Dynamic Analysis Conveyor Design Software

Helix delta-T Dynamics Version 5 Sample Calculation Reports

Muja 6.1km Conveyor Dynamic Analysis Calculation Reports

Prepared for:

To whom it may concern

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<u>Dynamic Analysis of long conveyors using the Helix delta-T software.</u>

Case study Muja 6.1 km long Conveyor, Western Australia

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Introduction

The Muja P2 conveyor, located near the Muja power Station near Collie in Western Australia was built in 1997 and commissioned in 1998. During the commissioning process, extensive testing and field measurements were taken by the designers, CDI Inc. and the main contractors, Barclay Mowlem. The results of these field measurements and tests were published in the Bulk Solids Handling journal, Volume 18, No.3 July 1998 on page 415 - Authors G Lodewijks and D Kruse. The results published in this paper give a detailed insight into the behaviour of this particular conveyor under various starting and stopping operations of the conveyor.

Helix Technologies have developed a Conveyor Dynamic Analysis software program module which forms a new module of the well established Helix delta-T Conveyor Design Program. This program is capable of performing detailed flexible body conveyor belt dynamic calculations for predicting Belt Tensions, Belt Velocities and Strains as well as movement of the gravity take-up pulley assembly during the starting and stopping of conveyors.

Objective

The objective of this report is to show the validity of the Helix delta-T Dynamic Analysis Calculations by comparing the output from the program with the detailed site measurements taken on the Muja conveyor.

Muja 6.1 km Conveyor Details

The main features of the Muja P2 Conveyor are:

Length	6100m
Vertical Lift	+/- 14m net lift
Material and Capacity	Coal, density 850 kg/m3, capacity 770 tph
Belt Speed	4.4 m/s
Belt Class	ST 800 N/mm x 800mm wide steel belt
Drives	2 x 315 kW at Head end
Brakes	Disc brake at Tail pulley
Other Features	Large dip in conveyor profile where belt drops -30m after tail and then rises up again +15m

Print Preview

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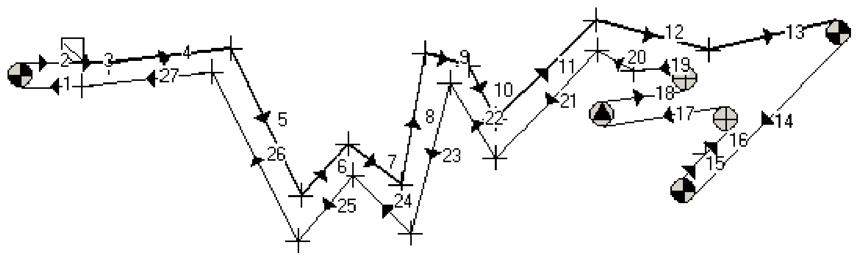
Conveyor Design Summary Report

