Belting along

Marco Sonnenschein, Ronny Lesniak and Martin Koch look at horizontal and vertical conveyors for inner cities

Figure 1: Toulouse metro with 200m curve radius

OVER the last ten years, belt conveyor systems have achieved state-of-the-art levels and have become the first choice for muck removal in both TBM and drill-and-blast driven tunnels. With time such a key criterion in tunnelling projects, it is essential that all equipment is operated in a way that derives optimum efficiency and minimises costs.

One of the key benefits of belt conveyors is that they are central to providing safer working conditions due to the separation of TBM supply lines and the transport of excavated soil. Therefore, fewer diesel locomotive rides are required, thereby reducing the risk of accident; in addition, a smaller ventilation duct is required due to the fewer exhaust fumes in the tunnel atmosphere – something that also helps to save money.

Conveyor systems installed in tunnel projects help to save space by means of vertical storage cassettes and compact, on-surface installations, which allow muck to be transported easily to the disposal area.

Challenging projects are without doubt the most interesting. One such example is the Metro Line in Hong Kong, an inner-city drill-and-blast project where several conveyors are installed.

The Gammon Nishimatsu WIL joint venture (GNWIL JV) is using a static conveyor installation to transport muck. To carry the soil to the barge-loading and stockpiling area, horizontal conveyors and one vertical conveyor form a reliable installation.

The vertical conveyor (figure 4), which has been designed for a capacity of 800t/h with a lifting height of 50m, transports the excavated soil from underground to the surface. The vertical conveyor was quickly installed within three weeks between the end of January and the beginning of February this year. Proper assembly planning by the project-management team, and efficient organisation of the assembly process by the supervisor and the GNWIL JV on site, contributed to a successful completion.

The surface installation conceals several challenges. For example, in order to reach the stockpile area, the conveyor arrangement had to cross over Shing Sai Road (figure 5). Installing a bridge-support system for the conveyor system with a span of 55m gives the cross-section rigidity. This was also important due to the busy traffic below the conveyor and because the installation was taking placed in an inner-city environment where people were living right next door to the job site. This threw up numerous challenges, such as how to reduce emissions and noise, not to mention the need to avoid muck falling out of the conveyor on to the road below.

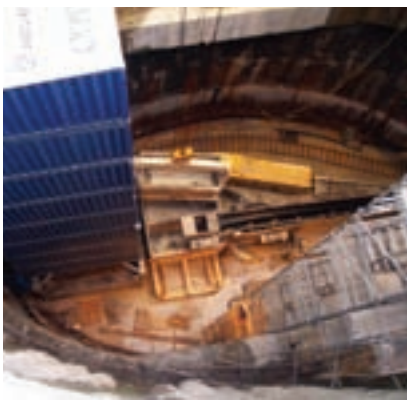

Figure 2: shaft installation, Copenhagen

Figure 3: angle booster drive Copenhagen

Besides challenging inner-city projects with static conveyor installations, inner-city TBM drives create their own challenges.

The alignment of TBM drives for metro or utility tunnels with radii of 200m, such as the Toulouse metro system in 2003 (figure 1) and the Copenhagen district heating tunnel, were both challenging schemes.

In Copenhagen, the project carried out by the MT Hoogjard and Hochtief Construction joint venture contained a real challenge because of the inner-city location, and the need for a vertical storage cassette to save space (figure 2). The alignment contained no curve section to →

Figure 6: alignment of Copenhagen long-distance heating tunnel

change the direction of the TBM drive, but a steep angle of 30°.

The TBM was dismantled and relaunched in the required direction, but the tunnel belt-conveyor installation was required to cater for this particular angle because the discharge area with all the mucking-out installations could not be relocated due to the inner-city surroundings. Also, the relocation of the storage cassette was not an option.

To solve the problem, the continuous tunnel belt conveyor had to go around the angle between both tunnels. A special booster drive was designed that guided the belt around the required angle, and assured the TBM's progress even through such a difficult alignment (figure 3).

Due to the diverse requirements generated by tunnel alignments and also by environmental conditions, suppliers of belt-conveyor systems need to develop technical solutions to suit each individual circumstance. Every project has its own blend of challenges that must be overcome. Conveyor manufacturers who can provide the right level of technical ability can convince clients to implement conveyors for their projects regardless of the obstacles.

