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ZISCO OVERLAND CONVEYOR

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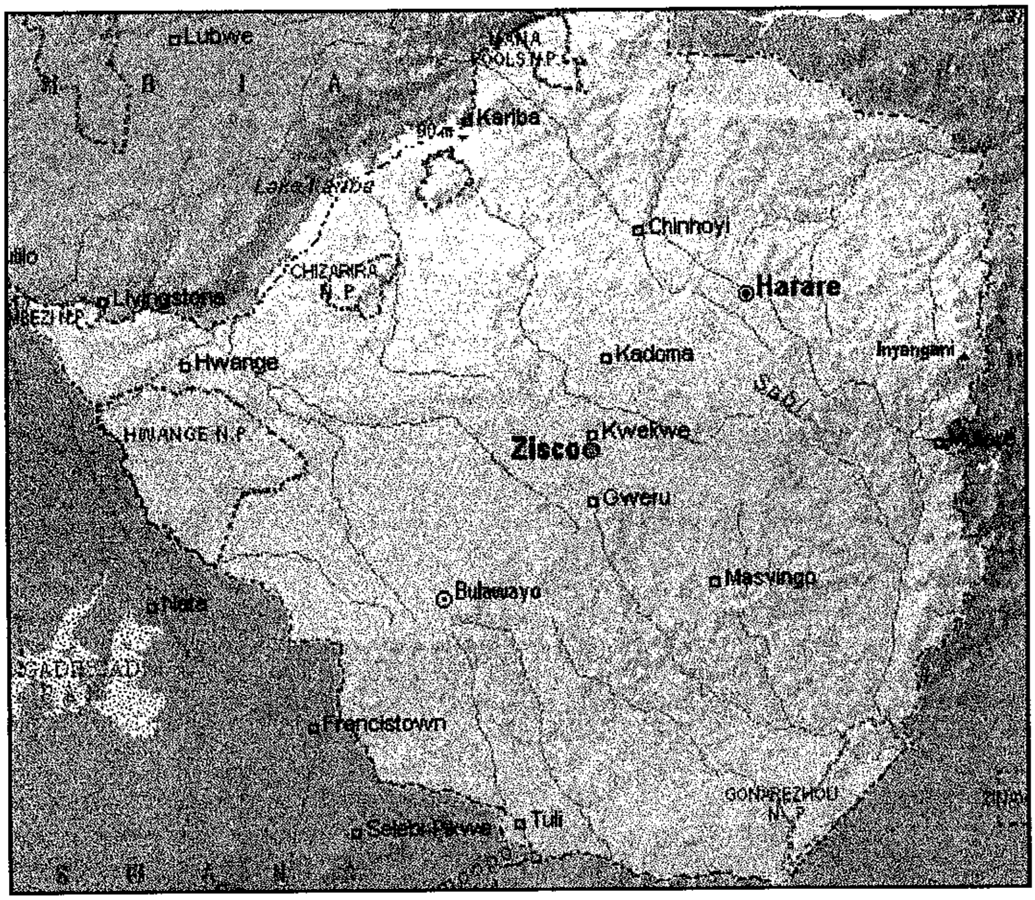
1. SYNOPSIS

This paper describes the design, construction, commissioning and related issues of the overland conveyor between Ripple Creek Mine and Orco plant at Redcliff in Zimbabwe operated by the Zimbabwe Iron and Steel Company, ZISCO. The detail describing the dynamic evaluation of this conveyor, does not form part of this paper.

The restructured ZISCO complex near KweKwe was commissioned at the start of 1997. This restructuring was necessitated by the depletion of the coarse iron ore supply from Buchwa mine, from where it is transported by rail to the steel plant. Additional supply of ore was available at Ripple Creek situated some 20 km south of the main plant and the use of a conventional trough conveyor as method of transporting the ore from Ripple Creek to Redcliff was found to be the most economical option.



Map of Zimbabwe

The project was awarded to Bateman in 1992 against international competition and included the overland conveyor as well as the crushing and screening plant, materials handling and stockpile equipment at the head and tail of the conveyor.