HELIX TECHNOLOGIES



Conveyed Material			
Material Description	***COAL BITUMINOUS SIZED***		
Low Bulk Density	***850*** kg/m3	High Bulk Density	***850*** kg/m3
Angle of Repose	***35*** deg	Surcharge Angle	***20*** deg
Material Lumpsize	***50*** mm	Uniform / Mixed Material	***Mixed Material***
Conveyer Data			
Conveying Distance	**6,083.16** m	Nett Lift / Lower (-)	**12.5** m
Design Capacity	***770*** tonnes/h	Belt Speed	***4.4*** m/s
Belt Details			
Belt Width Selected	**800** mm	Belt Percentage Full	**82** %
Belt Class Selected	**ST 800**	Top Cover Thickness	**6** mm
Belt Rated Tension	**120** kN/m	Bottom Cover Thickness	**5** mm
Belt Plies	**0**	Belt Mass	**14.28** kg/m
Belt Tensions and Power Calculations ISO			
Effective Tension	**110.56** kN	Belt Power (Te xV)	**486.46** kW
Maximum Tension Tmax	**138.62** kN	Drive Efficiency (Ave)	**94** %
Minimum Tension Tmin	**29.48** kN	Total Absorbed Power	**517.52** kW
Sag Tension **1** %	**20.82** kN	Installed Power	**630.18** kW
Takeup Type	***Horizontal Gravity***	Takeup Mass	***6,142*** kg
Carry and Return Idlers			
Carry Idler Trough Angle	***35*** deg	Return Idler Trough Angle	***10*** deg
Carry Idler Spacing	***2.7*** m	Return Idler Spacing	***5.4*** m
Carry Idler No Rolls x Dia	***3 x 133*** mm	Return Idler No Rolls x Dia	***2 x 152*** mm
Carry Idler Shaft Dia	***27*** mm	Return Idler Shaft Dia	***27*** mm
Carry Idler Brg Life L10h	**88,472** hrs	Return Idler Brg Life L10h	**2,005,561** hrs
Carry Idler Shaft Deflection	**4.63** min	Return Idler Shaft Deflection	**1.7** min
Dynamics and Miscellaneous Data			
Start-up Factor - Fully Loaded	***140*** %	CEMA Temperature Factor Kt	***1***
Start-up Factor - Empty	***140*** %	Total Braking Force	***18.37*** kN
Starting Time - Fully Loaded	**31.08** sec	Stopping Time - Loaded, Braking	**20.38** sec
Starting Time - Empty	**9.17** sec	Stopping Time - Loaded, Coasting	**23.76** sec

Designers Comments:

Dynamic Analysis Test run - Muja Power station conveyor - Bulk Solids Handling

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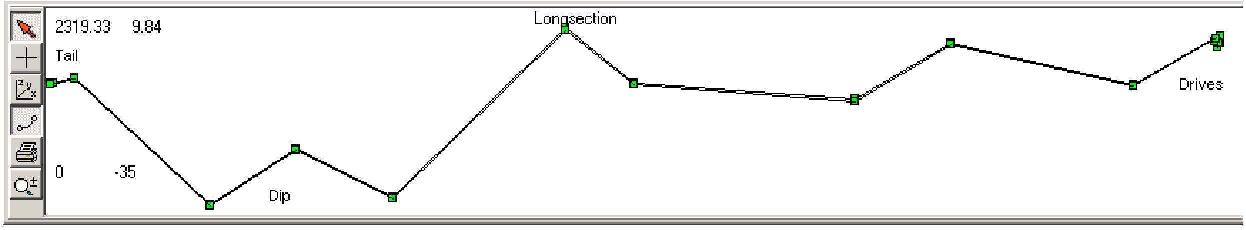
Design Summary Report from Helix delta-T software



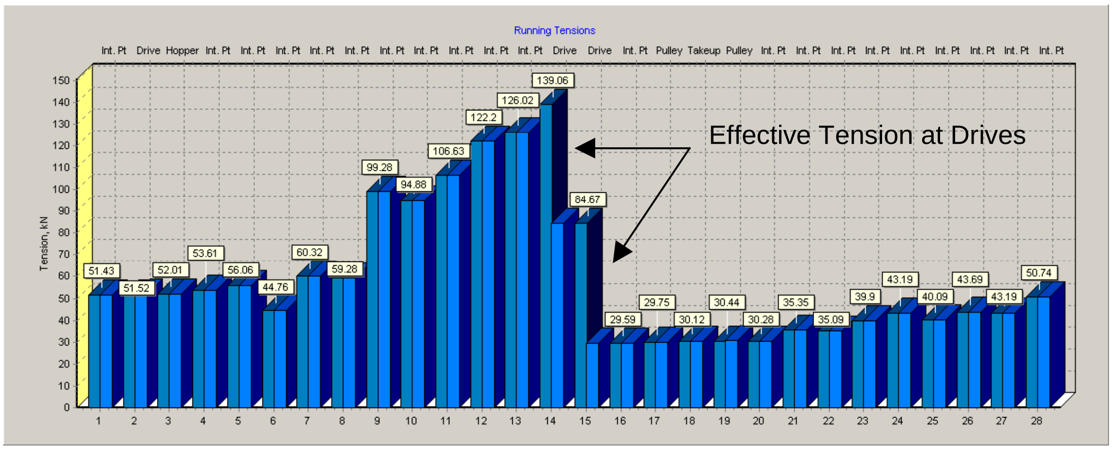
Longsection drawing of Muja Conveyor showing large profile dip after Tail

