

Harnessing Gravity

Don Unmacht, National Cement Co. and Mark Alspaugh, Overland Conveyor Co., Inc., USA, describe the new rock conveying system planned for National Cement's Lebec plant.



The Lebec plant.

Introduction

National Cement Company (NCC) owns and operates a cement plant near the towns of Lebec and Gorman in California (referred to as the Lebec Plant). The plant is situated on the southern down slope of the Tehachapi Mountains at the western edge of the Antelope Valley.

The ground elevation at the plant is 3510 ft.; however the topography of the plant is rugged and some plant components are higher and lower than this level. The peak elevation in the quarry is above 5200 ft.

The cement plant operates 24 hours a day, every day. It consumes some 1.5 million tpa of quarried limestone. At present, NCC operates its quarry 10 hours per day, seven days per week and uses a minimum of four 100 t trucks per shift. The truck haul at Lebec is, relatively speaking, very expensive due to the steep grades the trucks must traverse and because of safety considerations.



Figure 2. Lebec plant, quarry and haul road.



Figure 2. A belt conveyor is adaptable to difficult terrain.
Photo Courtesy Continental Crushing and Conveying



Figure 3. A horizontally-curving conveyor.



Figure 4. Control room.

Plans

In the future, it is likely NCC will build an aggregate plant next to its Lebec plant using onsite non cement-grade dolomitic limestone as raw feed. This proposed aggregate plant is currently planned to produce 4 million tpa. During the most recent analysis of the proposed aggregate plant, it was fairly obvious that a conveyor system would be a far more economical means of transporting rock than purchasing the large number of additional haul trucks required to handle the significant increase in raw materials hauled from the quarry.

Although the implementation of the aggregate plant is currently on hold, depletion of reserves in the current quarry will require NCC to open a new quarry in 2009 or 2010. This new quarry will require building a substantial new road for the pit trucks and this road would be a more difficult haul requiring at least one and perhaps, at times, two additional haulage units to carry the current cement plant requirements. Clearly, if a conveyor system can be built at a reasonable cost, it makes perfect sense to do it now and design it to handle the increased future requirements.

Conveying

A study was commissioned in 2007 to evaluate the installation of a belt conveyor to haul 2000 tph of stone down the approximate 1.5 mile route with a 1200 ft. vertical drop.

In general, a belt conveyor has several attractive attributes in this type of project.

- It is adaptable to difficult terrain (Figure 2) as it can traverse up and down 30 - 35% grades (compared to 9% maximum for trucks).
- Horizontally curving conveyors (Figure 3) have also become accepted. When large hills or mountains are in the way, the designer can sometimes go around rather than through in order to minimise expensive and time-consuming earthwork, making a smaller footprint on the terrain.
- Since conveyors carry small loads continuously versus trucks that carry heavy loads sporadically, the intermediate structure for the conveyor can be quite small and often laid directly on the ground with no foundations.
- Continuous operation also means no scheduling or dispatching, as the material is loaded and unloaded automatically. Belt loads and, therefore, shift tonnage can be adjusted easier on the fly without changing haulage costs.
- One person can monitor and operate the complete crushing and conveying system from a central control room (Figure 4), removing operators from possible safety concerns.
- Belt conveyors can haul many tonnes of bulk material. If a belt conveyor operated the same hours as the existing trucks operate (3750 hours/year), an average rate of 1200 tph (60% of design capacity) would yield 4.5 million tpa; enough for a cement and aggregate operation.

The Lebec overland conveyor would be operating in relatively rough terrain. Therefore, a route evaluation was performed first.

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Figure 5. Three possible conveyor routes.

Route evaluation

In Figure 2, the location of the crusher and overland conveyor loading section is marked as well as the discharge location into the existing plant truck dump. Route A (red) is straight between these two points while route B (blue) and route C (orange) curves down the hill in order to miss the highest peaks.

Each route was plotted, the conveyor mechanical components are defined and the amount of earthworks required to build the conveyor/road pad calculated as in Figure 6.

In plan view (top drawing), the amount of cut (light blue areas) and fill (dark blue areas) are shown. An estimated total of 425 000 yd³ of dirt and rock would need to be moved. By contrast, route C (Figure 7) is curved to better adapt to the existing terrain and requires only 180 000 yd³ of dirt and rock movement.

