

Shortbridge System



INNOVATIVE
CONVEYING SYSTEMS INTERNATIONAL



The Next Generation of Bulk Conveying Technology

Executive Summary

- » The ICS Shortbridge is designed to make tunnelling more efficient by reducing delays caused by traffic conflict between trucks and support equipment.
- » The ICS Shortbridge is based on a new patented bulk materials handling technology known as the Innovative Conveying System that offers remarkable capabilities, including tight-radius-curves, steep-angle-conveying, full mobility while operating, and speedy replacement of belt sections or other components.
- » The ICS Shortbridge occupies a footprint of approximately 1.5 metres (along its body). It can sit unobtrusively alongside the tunnel wall (or at any position desired) safely conveying the spoils from the roadheader, past the support equipment and to a discretionary point where the trucks can be charged. Equipment can safely operate close to the system or over it. The result is that rockbolting, meshing and shotcreting can be conducted simultaneously with spoils removal, alleviating any delays that may occur through traffic conflict.
- » A productivity model has been composed by ICS Pty Ltd to estimate the productivity benefits possible through use of the Shortbridge. This indicates that productivity advantages can be quite substantial, and rarely lower than 35% (in the full-block scenario).
- » The Shortbridge also offers qualitative advantages. These include enhanced safety, improved operational flexibility, and low risk. The latter refers to the fact that the Shortbridge does not conflict with, or replace, existing equipment, but rather enhances its efficiency. Additionally its introduction into an existing tunnel is a simple and swift matter, as is an exit if so required. The option to rent a system before purchasing also helps to minimise the risk.

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Introduction

Main objective - improve productivity

The ICS Shortbridge is designed to substantially improve tunnelling productivity by reducing the traffic conflict that typically occurs between the trucks and support equipment. Tunnels vary widely in their economic characteristics, with the consequence that the productivity advantage offered by the Shortbridge also varies according to those characteristics. ICS has developed a computer model to assist in calculating likely productivity gains in different scenarios. The results indicate that for a large proportion of scenarios the Shortbridge would increase tunnelling efficiency by well over 50%, with few scenarios offering less than 35%.

Reduces interruptions to the main material flow

The Shortbridge is designed for use behind a roadheader, although it can be adapted for drill and blast operations. It improves efficiency by reducing the interruption to the main material flow, meaning that the spoils produced by the roadheader can be evacuated continually to enable it to progress. This is achieved by directing the roadheader spoils into the mobile feeder of the Shortbridge, from where the unique belt transports them to a designated discharge point closer to the tunnel entrance.

This location of the discharge point is entirely discretionary as the modular nature of the system enables easy contraction or extension of the conveying path. However, for the sake of simplicity, most of the efficiency calculations are based on the spoils being conveyed to a point approximately sixty metres behind the roadheader.

At the discharge point the mobile discharge system loads the trucks (via a short transfer conveyor or a front end loader). The overall width of the Shortbridge, along its body, is only 1.5 metres. In all but the smallest tunnels this provides sufficient floor space for support equipment to operate. Therefore, rockbolting, meshing, shotcreting and other support activities can take place without any interference to the evacuation of spoils.

Overall efficiency significantly increased

In this way material can flow from the roadheader while support operations are taking place. In conventional tunnelling operations, activities are largely in series, meaning that support activities must often wait for the trucks (at least for some of the time during the period of support activities), with the reverse also applying. Delays are discussed in more detail later in the document. The Shortbridge removes this constricting interdependence and allows primary and secondary activities to be performed simultaneously, with the result that overall efficiency is significantly increased.

Diagram 1: The Shortbridge in action

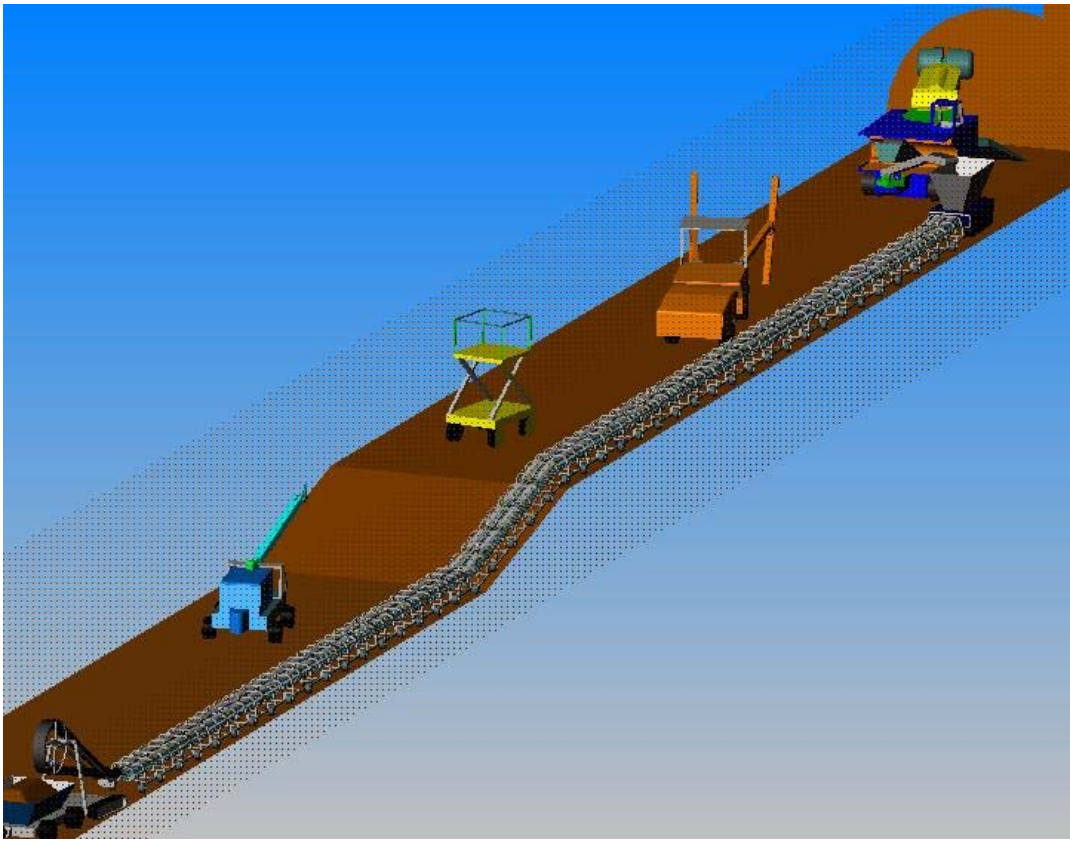


Diagram depicting the ICS Shortbridge conveying material past the support equipment

The Technological Context

Based on patented technology

The Shortbridge is based on a unique patented technology known as the Innovative Conveying System, abbreviated in this document to "ICS". The term "Shortbridge" is intended to describe the fact that it functions as a bridge between the roadheader and the trucks. The effect is to raise tunnelling efficiency by a substantial amount. The general ICS technology comfortably meets the technical demands represented by the Shortbridge.