The overland conveyor, when commissioned in January 1997 was the longest single flight, curved, steel cord conveyor in the world, having a total length of 15.6 km. Various factors, as described later in this paper, contributed to the extended period between contract award and final commissioning. The financial constraints alone postponed the effective start of the contract to 1994.

2. INTRODUCTION

The Zisco complex comprises of blast furnaces, coke ovens, steel mills as well as sinter and limestone plants near the town of Redcliff. Iron ore for this plant is mined at Ripple Creek and Buchwa mines and are operated by Bimco. The iron ore from the Ripple Creek Mine, some 20 km south of the mine plant at Redcliff, is transported to the steel complex by overland conveyor and while the iron ore from Buchwa mine is transported by rail.

Other resources required at the plant are coal that is transported by rail to the site, stockpiled at the complex, and converted to coke in existing coking ovens, limestone that is sourced from a quarry adjacent to the main plant at Redcliff and electrical power, susceptible to cuts, that is obtained from the national grid.

The Zisco project raised several distinct challenges not usually found in turnkey projects. One of the major obstacles to overcome was the concessionary funding of the project by several nations, i.e. South Africa, Zimbabwe and the UK, resulting in a mixture of currencies. This also resulted in the requirement to source equipment from these funding countries.

The requirement to maximise Zimbabwean content added to the challenge. Bateman had to source and as far as possible use steel available in Zimbabwe. This meant that local fabricators had to be used. Customs and civil servant strikes, limited infrastructure, distance from major commercial centres and other large projects in Zimbabwe stretching the already thin resources, caused numerous delays.

The heaviest rainfall before and during commissioning not experienced in Zimbabwe for the previous 20 years, added another dimension to the problems Bateman faced.

3. THE RIPPLE CREEK PLANT

The Ripple Creek plant processes material from Zisco's new open cast mine at Ripple Creek. It comprises crushing, screening, sampling and blending facilities. The run-of-mine ore consists of material up to 900 mm in size. Primary crushing and screening at a rate of 1,000 tph reduces this to -150 mm, followed by secondary crushing, screening and sampling to produce a -31,5 mm product. Blending to a constant grade is achieved in a stockyard with two 60 000 tonne blending stockpiles in line. Material is layered in a form suitable for blending onto the stockpiles by means of a 1 000 tph BATEMAN / SCHADE luffing stacker, and recovered using a 500 tonne / hr BATEMAN/SCHADE double harrow bridge reclaimer. The reclaimed ore passes through a second sampling plant before being transferred to the overland belt.

4. THE OVERLAND CONVEYOR BELT FROM RIPPLE CREEK TO REDCLIFF

4.1 Design Considerations

The conveyor was to be designed to be absolutely reliable and to incorporate accurate balance between speed and belt width to keep the cost of belt and idler replacement to a minimum.

The requirements for the design of the system included the following major items:

- Duty 500 tph average
- Lowest possible cost
- Cater for local residents and wildlife crossings
- Cater for flash flooding
- Be as quiet running as possible

The final design was carried out by Bateman and developed in conjunction with Conveyor Dynamics Incorporated (USA) using their engineering and dynamic simulation techniques.