Technology

Two relatively new belt conveyor technologies (from the last 20 years) have been utilised in order to make this “S” type route possible.

First, when a conveyor includes an arc connecting two linear sections with different headings, the route is said to include a horizontal curve. Since the conveyor belt is being pulled through this arc, there is a motivating force (FT) pulling the belt to the inside of the curve (Figure 8). Physically restraining the belt edge can damage the belt. Therefore, the designer must try to balance this motivating force through gravity and friction by banking the structure in the opposite direction.

Since the mid-1980s, many long conveyors have used this technology

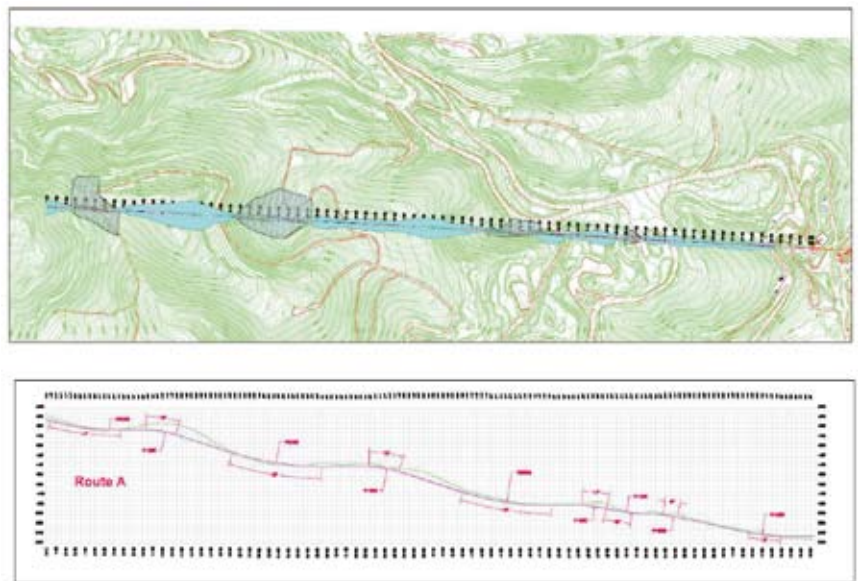


Figure 6. Route A - plan and profile view.

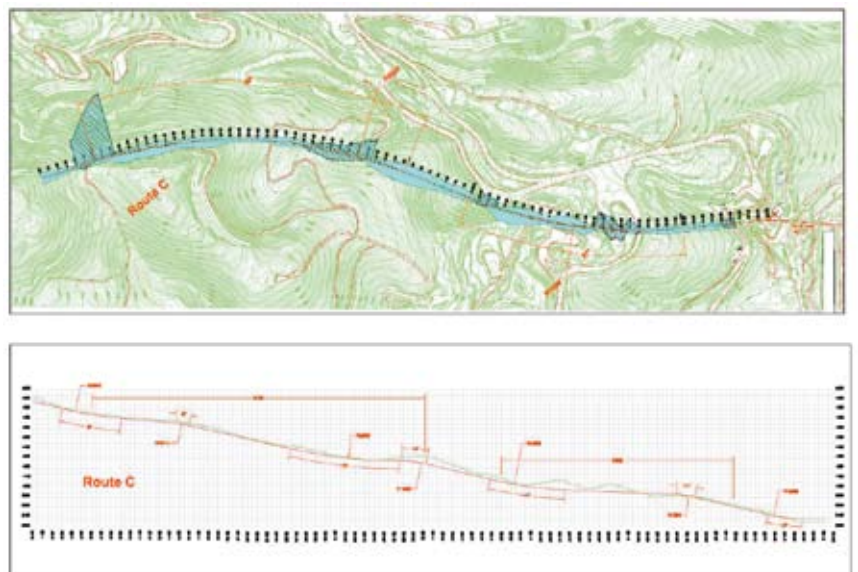


Figure 7. Route C - plan and profile view.

successfully, eliminating dusty transfers and minimising earthwork.