Three main elements - unprecedented capabilities

The ICS combines three elements to produce a conveying system with unprecedented capabilities. The central element is the patented belt. It belongs to the general class of wrap-around-belts, but is unique in that it possesses inherent corrugations, which grant it the ability to conform to tight bends in the horizontal and vertical planes (whether empty or fully loaded). The second element is the drive system, which consists of drive units mounted so as to motivate the belt by its top edges. These edges are hook shaped (in cross section) and not only facilitate the suspension of the belt on a series of idler wheels, but also provide an excellent contact area for the caterpillar drives to generate substantial tractive forces. The third element is the articulated frame system, which is composed of a series of sections that couple together via a single-point connection between frames and present the series of idler wheels for the belt to suspend from. These frames can be mounted on wheels, tracks or skids. Alternatively the system can be suspended, eliminating the need for substantial frames. This is made possible by the minimal belt tension in the system.

Some key capabilities

The ICS can convey a wide range of materials ranging in size from dust to boulders. The belt offers a range of cross section sizes to suit the application. It can lift materials up steep angles by enclosing the material and inducing bridging. The ICS can convey materials around tight curves, made possible by the unique belt geometry and the fact that the side-mounted drives do not rely on belt tension for motivation. An ICS can also be shortened and lengthened swiftly on account of its modular frames and the easy joining of belt sections. Another highly useful feature is that the entire system can be made mobile, whereupon the feeding module can coordinate with the loading machine and the discharge module can deposit the material while travelling, effectively functioning as its own stacker.

Broad applicability

The capabilities of the technology make it suitable for use in a wide range of bulk materials handling applications, ranging from the transport of powders through to the evacuation of large rocks from an open cut mine.

The Shortbridge fits into the general class of applications that involve particles up to 250 mm in cross section. Although the primary target for the Shortbridge is tunnelling, the same basic components can be configured for highwall coal mining, conveying grains and powders, and selected underground mining applications.

Diagram 2: Key elements of the ICS technology

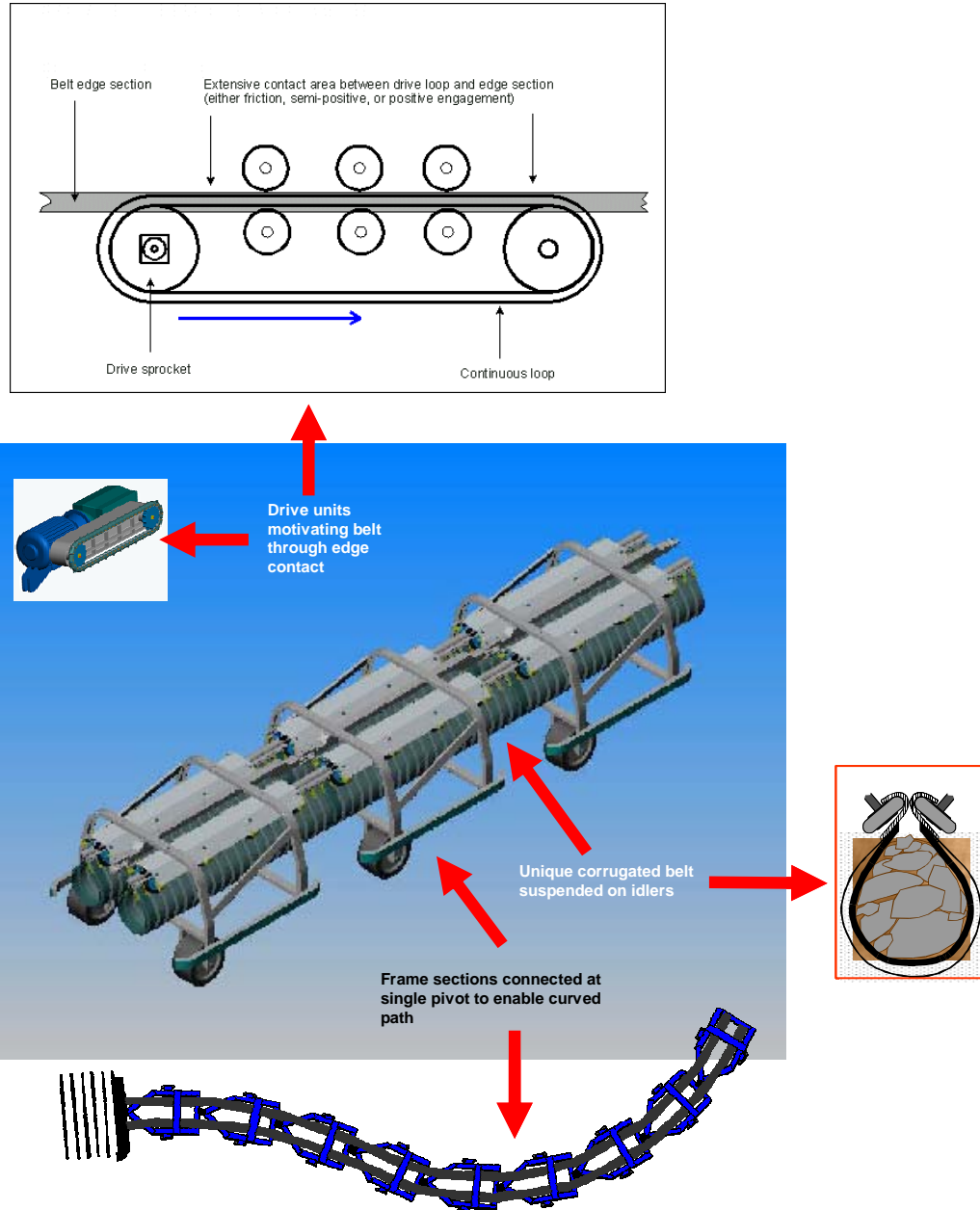


Diagram depicting the three main elements of the ICS technology. The central diagram shows the system in Shortbridge configuration. It should be noted that the technology can assume different configurations to suit different tasks. The belt size can range from a 200mm cross section to 1.3 metres. The drives can vary in horsepower and can be distributed along the length of the system as required. The size and style of segmented frames are dictated by the task requirements. The frames can be fixed to ground or infrastructure, mounted on wheels, tracks or slides, or suspended from a superstructure.

Description of the Shortbridge

As described in the previous section, the Shortbridge is based on a new and unique patented conveying technology that offers far more extensive capabilities than those required for this application. The significance of this lies in the fact that the features of the Shortbridge lie well within the capabilities of the technology on which it is based.