H+E Logistik has experience in engineering conveyor systems for problematic project applications and amasses increasing technical experience from each project, thereby raising the benchmark for conveyor systems in tunnelling applications.

Figure 5: conveyor crossing of Shing Sai Road, Hong Kong

Figure 4: vertical conveyor, Hong Kong

Marco Sonnenschein, Ronny Lesniak and Martin Koch are all senior project managers at H+E Logistik

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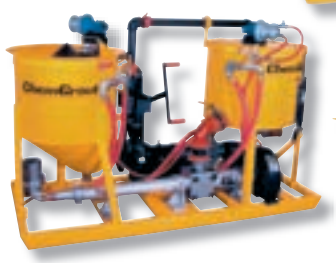

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Belt and brace conveying

Barbara Stack looks at the development of the main conveyors for spoil removal

WHILE at first glance the principle of a conveyor belt appears to be quite simple, in practice it is far from that. There are many different types of conveyor with many different applications.

For a start it is necessary to know whether the material being transported is in solid, powder or liquid form as each requires a certain method of conveyance. Some materials can be carried on open, relatively flat surfaces; others require deeply troughed conveyor belts or even a totally enclosed conveyor to prevent spillage.

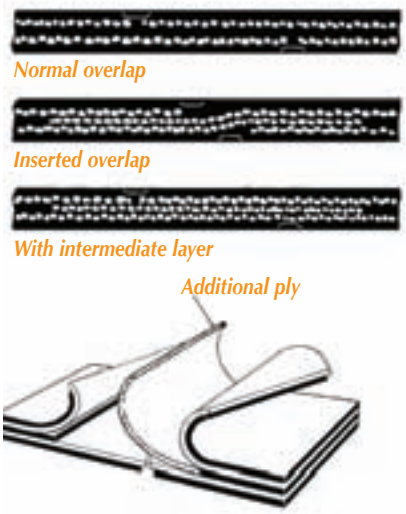
Environmental regulations may also apply, or it might simply be a matter of economy and the expected life of the conveyor that dictate a purchaser's choice. To avoid overloading, daily, and occasionally hourly, tonnage may need to be calculated.

As belts have various kinds of surface, it is essential to select the correct type for the load. Thus it is of significance to know whether the conveyor will be carrying overburden, sand, rock or an abrasive mixture of pebbles and gravel, for example. The strength of the belt material will depend on the distance it travels. Some manufacturers specialise in long-distance belts; others on the shorter runs. Therefore, the selection of an expensive steel-cord belt will be a measure of the coarseness or abrasiveness of the material and the distance it needs to go.

So far as inclines are concerned, the type of material and angle of inclination is important. Lower frictional co-efficients may require special belts such as those fitted with cleats or, alternatively, a sandwich-type belt may be used.

A belt is continually under tension, and is supported by a steel framework and a system of idlers. These idlers, which are in a trough or v-shape, form the belt's profile.

Splices for two-ply conveyor belts



Splicing of Textile Belts
Photo: Phoenix AG, Germany

TEXTILE CONVEYOR BELTS

Conveyor belts made with a carcass of textiles normally consist of several superimposed plies. This carcass is then encased with a rubber

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coating to protect the textile core from mechanical damage and external injury. Originally, such belts were made of cotton and rayon, but these were superseded by polyester and polyamide constructions.

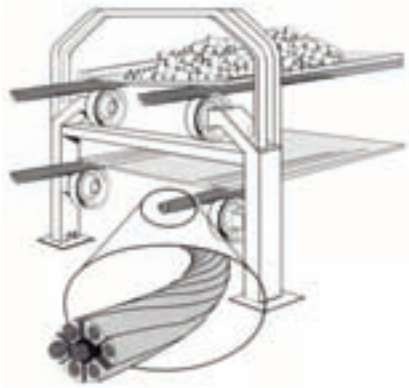
STEEL-CORD BELTS

Steel-corded cable belts are made from longitudinally placed strands of steel wire, wound together to form a rope. They are then impregnated with a bonding material. Cross-ties are sometimes provided to give additional lateral strength and prevent splitting.