4.2 Conveyor Layout

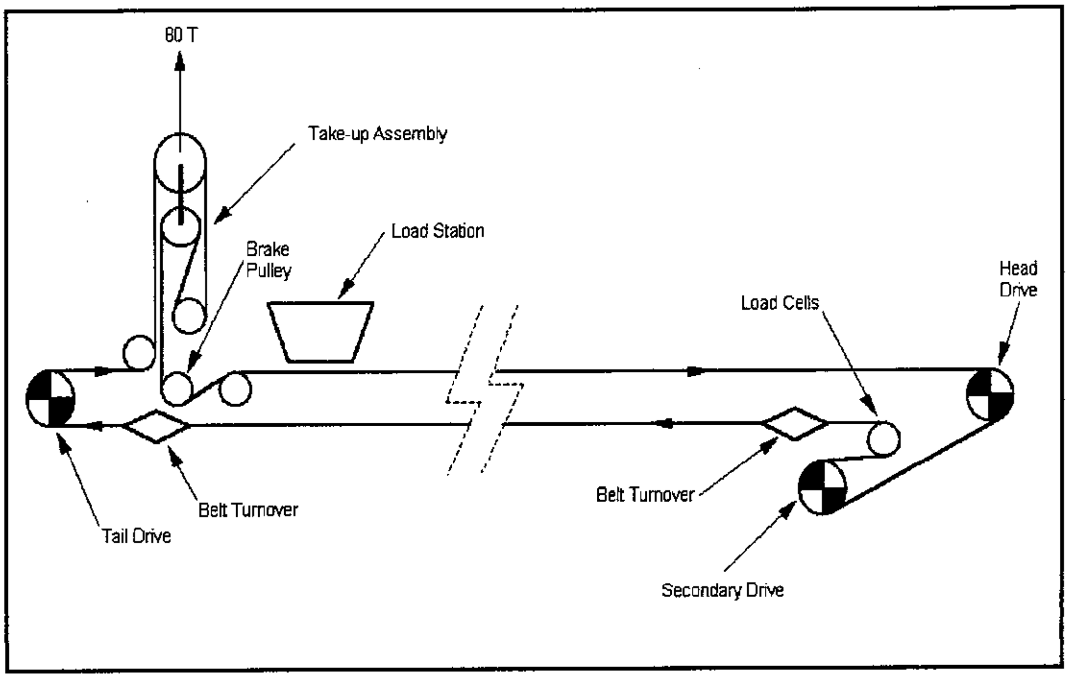


Fig 1 Schematic Layout

Iron ore is fed at the tail of the conveyor at 500 tph just after the vertical gravity take-up. One 250kW drive and a disc brake are installed at the tail.

The terrain between Redcliff (the head of the conveyor) and Ripple Creek (the tail) undulates about an even elevation (91m drop), although roughly 5 km from Ripple Creek, a rocky ridge traverses the route. This meant that conveyor either had to rise and fall steeply, or a deep cutting had to be blasted, if the conveyor was to be straight.

The compromise was to climb the ridge on a minor slope and reduce the depth of the cutting. To achieve this it was necessary to install a 6 km radius horisontal curve in the conveyor.

At the head of the overland conveyor, three drive units were installed – the primary pulley fitted with two units (2 x 250 kW) and a single (1 x 250 kW) secondary unit.

Flywheels were installed at these drives to prevent unacceptable low belt tension during stopping.

The load cells installed at the pulley after the secondary drive controls the maximum torque to limit return belt sag during start-up.

The return belt is turned over through two custom designed belt turnover mechanisms. This ensures that only the clean side of the belt is in contact with the idlers and promotes idler and belt life.

4.3 Conveyor Belt

The conveyor belt was imported from Bridgestone in Japan, who was also responsible for the belt splicing.

Width	750mm
Strength	ST-880 N/mm
Speed	4.25m/s
Tonnage	500 tph
Cover thickness (top x bottom)	6 x 4 mm
Approx Weight	14.2 kg/m
Total belt length installed	31 372m
Loading at 20 deg surcharge angle	40% of CEMA
Belt edge clearance to ore	162 mm
Number of splices	56
Tension under max acceleration (SF=4.2)	144 kN
Running tension (SF=5.4)	110 kN
Elasticity (estimated)	34 000 kN

Table 1 : Belt Data

4.4 Conveyor Drive System

Four AC variable frequency 250 kW, 1500 rpm motors drive the conveyor.

Two drive pulleys (2 x 250kW and 1 x 250kW) at the conveyor's head end at Redcliff and the one drive (1 x 250kW) at the tail, are electronically controlled and provide a soft start, stop and an inspection speed of 1 m/s for easy belt maintenance.

At full speed the belt travels at a rate of 4,25 m/s. It takes 500 seconds to reach full speed and 3 min to come to a complete standstill.