The basic idea

The idea of the Shortbridge is quite simple. It is to convey the spoils from the face of the tunnel to a point far enough removed for trucks to accept the material without interfering with the support equipment. It does this by using a unique conveying technology, described below, that occupies no more than 1.5 metres of the tunnel floor (along its body), allowing equipment and personnel to work safely beside and over it. The calculated productivity gains are very substantial (more likely to be greater than 50% than not).

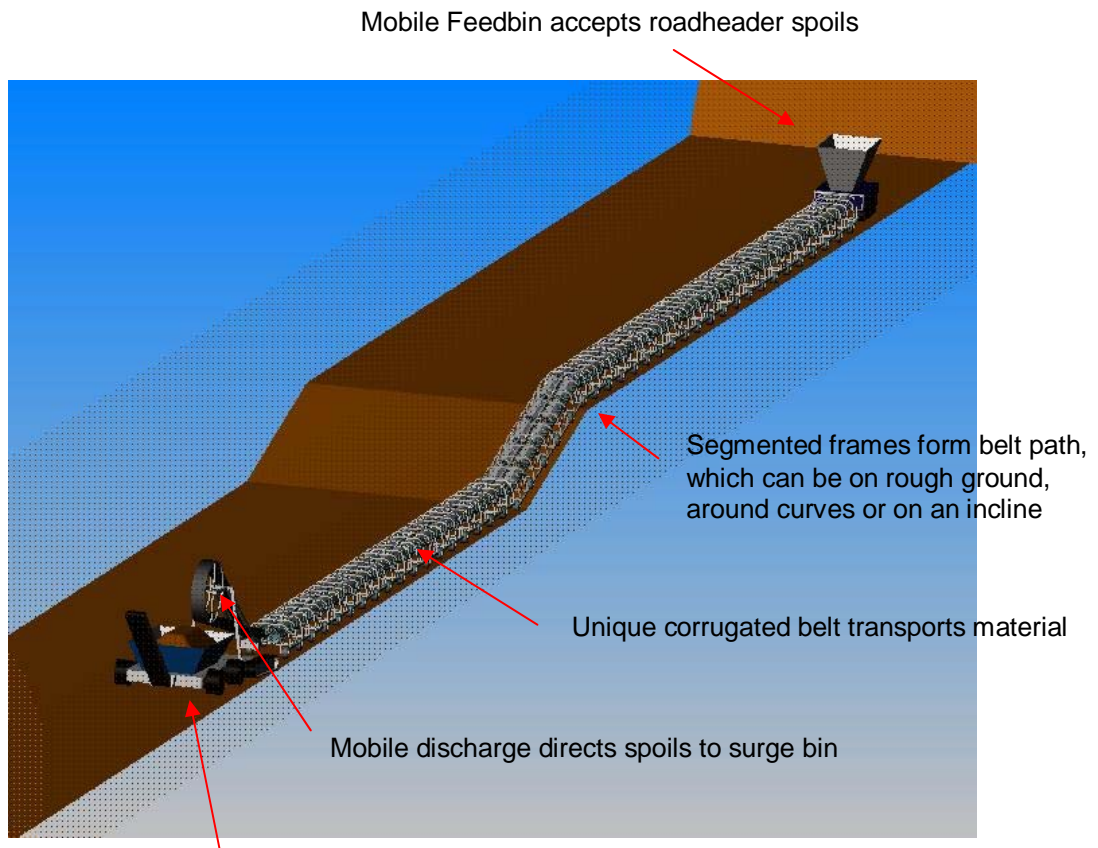
The basic process

The Shortbridge conveys the material in a unique corrugated belt patented that forms a continuous loop. In its normal operating position the belt adopts a closed shape in the cross section, in effect hugging and enclosing the spoils for the length of their journey. The material enters the belt through a feeder module that accepts the spoils directly from the roadheader and feeds them into the belt so as to fill it to just below its apex, resulting in a highly efficient volumetric use. The entire system is able to move while operating, enabling a continual coordination with the roadheader.

At the other end the material is discharged by passing the belt over a vertical loop. The unique corrugations inherent within the structure of the belt itself allow the belt to change direction in the horizontal and the vertical planes and to open at the discharge. Depending on the dimensions of the tunnel, the material can be either directed into a surge bin, from which the trucks can be loaded, or deposited on the floor of the tunnel from where a front end loader can load the trucks.

The belt is typically driven by two drive stations that impart their energy by mating with its edge section. This alleviates the need for the belt to be in high tension (as would be the case with a conventional conveyor) . Consequently, the system is "loose", meaning it can accommodate deviation from a straight line and can assume a variety of standing angles along its length, enabling it to cope with uneven floors and rough ground. Additionally, being totally mobile, the system can travel in and out of the tunnel as required, making its introduction to an existing tunnel a low risk proposition, particularly as in its basic configuration the Shortbridge does not require appreciable changes to equipment or methods.

Diagram 3: The operating logic of the Shortbridge



Surge bin with transfer conveyor fills trucks

Diagram depicting the basic components of the Shortbridge and how they combine in operation. The modularity of the system means that the length is discretionary. In other words, the system can be as long or longer than the tunnel if so required. The shorter length has the specific objective of alleviating traffic conflicts without requiring any equipment or operational changes, thus minimising the risk of introducing a system into an existing tunnel. The transfer conveyor is discretionary, its task being able to be performed by a front end loader if that is preferred.

The Basic Architecture of Tunnel Economics

Classes of benefits

The ICS Shortbridge offers two basic types of benefits. The first of these is productivity improvement, meaning an increase in the metres of tunnel produced each shift. The second category is composed of qualitative benefits, namely those that are important but not easily reducible to numbers. These include enhanced safety, operational convenience, environmental performance and other aspects that are likely to improve industrial and commercial politics. The associated diagram deals with the first of these categories of benefits, while the second category is addressed in a later section of this document.

Principal measure of tunnel economics

The principal measure of tunnel economics, in this document, is the cost per Tunnel Metre Advanced (TMA). This is derived by dividing the production per calendar day (taking into account non-productive days) into the overall daily costs. The latter is composed of fixed and variable costs, but for the sake of clarity this is not overtly expressed in the diagram. The reason is that the illustration was composed specifically as a preparation for illustrating how the Shortbridge exerts its influence on tunnelling performance, with the result that there is more emphasis on the production drivers than there is on cost.