Static or Rigid Body Design

The initial design calculations for a conveyor using the Helix delta-T software involve building the model of the conveyor using the drag & drop sketching facility, specifying equipment sizes or selecting them from the databases, optimising the drive sizes, inertia's and braking forces etc. This process includes optimisation of the belt class, takeup mass or tension, braking forces, and motor sizes. Also, rationalisation of equipment such as pulleys and shafts, gearboxes, fluid couplings and so on may be completed.

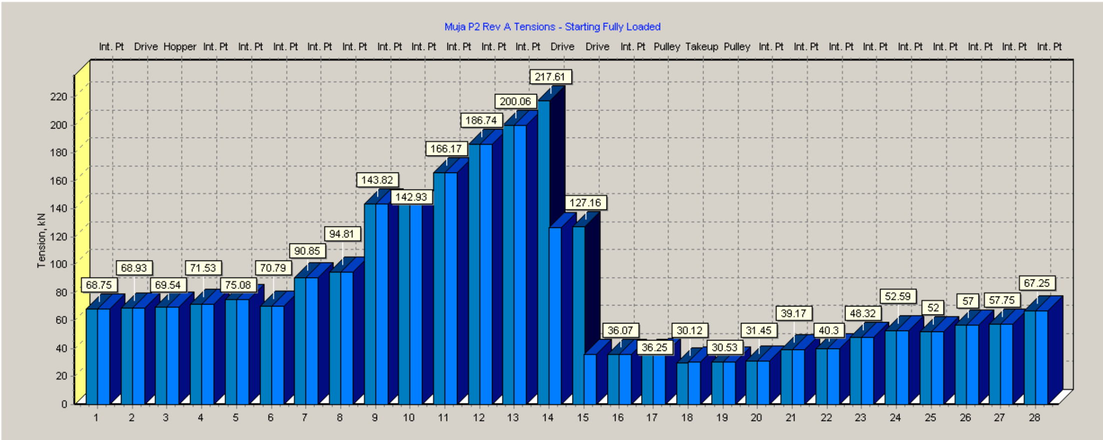
Once the rigid body or Static design calculations have been completed, a set of design reports including belt tension graphs may be obtained. These reports are too numerous to show here, but the ones of most interest are the Belt Tension graphs. These are shown in Bar graph format below in order to display the split between T1 and T2 Driving and Braking tensions present at the drives and Tail brake.