The second new technology utilised is intermediate drives. The great majority of belt conveyors used in many industries have one location where the belt is attached through a pulley to a motor or prime mover of some sort. The drive provides the power to move the material from one point to another by lifting or lowering the material and overcoming resistance to this motion referred to as friction or drag. The motor stresses the belt (trying to pull it apart) and the stress in the belt is transmitted around the conveyor depending on the profile of the conveyor. A generic belt tension diagram with a single drive location would look like the black line in Figure 9. The belt would have to be sized for the peak stress near the black arrow. By splitting the drives up and installing half the power at the midpoint (shown with the red arrow), the tension diagram shows two peaks nearly half the size of the black

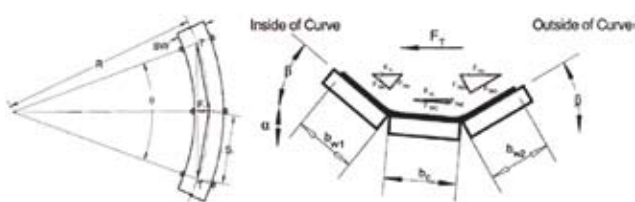


Figure 8. (Please provide a caption)

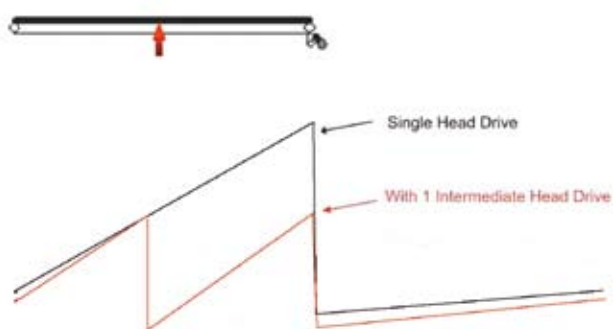


Figure 9. (Please provide a caption).



Figure 10. (Please provide a caption).
Photo Courtesy Continental Crushing and Conveying

peak. This configuration allows for half the belt rating (and a large decrease in belt cost) and also allows the belt to traverse smaller horizontal and vertical curve radii.

Intermediate drives began being installed in underground coal mines in the mid-1980s in order to decrease large components, which are difficult to install in confined underground tunnels. Now that the technology has been completely tested and verified, it is now being used in several surface projects (Figure 10), mainly in order to help optimise complex routes such as Lebec.

Final analysis

In the final analysis, two practical overland conveyor designs were developed.

- A straight-line conveyor from loading to discharge provides the least complexity and risk but requires more ground preparation and larger components.
- A winding route involving horizontal curves and intermediate drives provides a more cost effective solution in terms of earthwork and components; however it also increases complexity and risks.

With either solution, the biggest advantage of an overland belt conveyor in this application may be the environmental impact.

- Belt conveyors operate very quietly.
- Dust is only an issue at the loading and discharge points where it can be contained and dealt with. Minimal dust is emitted along the intermediate route.
- The Lebec overland conveyor will actually produce more power than it requires, making it very energy efficient. Over the 8100 ft. haul length, the material will drop about 1200 ft. in height. When fully loaded and using gravity to its advantage, the conveyor will actually generate over 2000 hp. When the belt is empty the conveyor will require only 400 hp to run. If, on average, the conveyor generates just 1000 hp during operation, it would produce almost 3 million kWh pa. Not only does this save nearly US\$275 000 in operating costs, but it is 3 million kWh that does not need to be produced by other means.

Conclusion

The engineering study of a downhill overland conveyor at NCC Lebec described in this article is technically achievable with either a very conventional approach or by using more advanced technology and optimisation. The tradeoffs are capital costs vs. complexity.

The conveyor may be economically justified for the existing cement plant considering the need to move to a new quarry. It would definitely be economically justified with the addition of a new aggregate plant and the need to haul substantially more material.

Interestingly, the potentially beneficial environmental impact and improved safety may be the most exciting aspects to arise from this study. A difficult truck haul route certainly has economic impacts, but also includes people issues. The easy control and versatility of a belt conveyor will take more people out of harm's way. And harnessing gravity, much like Niagara Falls harnesses the power of water, is a smart use of the natural placement of raw materials above the plant. Only a belt conveyor has the ability to harness gravity and use this potential energy constructively. 🌍