Sophisticated finite element technology from Conveyor Dynamics Inc. (USA) was used to conduct dynamic analysis during the design phase to establish that the design parameters to account for all the phenomena relating to the transmission and accumulation of dynamic shock waves and resonance that could occur during all operating conditions. Startup and stopping was also simulated.

The belt speed and slip is monitored and its dynamic tension is measured using load cells at the snub pulley at the head end after the secondary drive (see Fig 1). The safety systems incorporate a long line signalling system (LLSS) reporting to the central control room and which comprises full wire alarm, start-up warning and belt alignment systems.

The drive systems at the head and tail of the conveyor are linked via radio signal for communication during startup and stop under normal and emergency conditions.

4.4.1 Start-up

During the first 20 seconds the drives are ramped to 5% speed and then maintained at this speed for 40 seconds. During the next 440 seconds the speed is ramped to 100%.

The slew rate is of the motors is limited to 2% torque per second (motor torque cannot change by more than 2% per second). The absolute maximum torque for all the drives is 150%.

This start up control works well for all load cases.

4.4.2 Controlled Stop

During controlled stop, the conveyor is stopped with the motors, not with the brake. During the first 60 seconds of the stop, both the head and tail drives adjust their torque so that their velocities match a predetermined speed ramp.

After 60 seconds the motors are turned off and the belt drifts to a smooth and gentle stop.

4.4.3 Emergency Brake Stop

The brake at the tail drive is used in conjunction with the flywheels on the head drives to to limit return belt sag when the motors are inoperable. During such an occurrence, the brake immediately applies 20% torque and after 20 seconds ramps to 100% torque and remains there until the conveyor is stationary.

The brake is failsafe – if hydraulic pressure is lost, the brake will immediately apply 100% torque to bring the conveyor gently to a standstill.

4.5 Belt Take-up

The take-up tower, at the tail of the conveyor, houses the vertical gravity take-up and belt storage (double sheaved – see fig 2) and its design optimises the dynamic behaviour of the system.

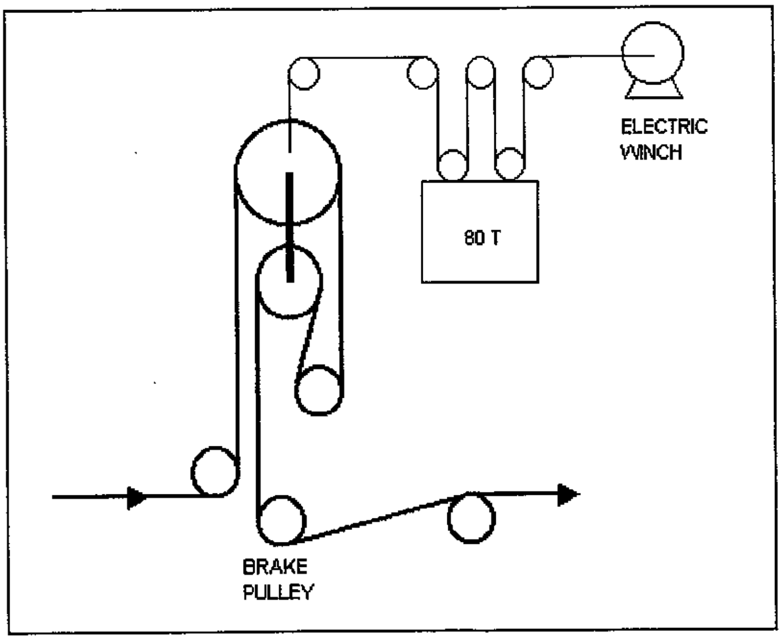


Fig 2 Belt Take up

The required belt line tension at the take-up is 47 kN. This tension is to prevent slippage of the belt on the drive pulleys during all running, acceleration and deceleration conditions and to limit belt sag to acceptable levels.

The 51m high structure, equivalent to a 15-storey building, houses the 80 tonne counterweight with a total belt storage capacity of 120 m.

The dynamic travel requirement is 16m while the static requirement is 13.8m. The total required travel is 29.8m.