When steel-cord belts were first produced, the importance of the splicing pattern was not fully understood. As the cord diameter to pitch diameter increased, the lack of space between cords necessitated a splice pattern, which involved an increasing number of butt joints, instead of cord overlaps. This caused an unacceptably thick section at the joining point, which resulted in belt failures over long haulage distances.

Subsequently, a new splicing method was introduced that used a ratio of two overlaps to one butt. The cords that had not been overlapped were then embedded with un-lapped cords on the opposite section. To ensure it remained attached to the rubber binding – despite the considerable strain produced by the load and movement – it was important to ensure each individual cord was embedded in the spliced section for an adequate length. This splicing method was tested successfully over a long distance by Anderson Group.

Figure 1: Triton cable *Photo: Cable Belt (Australia)*



Triton cable runs in a v-shaped groove on the underside of the belt
The oval inset shows how Triton cables are made up of six strands of steel wire; each strand in a separate wedge-shaped jacket of Hytrel

The tests indicated that the splicing method would adequately meet the requirements laid down in the specifications for the South Drift section of the Selby coalfields in the UK. As a result, Anderson Group was awarded the conveyor system contract for that project.

Cable Belt produced a similarly strengthened belt for long distances. Its special feature was that it was not under tension. Two steel Triton cables, which ran parallel in v-shaped grooves on the underside of the belt, served to support and drive it. The Triton cable (see figure 1) consisted of six individually elastomer-coated, steel strands wound around an elastomer-coated, round, central strand. On closing, the individual strands locked together around the plastic-coated core to form a complete cable.

Subsequently, Cable Belt reinforced its belts by adding small, steel bars of rectangular section laid across the belt width. Unfortunately, extensive experience in the field indicated that the belts were affected by shrinkage at times. This, and the additional problem of steel bars breaking through the edge of the belt under certain conditions, led to the development of a new belt material that was reinforced by steel mesh.

While still being slit-resistant, the new belt was found to be more flexible, permitting self-centring of the product. Due to its increased strength, greater loads could be carried safely. Since then, all cable belts incorporated the all-important steel-mesh reinforcement.

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Sicon enclosed belt conveyor

Photo: Scanianinventor Conveyor, Sicon, Sweden

CURVED CONVEYORS

Dowty Meco introduced curved conveyors for use on the surface. These eliminated transfer points, and reduced the number of central system and intermediate driving units that required a special power supply.

SIDE-FRAME BELT SYSTEMS

When belt conveyors were first introduced they were usually made with rigid side frames. Not only did the construction take up valuable road space, but it was costly to install and difficult to extend – therefore not a good design for a tunnel. Pioneered by Continental Conveyor and Equipment Company, the advent of the wire-rope, side-frame belt conveyor changed the scene and has now been in existence for many years in underground mining.

Consisting of rope supports, wire-rope side-frames, wire-rope tie-off stands, and the appropriate carrying and return idlers, this system has the advantage of easy assembly, extension, retraction and removal. In addition, the conveyor can be suspended from the crown or side wall of a tunnel, leaving more room for other tunnelling activities.

Strangely, the use of channel-type, rigid structures began to increase soon after the wire-rope conveyor became popular. This was not, in fact, a reversal in technology as the new channel structures (built of light sections that could be man-handled) were designed to join together easily. This system could be roof-hung or floor-mounted, and no tie-offs were required, as was the case with wire ropes, which needed to be tensioned.

MONORAIL SYSTEMS

In these transport systems, buckets or carriages are suspended from trolley conveyors by hooks, magnets or carriers designed for the particular load being handled. They are coupled together on an endless, propelling, tensioned cable, chain or other linkage. The monorail system was primarily designed to carry light loads of supplies and equipment to workings.

Normally, the rails are supported at the crown by rockbolts or they may be attached to permanent tunnel-support segments. Later, design engineers began to produce new types of monorail systems consisting, perhaps, of continuous belting, rather than individual buckets or trolleys.

An example is the Sicon enclosed belt conveyor (see figure 2). This was driven directly by a drive drum that made contact with one of the external top surfaces of the belt conveyor in its enclosed form. The belt was supported on hooks mounted on brackets, which could be attached to the wall or crown of the tunnel, or, alternatively, they could be free-standing in a frame structure provided for that purpose.