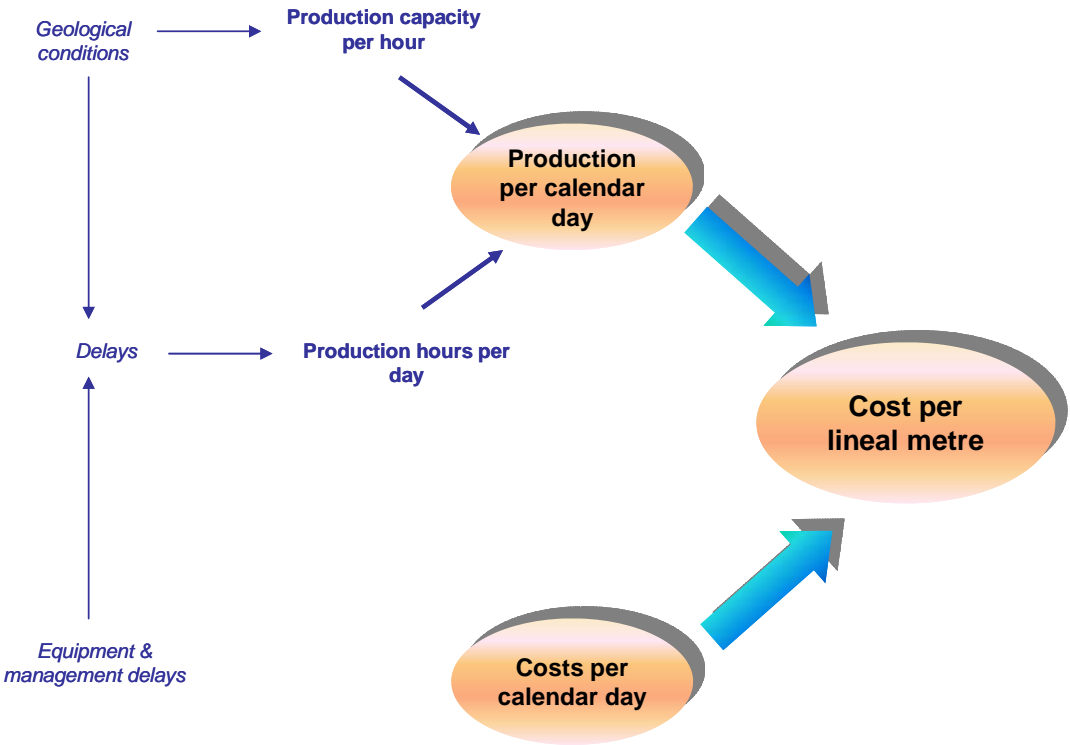
Two main drivers

Daily production (measured in TMA) is a function of the hourly production capacity and the production hours per calendar day. The former is largely determined by the particular roadheader in use and the geological conditions it faces. The latter, production hours, is the result of subtracting the time lost by delays from the standard shift hours. Of these two main drivers, it is production hours that is of particular interest by virtue of its direct dependence on delays.

Connection to economics

Delays have a multitude of causes, which we have gathered into three broad categories. The first of these is geological delays, meaning those caused by troublesome geological conditions. The second category of interruption is known as management delays, which includes a wide range of sources, such as industrial action, financial constraints, and supply issues. The third category is composed of equipment delays. Machinery breakdown is a classic example of this category. However, it is another constituent of this category that is of most interest to us, because it represents that point of tunnel economics where the Shortbridge exerts its most direct advantage. That element is traffic conflict, which is dealt with in the pages that follow.

Diagram 4: The basic architecture of tunnelling economics



The depiction of tunnelling economics is not intended as a comprehensive representation. The emphasis is on production hours, as this is the point at which the Shortbridge exerts its influence.

The Shortbridge Influence on Productivity

The previous section dealt with the basic architecture of tunnelling economics, with particular emphasis on how the functional capabilities of the Shortbridge intersect with the economics of tunnelling. The key point of intersection is at that category known as traffic delays, which is a component of the more general class of equipment delays.

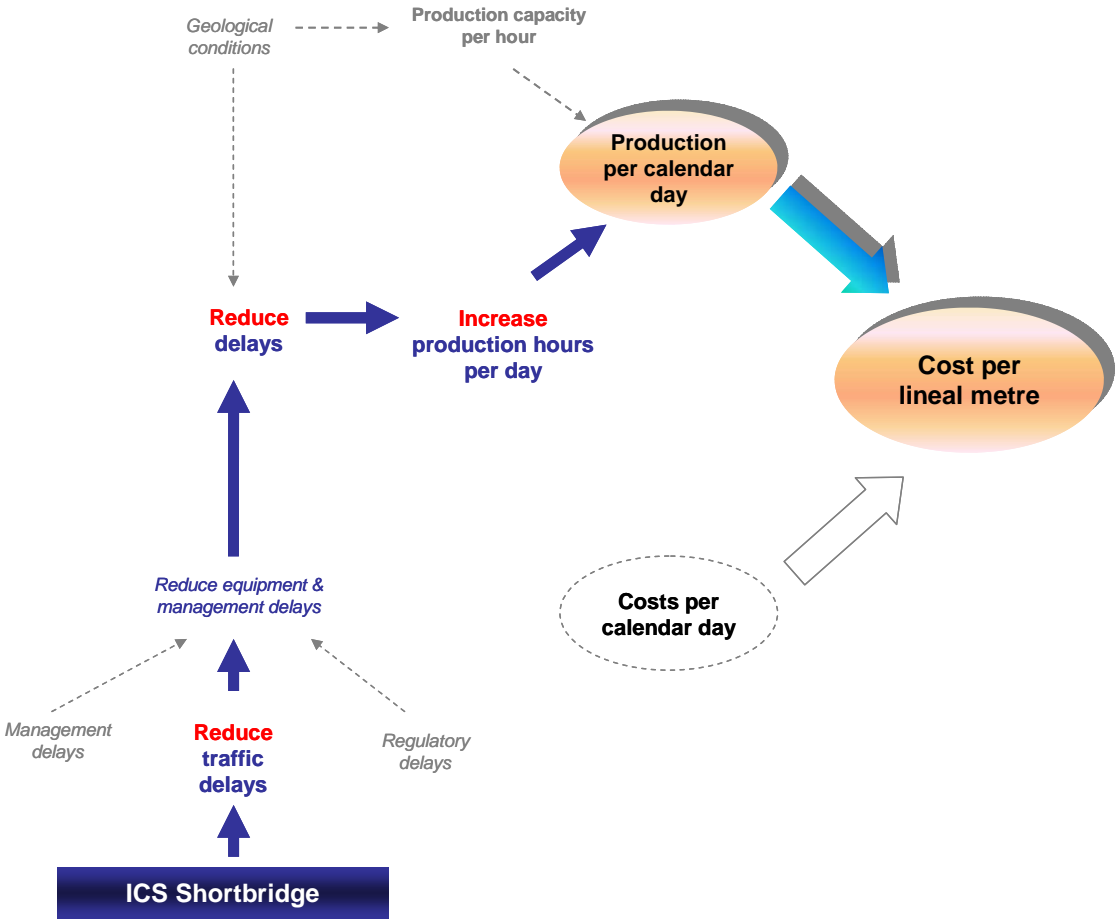
The line of logic begins with the proposition that the Shortbridge alleviates conflict between trucks and support equipment. It achieves this by unobtrusively evacuating the roadheader spoils to a distant point (the length being discretionary) at which the trucks can be loaded, leaving the intermediate zone free for other equipment. This has the direct effect of reducing traffic delays, leading to the second main link in the chain of reasoning. This is, that a reduction in traffic delays results in increased production hours, by which is meant the time that the roadheader is actually advancing the tunnel. The third stage of the logic then rests on the conclusion that increased operating hours calculate to higher productivity, which, for a given set of costs, translates into better economics. The modest investment capital represented by the Shortbridge, and its low operating cost, ensure that the net economic gains resulting from its application are largely preserved.

