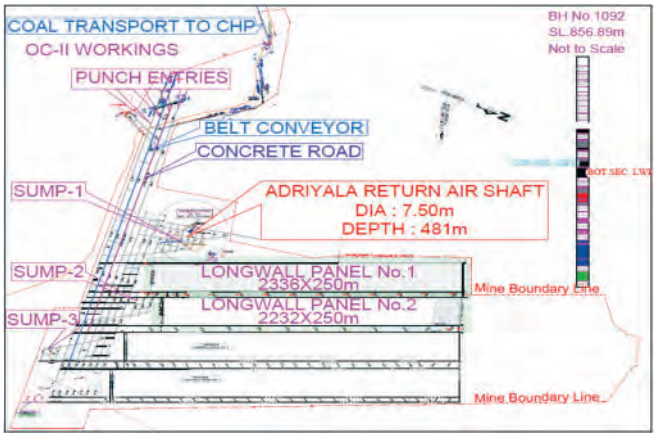

Fig.1 Layout of workings of ALP

observed for successful working of longwall mines:

- Longer panel lengths
- Wider face widths
- Only one longwall per mine
- Less circuitous coal and material transport route

  Hence the longwall panels of ALP are planned
- With trunk roadways (punch entries) to one side of the property.
- The length of the longwall panels more than 2.0 km
- With face lengths of 250 m

The equipment is procured from various global companies. The main longwall package is procured from Bucyrus (now Caterpillar) Germany. The package includes major equipment like shearer and supports from Germany, the gate belt from USA, diesel equipment from Australia and electrical equipment from UK. Other major procurements include the trunk conveyor system from CODCO China, roadheaders from UK and Germany, ventilation fan from Spain, 11 kV electrical systems from UK and 120 tonne crane from USA.

The rated production from the project is 2.817 million tonnes per annum and has planned life of 35 years. The adoption of diesel technology for transport of longwall equipment and other material in the mine is described in the following sections. About 7500 tonnes of LW equipment is transported to underground and installed.

2. Punch entries

The unique feature of the project is that the main entries are planned through the highwall of adjacent rise side opencast mine. A platform of about 200m×150m is prepared adjacent to highwall at No.1 seam floor (120m depth from surface). The highwall was dressed at proposed locations of punch entries in No.1 seam then RCC blocks of 5.5m×3.6m x1.0m dimensions were spread on the floor from highwall for about 15m with the help of 40 tonne crane. The gap between highwall and blocks was covered to prevent fall of loose boulders from highwall in to the RCC blocks as shown in Fig.2. The highwall was stabilized with cable bolting and cement injection along the periphery of the proposed punch entry. Then four punch entries were driven in top section of No.1 seam. Initially, goal post supporting was done for 20m distance from entry of drivage in addition to roof bolting. These are the four main entries for the project and each planned for specific purpose of man riding system, trunk belts, free steered vehicles roadway and haulage system besides ventilation.

Fig.2 Overview of punch entry of ALP

Details of punch entries:

Manner of drivage	Roadheaders
Number of entries	4
	Length of each drivage – 1810m (up to dip side gate of first longwall panel i.e. 69L)
Gradient	1 in 5
Entry dimensions	5.5m × 3.6m

3. Details of diesel vehicles

The transport of longwall equipment and general works throughout the mine is planned with diesel vehicles. Accordingly, six diesel vehicles are supplied along with the longwall package by Caterpillar, Germany and the details of the machines are:

There are two CL210, two CL215, two SH660D roof support carriers and four SH150 shield trailers with required attachments were provided with longwall package. The CL210 is of 10t capacity and CL215 is of 15t capacity utility vehicles and SH660D is of 60t capacity roof support carrier. They are used for all works in mine including longwall installation and salvage operations. The SH660D support carrier is used for transport of longwall supports and other heavy equipment.

For all CL210, CL215 and SH660D machines, the motive force is provided by a 172kW Caterpillar 3126 turbo charged 4-stroke inline 6-cylinder flameproof diesel engine. Flame proofing of the system includes a wet exhaust conditioning system for CL215 and SH660D and dry exhaust system for CL210 complete with exhaust and intake flame traps. The start system is pneumatic. The diesel control system (DCS) is an intrinsically safe electronic monitoring system. The engine output is connected to the constant four-wheel drive via a drive coupling and converter through a four-speed bidirectional power shift transmission to heavy-duty axles.

The CL210 utilizes a dry exhaust system complete with a replaceable particulate filter, catalysed exhaust post treatment purifier and an exhaust outlet flame trap. The CL215 utilizes a wet bath exhaust system complete with replaceable particulate filter.