Rigid body calculation - Running full belt tensions

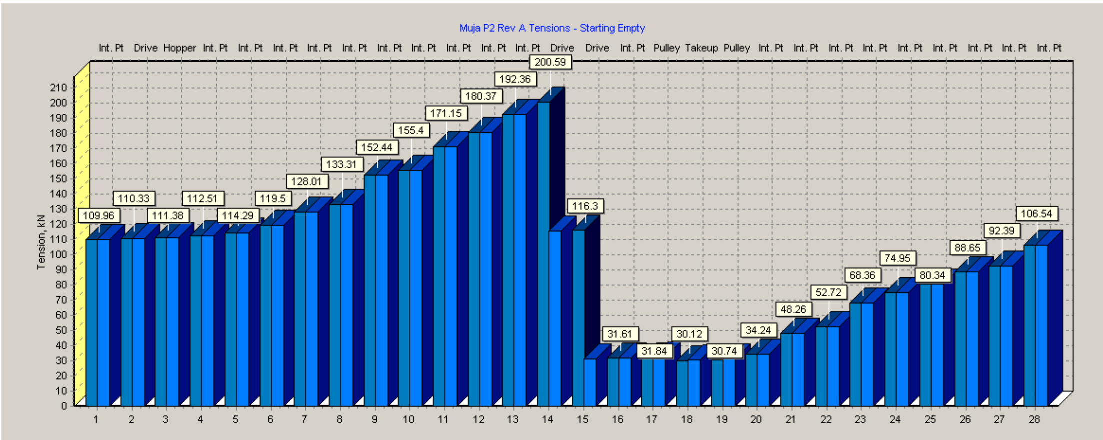


Note split between T1 and T2 tensions at the two drive pulleys

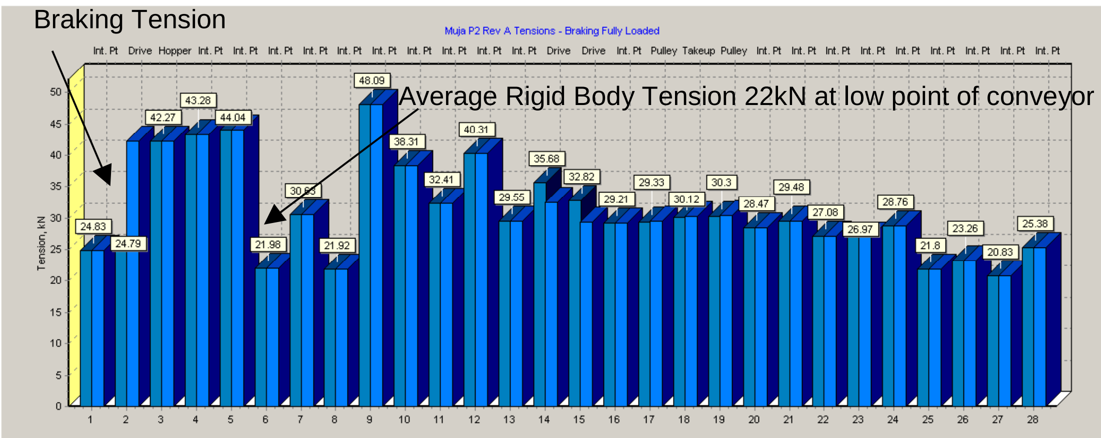
Rigid body calculation - Starting full belt tensions