4.6 Idlers

A design of idlers, idler spacing and diameter, reduces belt flap and vibrations. The idler spacing are also designed to minimise harmonic vibration and on the curved portion of the belt are half that on the straight sections.

	1400 m from Head	Straight Section	Curve 5711 m from Tail
Idler Spacing Carry Side	2,5m	5m	2,5m
Idler Spacing Return Side	10m	10m	5m
Roll Diameter Carry Side	152mm	152mm	152mm
Roll Diameter Return Side	127mm	127mm	127mm
Rolls Carry Side	3	3	3
Rolls Return Side	2	2	3
Trough Angle Carry Side	25	25	25
Trough Angle Return Side	10	10	25

Table 2 : Idler Data

4.7 Support Structure

More than 4 000 specially designed free-standing (no connecting stringers) portal frames support the belt. This arrangement eliminates the transmission of harmonic vibrations and reduced the cost.

The placement of the sleepers in line with the direction of the conveyor is unique to this conveyor and assisted with the stability of the conveyor structure.

The entire length of the conveyor is covered with metal sheeting to avoid water accumulation that during a heavy downpour of rain that would double the weight of material being conveyed. This also protects the belt against ultra-violet damage and provides electrical (earthing) continuity of the structures.

5. FABRICATION AND CONSTRUCTION PHASE

Components were manufactured and imported from Japan, South Africa and the United Kingdom.

A requirement to maximise local (Zimbabwean) content, lead to the manufacture of steel for the portal frames by Zisco.

Zimbabwean fabricators were not very reliable as far as meeting delivery dates. Changing of ownership of some of these companies during the contract did not help either.

The isolation of the site, lack of local infrastructure and resources made this an extremely difficult construction with many problems being solved on the run. There was only one crane in Zimbabwe big enough for the contract. The crane was stationed in Harare, 250km from the site. The owners, due to the unavailability of spares, where not in a position to maintain the crane.

Things that are normally taken for granted required special attention. Sometimes even nuts and bolts had to be flown in by charter due to being unavailable in Zimbabwe.

Various delays by customs due to strikes caused imported material and equipment to be held up at the border for sometimes longer than two weeks. The client did not always accept these delays as valid and caused major headaches.

6. COMMISSIONING

The conveyor system was commissioned on time during January 1997 over a period of 14 days.

Apart form heavy rainfall and subsequent flooding during this period , no major discrepancies occurred and the conveyor has been in operation since then without problems.

Thunderstorms played havoc during this period and static build-up in the structure cause various failures of the pull-key switches and other electronic equipment.

The following table compares actual data with data calculated during the design.

	Actual	Design
Installed Power	4 x 250 kW	4 x 200 kW
Absorbed Power (500 tph)	440 - 484 kW	554 kW
Absorbed power (Empty)	235 - 260 kW	454 kW

Table 3 : Comparative Data

7. CONCLUSION

The overland conveyor that was supplied on a turnkey basis to Zisco in Zimbabwe by Bateman Materials Handling Ltd, is a technical breakthrough in its field.

Being designed entirely by Bateman with the assistance of CDI, financed from three countries, equipment sourced from various countries and constructed under difficult circumstances is a testimony to the ability of Bateman to apply its innovative technology anywhere in the world.

8. AUTHORS

EL du Toit (Presenter):

Ludwig du Toit graduated from Stellenbosch University as a Mechanical Engineer. He joined Bateman Materials Handling Ltd in April 1996 as General Manager – Marketing and Sales. He was previously employed by Deutsche Babcock (Pty) as Divisional Manager Marketing. Before that he was with Mannesmann Anlagenbau (Pty) Ltd and the AEC.

AEW Fletcher:

Eric Fletcher graduated from the Camborne School of Mines having previously worked on mines in Ghana and South Africa. On returning to South Africa he rejoined one of the Major Mining Houses prior to moving into the field of Capital Equipment. He joined Bateman Materials Handling Ltd in 1991 as Marketing Manager and became Marketing Manager of BMH-Brandt in 1996. He has published several papers on Mechanised Mining Equipment and Marketing.

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