The line of logic is necessarily based on an idealised set of assumptions, which remove those aspects that are more a function of the practicalities of tunnelling rather than its fundamentals. These do not lend themselves to general quantification. That is, the economic calculations described in this section refer to the general characteristics of tunnelling with a roadheader and trucks. The conclusion that a reduction in traffic delays leads to an increase in productivity is a robust one, certainly to the degree that a general view will allow.

Whether the specific characteristics of a particular tunnel are favourable to capitalising on this increased production capability is something to be assessed on a case by case basis. However, field research conducted by the company indicates that in most cases where the potential specific advantage is combated by general project constraints it is because the supposed inevitability of traffic delays has been programmed into the project plan.

Our investigations indicate that the majority of roadheader/truck tunnels stand to benefit from an application of the Shortbridge. Where the critical variation occurs is the degree to which the project plan would require modification.

Diagram 5: Shortbridge influence on cost per TMA



The Shortbridge is designed to reduce traffic delays, which has the effect of increasing productive hours per day and therefore reduces the cost per TMA (Tunnel Metres Advanced).

Traffic Delays

The comments in the preceding pages explain how the Shortbridge creates productivity advantages through reducing traffic delays. This current section draws attention to the two categories of delay identified by ICS as a result of theoretical and field investigations.

Modelling necessitates categories

ICS has composed a computer model to deliver insights into the key productivity implications of the Shortbridge. This has necessitated the creation of two categories of traffic delay: the full-block delay and the half-block delay. Each of these represents an idealised scenario of the spatial relationship between the trucks used to evacuate the spoils and the equipment used to install support elements such as rockbolts, mesh and shotcrete.

Full-block delay

A full block traffic delay refers to a situation where the trucks and support equipment exclude each other from the un-completed section of the tunnel. That is, when the trucks are carting spoils away from the roadheader, the support equipment cannot work on the un-completed zone. Equally, when the support equipment is attending to its tasks the trucks cannot reach the roadheader. In such a situation the roadheader will be required to pause when it has accumulated its maximum allowable stock pile in front of the machine.

Half-block delay

A half-block traffic delay deals with the situation where the trucks and support equipment can theoretically work simultaneously. In other words, the tunnel is wide enough for trucks to pass by the support equipment while it is working. However, this dramatically elevates the degree of hazard represented by the zone of overlap. In terms of its effect on productivity, this delay is different from that of the full-block situation. The principal reason for this is that each support activity makes a partial contribution to the delay (while in the full-block scenario it is the support activity of longest duration which determines the extent of the delay).

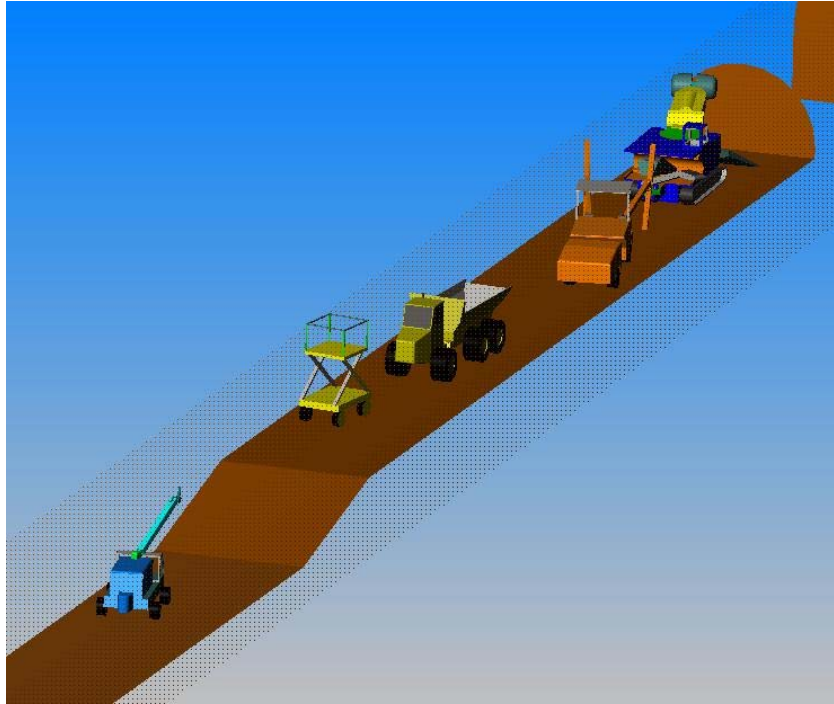
Spectrum of widths

The two delay categories cover the practical spectrum of traffic delays. Full block delays tend to be associated with the smaller diameter tunnel, while half block delays are more prevalent in the larger tunnels. For tunnels at either end of the spectrum the type of traffic delay involved is normally fairly clear. However, the mid range of the spectrum presents cases where the situation is not so clear. For instance, the tunnel may be sufficiently wide to theoretically enable trucks to carefully squeeze their way past the support equipment, but management may decide (perhaps for safety reasons) to treat the situation as a full block.

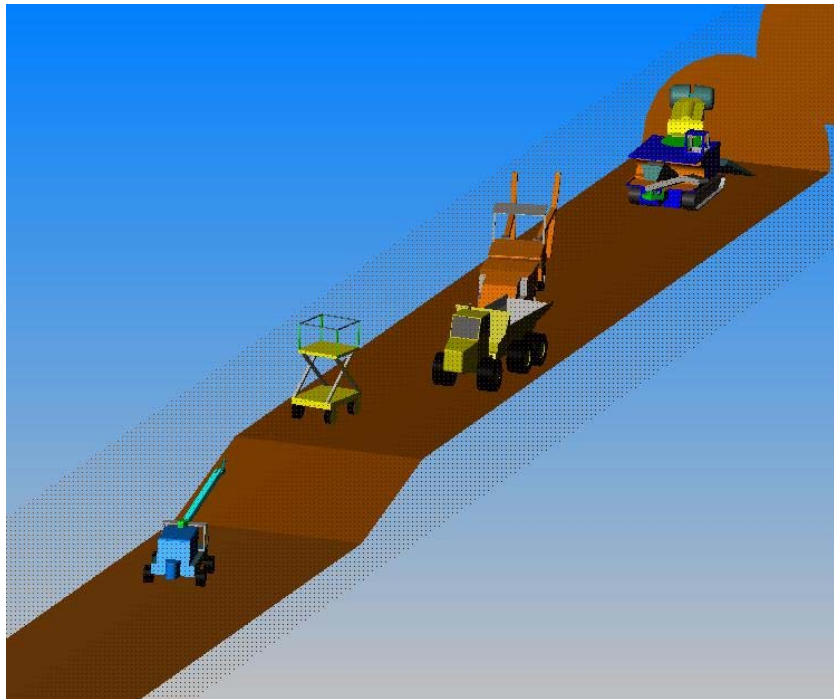
Another example would be that of a tunnel that changes structure at different phases. For example, it may begin as two narrow parallel tunnels but at a later stage be transformed into one large tunnel upon removal of the middle pillar. Therefore, it would alternate between full block and half block scenarios.