The major advantages of the Sicon system was its ability to negotiate narrow curves and the totally enclosed handling it provided. For loading purposes, either vibration, a screw feeder or a chain conveyor is used.

TBM BRIDGE CONVEYORS

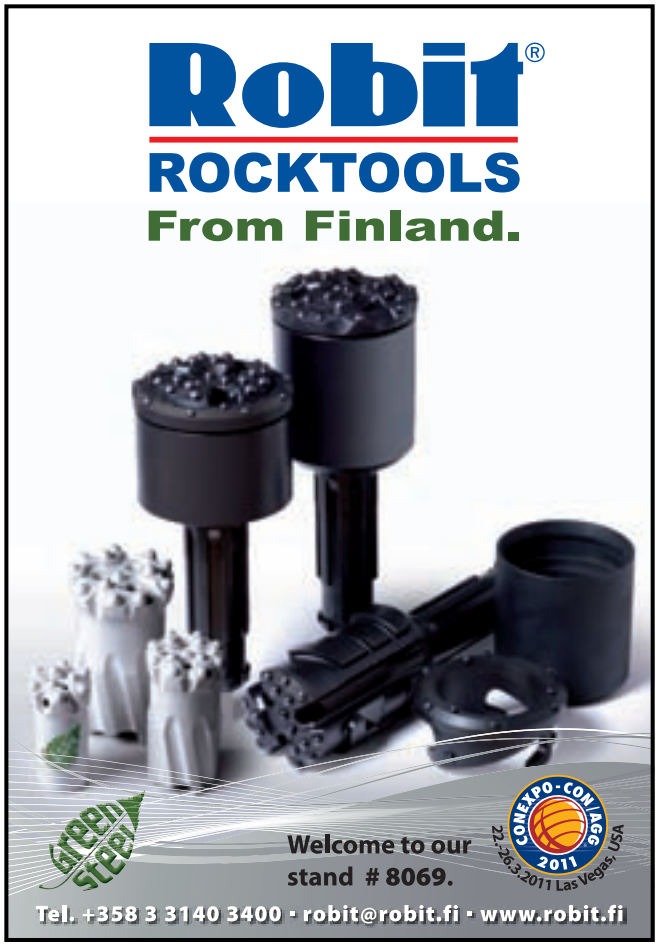
The adaptation of coal-mining technology to tunnel-boring machines began in earnest when a contractor's conveyor system was used behind a Jarva MIK 26 at the Entrenchment Creek project in Atlanta. A Long-Airdox conventional belt conveyor was used behind a bridge conveyor connected to the TBM.

During operation the TBM would bore about 30m, towing the bridge conveyor, which, in turn, deposited its spoil on to the continuous conveyor. At the end of the 30m section, the tail roll (known as the 'advancing tail piece') section would be detached from the tunnel floor, towed forward another 30m and then re-anchored.

The next innovative step was to mount the continuous tail-piece on to one of the back-up decks towed by the TBM. Once more, a bridge conveyor received material from the TBM and transferred it over the track-laying zone at the rear of the machine to a position near the sidewall. From this point the material was deposited on the outward section of the continuously advancing main tunnel conveyor.

The main problem associated with the above method was that the bridge conveyor was there to accommodate the steering motion of the TBM at its rear, and bridge the gap between the TBM and the continuous conveyor system. In practice, operators found that it was difficult to position the tail-piece so that it met the continuous belt track at the correct angle of inclination and height.

While the continuous belt system needed to track in a straight line to follow the sidewall, the TBM, on the other hand, might well steer right, left, up or down, or a combination of those directions. In other words, in order to overcome these intricate complexities, it was necessary for the tail-piece to have lateral, vertical and roll motion.

Terratec Asia-Pacific refined the technology further. By strategic placement of the continuous conveyor at the crown of the tunnel, instead of at the sidewall, the need for a bridge conveyor was eliminated. In the new system, the TBM conveyor emptied directly on to the continuous conveyor suspended from the crown. This overcame the problem of matching the undulating tail-piece of the bridge conveyor with the continuous conveyor inlet section.

Barbara Stack is author of the Encyclopaedia of Tunnelling, Mining and Drilling Equipment