Rigid body calculation - Starting Empty belt tensions



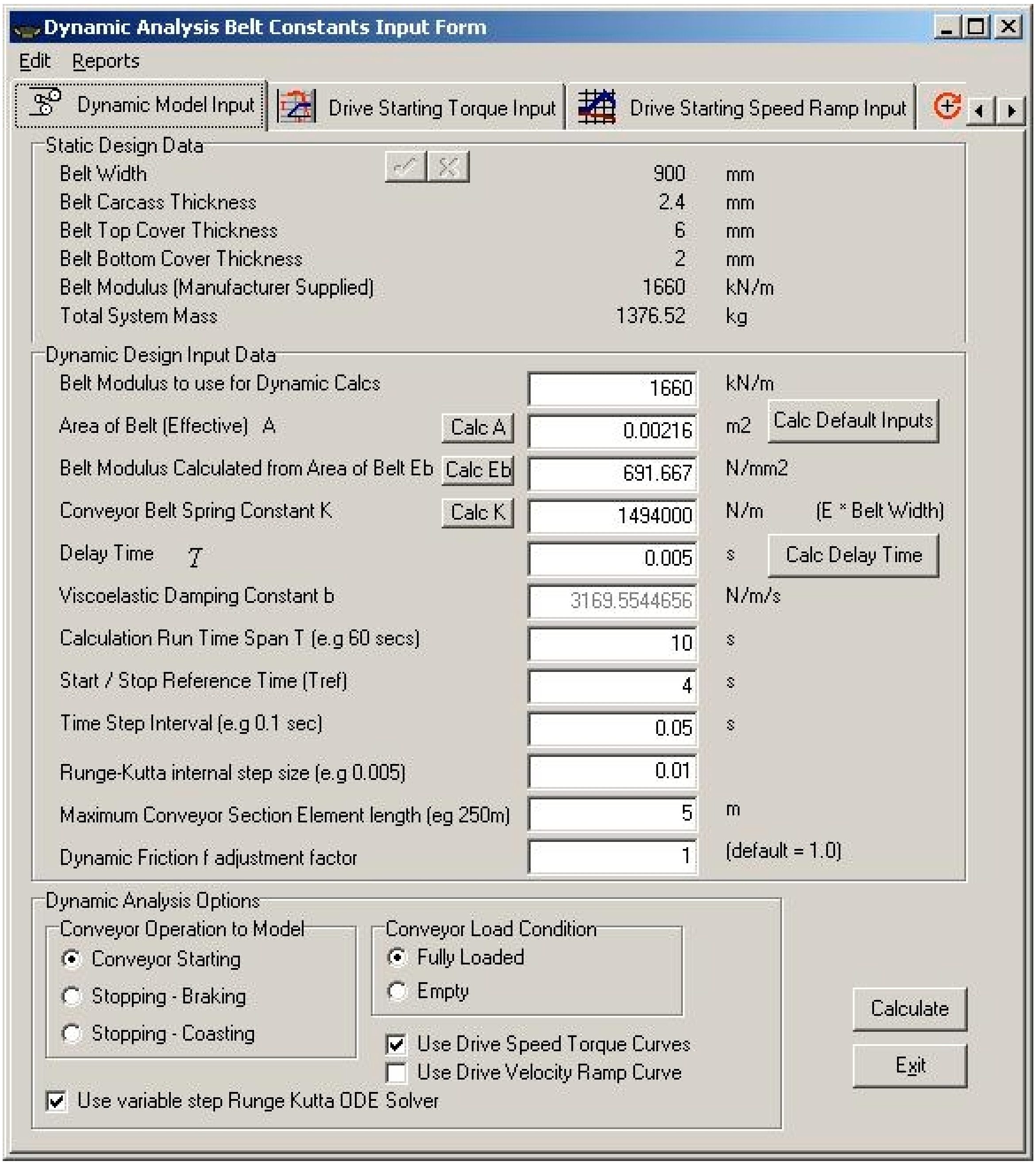
Rigid body calculation - Stopping full belt tensions



Note that the average tension at the low point of the conveyor during an emergency stop is about 22kN. The static calculations do not show up any potential problems at this point.

Dynamic Analysis Calculations

Once the Static or Rigid body calculations have been completed, it is easy to perform the Dynamic Analysis calculations. Only a few additional input values are required as well as the Drive Torque vs Speed relationships for starting must be input.