Clearly, the two categories of traffic delay are sufficiently comprehensive in their coverage of possible situations to be highly useful in understanding the connection between traffic delays and productivity. This is the province of the computer model, which is explained in the following diagram.

Diagram 6: Traffic delays



The full-block scenario, whereby the tunnel width does not allow the trucks to pass by the support equipment.



The half-block scenario whereby trucks can proceed past the support equipment, but with intermittent delays and a general slowing down.

Reference Calculations

Need for a model

The ICS Shortbridge offers a range of benefits for the tunnel contractor, including productivity advantages, safety enhancements, and operational flexibility. The main focus of attention in this information document is on the first of these, although the other benefits are described briefly towards the end of the document. The emphasis on productivity (and, by extension, economic benefits) raises the need for determining the extent of this advantage. That is, a productivity advantage implies a comparison between two scenarios: a before and an after (application of the Shortbridge). For this reason the Company developed a computer model of the tunnelling process.

Logic of the model

The model is constructed in the software program known as "Analytica", a product of Lumina Decision Systems. Despite its modest objectives the model contains a large number of variables with multiple relationships. However, its logic is relatively simple. The primary variable is roadheader productivity (in BCM per hour). This is expressed as a range of values beginning at 25 BCM per hour and rising to 85 BCM per hour in increments of 15. The reason for expressing the key variable as a range is that it encompasses most roadheader productivity scenarios. This productivity capacity translates to tunnel metres advanced per hour (TMA per hour), clearly a function of the tunnel dimensions. This further converted to metres advanced per shift by multiplying the TMA per hour by the productive hours per shift. These are simply the standard shift hours less production time lost to delays. The assumption is that the roadheader cannot continue without being serviced by the trucks, except to the extent that a buffer stockpile at its front apron allows it to continue attacking the face for a limited time.

Reference assumptions

The associated diagram is an excerpt from the Analytica module showing the key assumptions on which the reference conclusions (appearing in the pages to follow) are based. Standard shift hours amount to 10 per calendar day. The tunnel width is set at 9 metres and the height at 7 metres. For the basic calculations, non-traffic delays are set at nil. A number of operational assumptions follow; rockbolts are required to service 1.2 square metres, the roadheader spoils buffer stockpile is set to 5 BCM and shotcrete average thickness is set at 50 mm. Shotcrete batch length refers to the metres of tunnel typically serviced in one shotcrete episode, while the ventilation batch length refers to the length intervals at which new ventilation infrastructure is installed.

The three variables referring to coverage nominate the fraction of wall area attended to by the respective support element. By wall area we mean the sides of the tunnel and the roof. The latter is assumed to be fully serviced with rockbolts, mesh and shotcrete. The coverage variables offer the choice of nominating the proportion of wall area to be serviced.

The time taken for the three elements of rockbolting is nominated in minutes, the rate at which mesh can be installed is presented in square metres per hour, and the rate of shotcrete application (after setup) is nominated in cubic metres of shotcrete per hour.

Basis for reference calculations

These assumptions, fed into the model, produce the results described in the pages to follow.

Diagram 7: Key reference assumptions for productivity calculations

ICS SHORTBRIDGE MODEL: MAIN ASSUMPTION SCHEDULE			
Standard shift hours	10	Rockbolt wall coverage	0.6
Tunnel width	9	Mesh coverage	0.7
Tunnel height	7	Shotcrete coverage	0.7
Ground delays	0	Rockbolt drill setup time	0.5
Regulatory delays	0	Rockbolt drill penetration time	1.5
Management delays	0	Rockbolt grouting time	2.5
Square metres per rockbolt	1.2		
Roadheader spoils buffer	5		
Shotcrete batch length	5		
Shotcrete thickness	0.05	Meshing capacity per hour	9
Ventilation batch length	10	Shotcreting capacity per hour	7

The above is an extract from the ICS Shortbridge Productivity Model composed in Analytica. The assumptions produce what is known in this document as the reference case. The physical and economic characteristics of tunnels vary widely, and the effect of the Shortbridge varies along with them. Therefore, for the sake of clarity, a single scenario is employed (the reference case) to illustrate the broad effects of the Shortbridge.

Calculation Logic - Full Block

The reason for including an explanation of the calculation method in this information document is to support the claims (of potential advantage) with a transparent line of reasoning. This not only provides an insight into how the impact of the Shortbridge may be quantified, but also what assumptions have had to be made to balance the two primary requirements of the computer model: first that it represent tunnelling sufficiently well for the conclusions to be credible, and, second, that the model be simple enough to be workable.

Key assumptions

The calculation of advantage in the full block scenario begins with the assumption that each of the primary support activities individually represents a full-block situation. A consequent assumption is that the primary support activities will be conducted simultaneously whenever practicable, on the basis that this will minimise the extent of the interruption to the trucks. From these two assumptions is drawn the conclusion that the duration of a full-block delay is approximately equal to the duration of the longest task activity.

Calculation method

The task duration for each of the three primary support activities (rockbolting, meshing and shotcreting) is calculated in the following manner. First, the dimensions of the tunnel are used to determine how many surface metres of tunnel wall area are involved in each TMA (Tunnel Metre Advanced). Secondly, a coverage rate is nominated. That is, an estimate is made of the percentage of that wall area that requires that support element. For instance, in the reference scenario only 60% of the wall area is deemed to need rockbolting. Thirdly, the quantity of that support element applicable to each square metre of supported wall area is nominated. For example, the reference case assumes that each rockbolt must service 1.2 square metres of wall area. Fourthly, the rate at which that support activity is performed is nominated, and the time taken for that support activity per TMA is calculated. As a hypothetical illustration, if there are 19 rockbolts per TMA and each rockbolt takes a total of 3 minutes, then rockbolting time for each TMA is 57 minutes. In the cases of shotcreting, a setup time is estimated and is applied to a batch length, meaning that length of tunnel typically serviced in one shotcreting episode. The corresponding time per TMA is then added to the pure production time. The final step is to identify the support task that occupies the most time per TMA and nominate it as the delay duration.

The link with productivity improvement

The total cycle time for a TMA is the production time plus this longest task duration. From this can be calculated the percentage of total time represented by the delay. It is this percentage that can be nullified by the application of the Shortbridge, resulting in a corresponding productivity improvement.