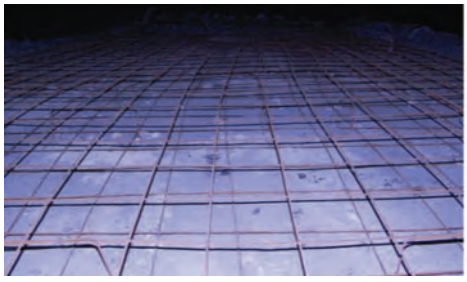

Fig.3(a) and (b) Construction of concrete roadway

(c) Concrete roadway for movement of diesel vehicles

The Caterpillar SH150 shield trailer is used for transporting longwall roof supports and can be fitted with optional attachments. The SH150 shield trailer is a 50 tonne capacity trailer fitted with a swiveling 5th wheel adaptor for towing, spring applied hydraulic release braked wheel hubs, four lift cylinders, a hydraulically driven winch, power assist hydraulic motors and two eject cylinders.

The maximum negotiable gradient is 1 in 4 and cross gradient is 1in 8 for all diesel vehicles. The tyres are solid type and maximum floor bearing pressure with payload of 55t is 15.65 kg/sq.cm at front tyres and 5.7kg/sq.cm at rear tyres.

The following attachments are procured along with the diesel vehicles:

- Crane
- Belt reeler
- Cable reeler
- Men basket
- Buckets
- Swivel plates, and
- Cookie plates

The following attachments were procured subsequently for the complete operation of diesel vehicles:

CL 210 (FBL-10):		
Belt structure pod	:	1
Longwall toolbox	:	1
Cable reeler	:	1
Duck bill	:	1
Cable boat for cable transport	:	1
Cassette carrier	:	1
Fuel pod	:	1
CL 215 (FBL-15):		
Belt structure pod	:	1
Duck bill	:	1
Cable boat for cable transport	:	1
Pipe Installation/recover trailer	:	1
10T multi-purpose trailer	:	2
Brain air loader pump/sludge pump	:	2
50T hydraulic winch	:	2

4. Preparation of mine for movement of diesel vehicles

The trunk roadways and gate roadways were driven with 5.5m × 3.6m and 5.2m × 3.6m dimensions; keeping in view of ventilation and transport of longwall equipment with diesel vehicles. The trunk road ways are driven in top section of 6.5m thick seam with stone roof in order to have stable roof for longer time, while as gate roadways were driven in bottom section with coal roof by leaving inferior overlying shaly/ clayey coal with stone floor.

a. Concreting of trunk roadway

As the trunk roadways were driven with coal floor, one of the roadways with weak coal floor has been concreted with Self compacting concrete (SCC) of 40MPa strength for 5.20m width to facilitate the movement of diesel vehicles with longwall equipment. The top gate which is the transport roadway was also concreted initially for about 200m along coal floor from concreted trunk roadway to entry point into the bottom section. In gate roadways, stone floor is strong enough to take load of heavy longwall equipment.

One batching plant is installed on surface, from there concrete is transported to punch entry mouth by mobile mixer and then concrete is unloaded on to another mixer mounted on track mounted trolley. The trolley with mixer is taken to bottom most point of the road way with the help of direct winch and floor mounted track. Concreting done from dip most point to upwards. Total 2.0km of floor concreting was completed in about 8 months. The surface of concreted roadway is provided with deep grooves across the roadway to avoid skidding of rubber tyred vehicles. Cross drain of 2" dia is provided at every 200m interval along the concreted roadway. Fig.3(a), (b) and (c) depicts the construction process of floor concreting.

Before concreting, the solid floor is exposed by removing loose coal and the bigger depressions are filled with sand on the floor.

b. Floor management

The longwall equipment each weighing about 35-50t is to be transported by diesel driven free steered tyre mounted vehicles. They require a stable and level floor. The cutting profile of roadheader does not provide this for following reasons.

i. The roadheader cuttings leave a small hump of coal at the dip and rise side of the floor. These not only reduce the effective width at the floor level of the gallery but require additional chipping on the dip side of the gate road manually for formation of drain.

ii. The roadheader does not clean the entire coal effectively.