Productivity Advantage: Full-block

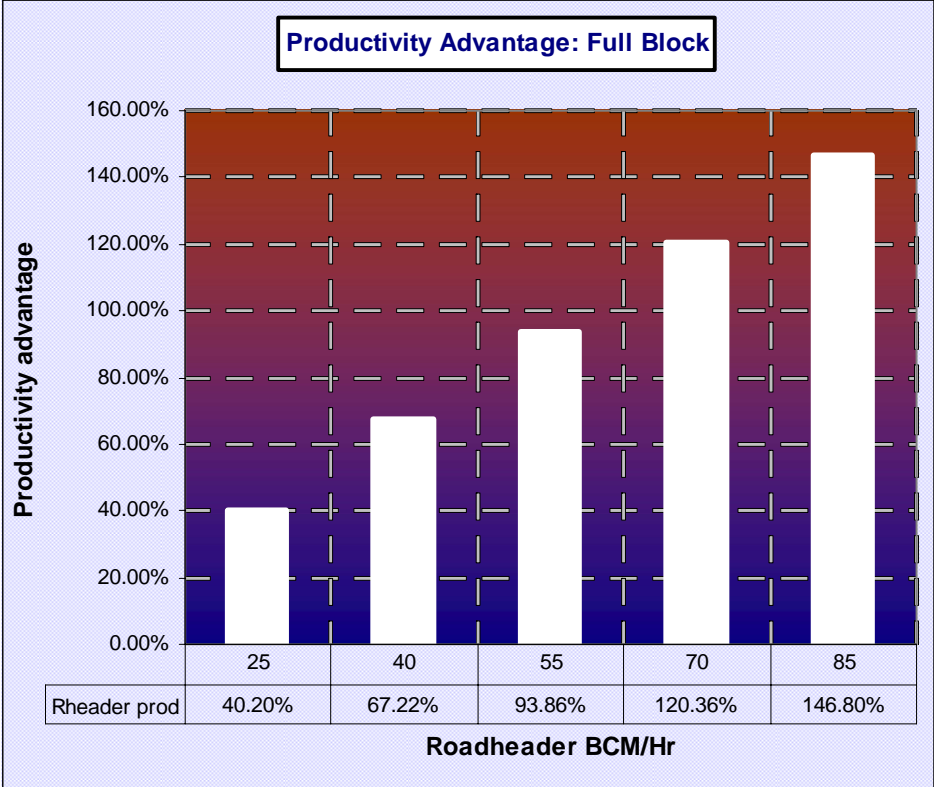
The core proposition underwriting the Shortbridge is that it can significantly increase tunnelling productivity by alleviating traffic conflict. A related proposition, at least equal in importance, is that the system can also deliver benefits in safety and operational flexibility. This section deals with the first of these propositions.

The assertion of productivity improvement is based on output from the computer model, which is supported by field observations. Productivity advantage is calculated by dividing the conventional productivity into the enhanced productivity, converting to a percentage, and then subtracting 100%. The parameters of any specific tunnel vary markedly over time, sometimes from day to day, defying single point calculations. A large number of scenarios based on different assumption sets were run through the model. The results lead to three broad conclusions.

1. The higher the production rate of the roadheader (in BCM per hour) the greater the advantage offered by the Shortbridge, all else being equal.
2. The smaller the cross-section of the tunnel (driven by a roadheader) the greater the advantage to be had, all else being equal.
3. The longer the duration of the longest support activity, the greater the advantage represented by the Shortbridge, all else being equal.

As an indication, the productivity advantage possible for the Shortbridge under the assumptions outlined in the previous section ranges from 40% to 140%. The range of values is due to the range of roadheader productivity assumptions (from 25 to 85 BCM per hour). It must be remembered that these calculations do not include the qualitative benefits possible from the Shortbridge, which are dealt with in the next section. For instance, the added safety offered by the Shortbridge does not find expression in the computer model, but carries a substantial real value to all those involved.

Diagram 8: Charts of full-block productivity advantage



Productivity advantage corresponding to possible roadheader production capacity (in BCM/Hr)

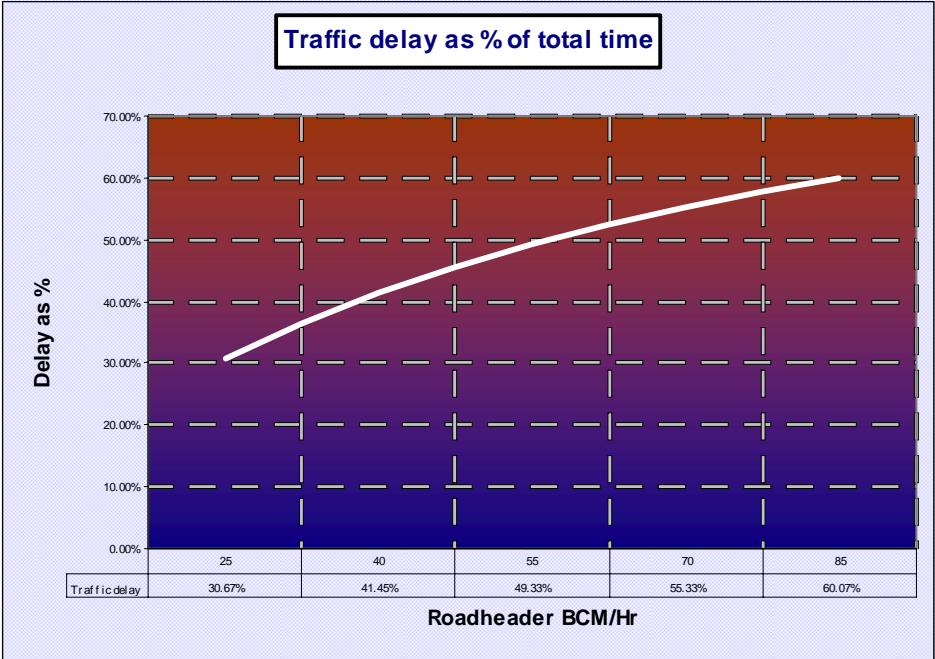


Chart showing how the duration of traffic delay increases with higher roadheader production.

Qualitative Benefits

The ICS Shortbridge offers the possibility of significant productivity improvements in tunnelling with a roadheader. That is known as its quantitative benefit. However, it also represents some qualitative advantages that are not so easily quantifiable, but are critical nonetheless. These include safety, operational flexibility and low risk.

Safety

A truck may theoretically be able to squeeze past the support equipment, but its motion is adverse to safety. An equipment operator may accidentally step or fall into its path, a part of the equipment may make contact with the truck as the operator manoeuvres into a difficult position, and so on.

By contrast, the Shortbridge not only offers a small footprint, but also less risk of contact and less impact if contact does accidentally occur. The system remains stationary during operation (though it can move while operating if desired) and the moving belt (which travels relatively slowly) is covered, minimising any dangers that may have eventuated from equipment working in close proximity.