Hence the following works were done before allowing the transport of longwall equipment with diesel vehicles.

i. One drain is prepared all along the roadway towards dip side to avoid the flooding of water all along the gallery.

ii. All depressions have been filled up with metal chips/ concrete/sand and some places chipping has been done to remove steps and humps in the sides.

iii. Ensured that no pipe line/electrical switches/cables/waste material were left on the floor.

iv. Ensured minimum of 4.5m effective width and 3.0m height all along the transport route.

c. Surface arrangements

i. Test ramp

- A concreted test ramp (50 m length) is provided close to mine entry with 1:4 gradient in order to train operators and to check whether everything is in order before going underground.
- An unconcreted (natural floor) test ramp of 50 m is provided close to the mine entry with 1:5 gradient in order to train operators.

ii. Surface training area

- A surface training area was constructed with fencing around the area and the 'roadways' are demarcated so that operators can become used to operating diesel machinery on the surface within the constraints of roadways widths etc prior to operating underground.

iii. Fire training

- As the presence of diesel in underground is a new hazard for the mine, operators have been trained on mitigating measures to avoid diesel fires

iv. Punch entry area (adjacent to portal)

- Large area has been levelled and compacted for suitable standard for repeated diesel vehicle movements
- Barricading was done to demarcate and separate underground diesel vehicles and opencut equipment
- Berm was made along toe of highwall at about 8 to 10m from highwall to prevent personnel from being near to highwall (loose/falling material)

v. Services (air/water)

- Services (reticulated air and water) have been installed at a dedicated location on the surface for the starting and watering of diesel vehicles

vi. Refuelling and servicing

- Dedicated refuelling point and service area have been provided for refueling and servicing of diesel vehicles

vii. Communications

- Intercom communication system is provided all along the transport route and surface control room.

viii. Lighting

- Sufficient lighting is provided at punch entry area to assist with night time loading and securing of loads to be conveyed by diesel vehicles

ix. Installation of diesel service bay

- For servicing of diesel equipment, a service bay was provided in underground, with a re-fillable diesel pod and built with fire protection (concrete and shotcrete) and provided lighting, fire extinguishers and required ventilation.

5. Ventilation requirements of diesel vehicles

The quantity of air circulated in a district/section/point where diesel operated equipment is used shall not be less than 0.06 cu.m/sec per kW of the machine or 3.5 cu.m/sec which ever is greater. There shall be continuous monitoring system on the vehicle for noxious gases.

The engine power of each vehicle (SH660D, CL210 and CL215) is 172kW requires fresh air of 619.2 cu.m/min per vehicle. About 3000 cu.m/min of air is being supplied to longwall face. Hence, it is not permissible to allow more than four diesel vehicles in face dip and top gate at any given time.

5(a) Ventilation in transport road ways

i. No vehicle shall be used in any roadway where –

- The velocity of air current is less than 30m/min in the general body of air;
- The presence of CH_4 in the general body of air exceeds 0.1%, or at any point in the roadway, exceeds 0.5%;
- The concentration of any noxious gas exceeds the maximum allowable concentration, given in the following table:

Gas	Maximum allowable concentration	
	Percentage by volume	Parts per million
Carbon dioxide	0.5	5000
Carbon monoxide	0.01	100
Oxides of nitrogen (as NO_2)	0.001	10
Aldehydes (as formaldehyde)	0.001	10

- Whenever the ventilation therein is interrupted for any reason whatsoever;
- The gas, emitted from the exhaust of the vehicle, contains more than 0.2% by volume of CO, or 0.1% by volume of oxides of nitrogen.

ii. When a vehicle is run at a place inbye of the last ventilation connection, the volume of the fresh intake ventilation, specified above, shall be circulated by an auxiliary fan, specially installed for the purpose, or by any other suitable means approved by the chief inspector.

iii. Not more than two vehicles shall be operated in a single air split, so however that, when more than one vehicle is used in any roadway, or in a common ventilation circuit, such additional quantity of air shall be circulated in the roadway as would be necessary to satisfy the above requirement at all times.

iv. The smoke in the exhaust gases may not exceed 2.0 Bosch units, as determined by the Bosch's smoke gauge indicator, or a similar device.

6. Training of diesel operators

Mini build of longwall equipment was done on surface before lowering of equipment by simulating under ground conditions for the following reasons;

- To assemble all the equipment as in underground with diesel vehicles
- To train SCCL team on diesel vehicles and longwall equipment operations
- To test the working of longwall equipment
- To have an idea on requirement of clearances/height/width of underground galleries
- To assess possible problems in underground and resolving them in advance
- To assess the requirement of man power and tools

The mini build was done for about one month and during this SCCL team was trained on diesel vehicles and face equipment operations.

A surface training area was constructed with fencing done around and the 'roadways' are demarcated so that operators can become used to operating diesel machinery on the surface within the constraints of roadways widths etc prior to operating underground.