Operational flexibility

The Shortbridge is designed to transport the spoils to a point past the support equipment, where the trucks can be safely loaded without having to contest for right of way in the un-completed zone. The consequence of this is that the support activities have the freedom to operate simultaneously with the roadheader. In most cases the latter has the longer cycle time, meaning that the support equipment is relieved of the pressure of minimising its time. Therefore, management has greater discretion in the placement and utilisation of the support equipment, and more time is available to attend to quality and safety.

Furthermore, there is no need for the support equipment to vacate the work area upon completion of their tasks. This further improves productivity through dispensing with the time and trouble associated with the relocations normally required.

Low risk

The Shortbridge complements existing equipment. Its primary effect is to help that equipment operate more effectively and efficiently. Therefore, it does not require any changes to the equipment being used in the tunnel. Similarly, the system fits in with existing practices, whatever their specific form may be in the respective tunnel. The Shortbridge is totally mobile (though its frame sections can be designed to be fixed or suspended as desired) and can be introduced into an existing tunnel simply driving it into position. If for some reason it must be removed from the tunnel then that becomes a simple exercise of driving the system out.

Additionally, in relation to other tunnelling equipment the Shortbridge represents a modest capital investment. ICS also offers the facility for customers to rent systems before making the purchase commitment. These factors contribute to qualifying the Shortbridge as a low risk equipment proposition.

Practical Observations

Personnel and light vehicle activity

There is often considerable activity in the vicinity of the roadheader. Tasks relating to supervision, observation and servicing continually draw personnel to that area. Light vehicles also infringe on the roadheader zone as they collect and deposit personnel.

Despite comprehensive practices designed to maximise the visibility of any entrant to the tunnel, the task of negotiating a truck through this population of people and vehicles adds considerably to driver stress. The intricate task of positioning the truck under the discharge conveyor demands a high level of concentration, which is disturbed by the attention required to account for nearby activity.

The Shortbridge system can reduce this stress. It locates truck loading activity well away from the roadheader. The bulk of personnel activity (and consequently of light vehicle activity) is normally at the working face or in the unsupported area. Therefore, the Shortbridge removes most of the interaction that would normally occur between the trucks and these other entrants.

Rough floor

Even in cases where the roadheader is well operated to produce a good floor line, the tunnel floor is still subject to degradation. A rough floor increase the hazard level in a tunnel. It also produces additional wear and tear on the trucks.

The Shortbridge can help to avoid this. It transfers truck activity to a point behind the roadheader by evacuating the material unobtrusively in the unique, small-width, flexible belt to the desired loading point. Therefore, the intermediate zone is left free for other equipment to work in without interrupting the flow of production. This provides more time and space for the floor to be properly maintained. Undulations can be filled and compacted to prevent unwanted pools (as noted above). Additionally, the floor can be engineered to channel water into draw points that are constructed without the pressure experienced in a typical tunnelling situation.

Summary

The two issues mentioned above are not merely cosmetic. They have a great deal of bearing on worker stress and morale. Therefore, they have an indirect, but important, influence on productivity. However, the most important benefit of reducing the problems mentioned above is the significant improvement in safety.

Diagram 9: Qualitative advantages



Remote Control Possibilities

The regulatory requirements

One of the principal safety hazards in tunnelling is represented by those sections of tunnel that are unsupported. Consequently, there are strict regulations in relation to the length of such sections. These vary between jurisdictions, but generally only to a minor degree.

The operational consequence

The length of unsupported tunnel permitted is most commonly less than the length of the roadheader. Sometimes this can be addressed by rockbolting the roof area immediately above the roadheader utilising the optional rockbolting attachment. However, this is not always feasible and does not always satisfy the safety criteria.

Consequently, in many instances the safety requirements necessitate that the roadheader exit from the working face to allow rockbolting or cable bolting equipment to stabilize the unsupported area. This imposes heavy productivity penalties by reducing the time that the roadheader is able to spend at the face.

A possible solution

Roadheaders lend themselves to remote control operation, whereby the operator may be located some distance from the machine. The Shortbridge also lends itself well to remote control operation, the key task simply being to ensure that the feedbin coordinates with the discharge conveyor of the roadheader. This is well within the capabilities of the Shortbridge, which can move while operating without interrupting the flow of material.

Of particular interest is the circumstance where the general geology presents as being strong and stable. In such cases, general experience would suggest that the geology would withstand an unsupported length considerably greater than that dictated by safety regulations. However, in the absence of certainty it is the regulations that must dictate what is permissible.

In such a circumstance, there may be merit in operating the roadheader and the Shortbridge remotely. The operators could be located in a custom vehicle equipped with the respective control and monitoring equipment. This vehicle can be positioned in an area that has been bolted and shotcreted, normally within 20 or 30 metres of the face. There is no conflict with the trucks, which are loaded well behind at the point where the Shortbridge terminates. The roadheader and the Shortbridge operate un-manned in the unsupported zone. In this way the strong geology may be exploited while complying with the regulations.

Summary

The ICS Shortbridge is designed to convey spoils from the roadheader in a tunnel unobtrusively past the support equipment. In doing so it reduces the delays caused by the conflict between the trucks and the support equipment, resulting in substantial increases in productivity.

The system is based on a new but tested technology known as the Innovative Conveying System (ICS). This technology can be applied to a wide range of bulk materials handling applications, but the current products are focused on those tasks involving particles up to 250 mm. The ICS has demonstrated impressive capabilities during testing, including high angle conveying, complex path capability (involving a series of tight curves), and full mobility while operating. Additionally it enables the swift and simple replacement of belt sections and other components.

The Shortbridge uses the same elements that enable such capabilities, but its typical duties mean that there is only a moderate call on the overall capabilities of the technology itself. This minimises technical risk.

A productivity model of the Shortbridge has been carefully composed by ICS to calculate the range of productivity benefits. The results in the reference case show very substantial productivity improvement capability, as high as 140% in cases where the roadheader is able to produce at high rates (and where the tunnel represents what is known in this document as a full-bridge scenario).

The Shortbridge also offers other advantages that do not lend themselves as easily to quantification as does productivity. These include safety, operational flexibility and low risk. The latter refers to the fact that the Shortbridge complements existing equipment, can be introduced to or exited from the tunnel swiftly and easily, and represents a modest capital investment (particularly in light of the option to rent units while evaluating their suitability).

Additionally, the Shortbridge lends itself well to remote control operation. Used in combination with a remote control roadheader, this can significantly improve safety and production by removing operators from the hazardous unsupported zone and facilitating continuous production and roof support.

While each tunnel represents its own unique challenges, the capabilities of the ICS Shortbridge are such that it offers advantages in most situations. It's combination of operational capabilities, economic advantages and low-risk purchase qualify it as an attractive proposition for those in the tunnelling industry.