7. Transport of longwall equipment

Risk assessment was done for transport of heavy equipment like shearer, shields, AFC/BSL drives, transwitch and power pack tank, basing on these safe operating procedures were prepared for each activity. Accordingly transport and installation were done in the planned order.

All equipment including energy train, boot end and BSL were transported along the tail gate-1 as tailgate-2 was not available for transport.

The sequence of transport and installation started with energy train power pack, push pull device, transwitches, water boost pumps, water tank, power pack system pumps, power pack tank, positive set pumps, mono rail for 330m distance and required hoses and cables. Then boot end - beam stage loader discharge to tail end - armoured face conveyor (AFC) main gate (MG) drive - MG supports then simultaneously AFC pans and shields - shearer and finally tail gate (TG) Drive. The energy train units are designed for transport with CL210/ CL215. Fig.4, 5 and 6 shows the transport of different longwall equipment with free steered diesel vehicles.

Before sending any diesel vehicle into underground with loads, it was ensured that the vehicle is tested with load for

Fig.4 Transport of pump unit with CLT210

Fig.5 Transport of shield with SH150 shield trailer

Fig.6 Transport of MG drive and shearer with SH660D

Fig.7 Testing of braking efficiency of diesel vehicles on test ramp

braking efficiency on test ramp constructed with 1 in 4 gradient near punch entry-1 as shown in Fig.7.

Risk assessment was done and safe operating procedures (SOP) were developed and implemented during transport and installation of all heavy equipment like shearer, all main drives, transwitches, water tank and shields and other heavy equipment. Total longwall equipment was transported safely with diesel vehicles from surface to longwall face within the scheduled time of two months.

8. Experiences during installation of longwall equipment

- The required ideal conditions for movement of diesel vehicles are dry competent floor, sufficient air supply with less humidity and adequate roadway dimensions
- Initially rubber tyres got damaged due to the presence of steel foundation bolts left in the floor used for anchoring of development conveyor drives. Later all steel foundation bolts were removed 3"-4" below the floor level along the transport route. But due to frequent movement of diesel vehicles with heavy loads resulted in erosion of floor stone for about 3"-4" and again the remaining steel bolts are exposed. Then it was decided to remove the total steel bolts from the floor and removed all.
- The main concreted roadway gradient is varying from 1 in 4 to 1 in 4.3 for about 300m from starting point and then flattens gradually with depth. There was no problem of uncontrolled movement of loaded vehicles at any point of time due to insufficient braking force.
- There are a few instances where vehicles skid along the roadway wherever loose coal/slush is lying coupled with wet conditions in the floor.
- When the diesel vehicles were moving over steep gradient area (steeper than 1 in 4.5) of concreted roadway, coolant spillage took place from top covers with CL215 vehicles.
- Frequent skidding of SH150 with load towards dip side was observed due to cross gradient and wet floor conditions. The cross gradient shall not be more than 1 in 10 for this specific case.
- At many places loaded shield canopy tip used to hit the roof during transport due to the presence of undulations in the floor though sufficient height of 3.0m was provided all along the roadway. The above problem was eliminated by levelling all undulations by chipping/filling with concrete, metal chips.
- It was planned and prepared a drain of 0.5m×0.5m along the tailgate and all the water was diverted into the drain and maintained as long as there is no movement of diesel vehicles. Once the diesel vehicle movement started all the slush in the gallery is pushed into drain and drain became inoperative. Hence a decision is taken not to prepare any drain in next transport roadway i.e., TG-3, instead small capacity pumps will be provided with small sumps and deliveries will be connected to 6" common lone discharging outbye of the roadway.
- Frequent failures of display board in alternator circuit, power up (PUP) switch, tyres, brake and steer hydraulic variable flow pump and lift and steer cylinders.
- With the use of diesel vehicles, the following have been eliminated in installation of longwall face
  * Loading and unloading stations at face.
  * Marching of shield in the face and anchoring of dowels in the floor for marching.
  * Reduced cycle time for installation shields and other equipment as the transport can be done up to the installation point and lifting, dragging and adjustments can be done with diesel vehicles.

9. Conclusions

The mine team has absorbed this technology within a short span of three months and completed longwall installation safely within the scheduled time of two months. The transport and installation of longwall equipment with diesel vehicles is more flexible, faster with less manpower than the conventional transport with track mounted Gyro Mining Trolleys (GMT) and hauling with winches. Diesel vehicles are being used for transport of all material required for underground workings, reeling/unreeling of cables and belts. The material and equipment transport with diesel vehicles has become a way of life at Adriyala project.

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