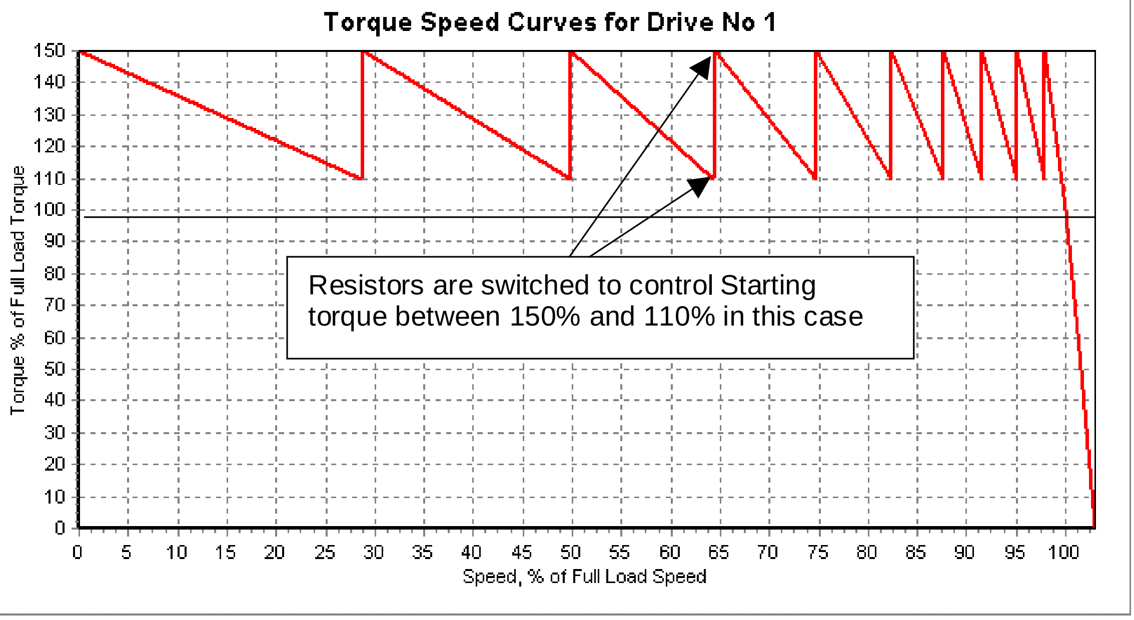


Dynamic Calculation Input form

A sample of the Dynamics Input form shows the input values required. All are readily available values which are either calculated for you by the software, or are simple input values such as the run time for the calculations etc. No specialist knowledge or data is required.

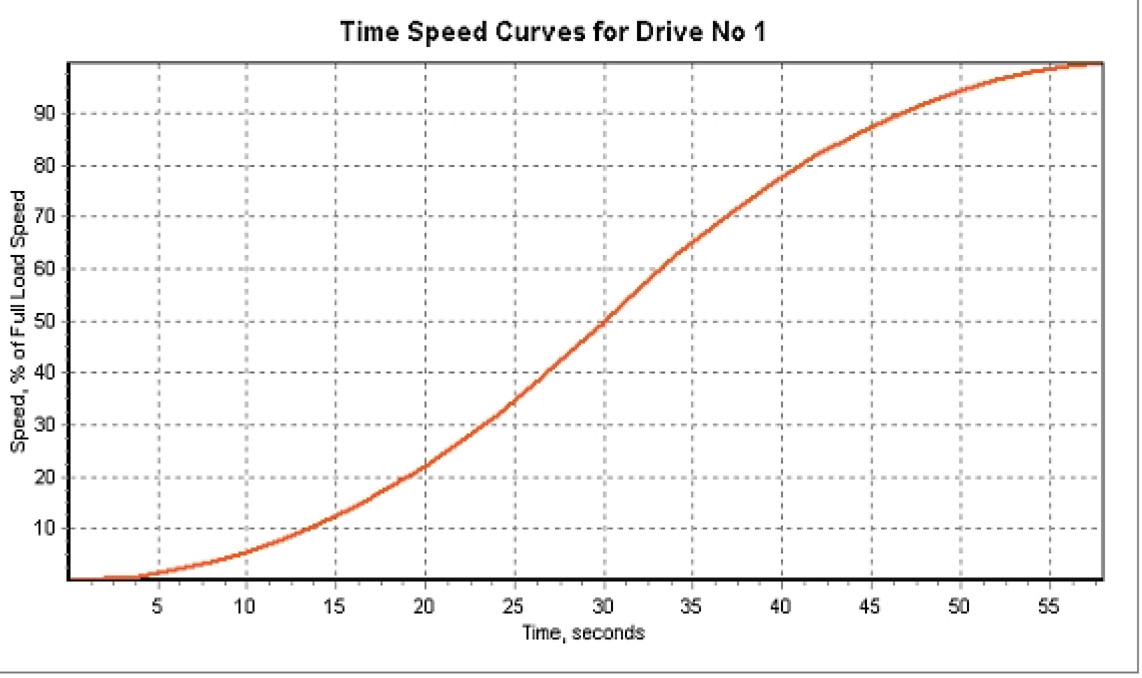
Drive Starting Torque vs Speed Curve input

You can choose to enter a Torque Controlled Drive starting method as shown above or a Time vs Speed Velocity Ramp or S curve as shown below. Both torque or Speed controlled starts can be manipulated to take on any form or shape by the designer, merely by altering the points which form the graphs.



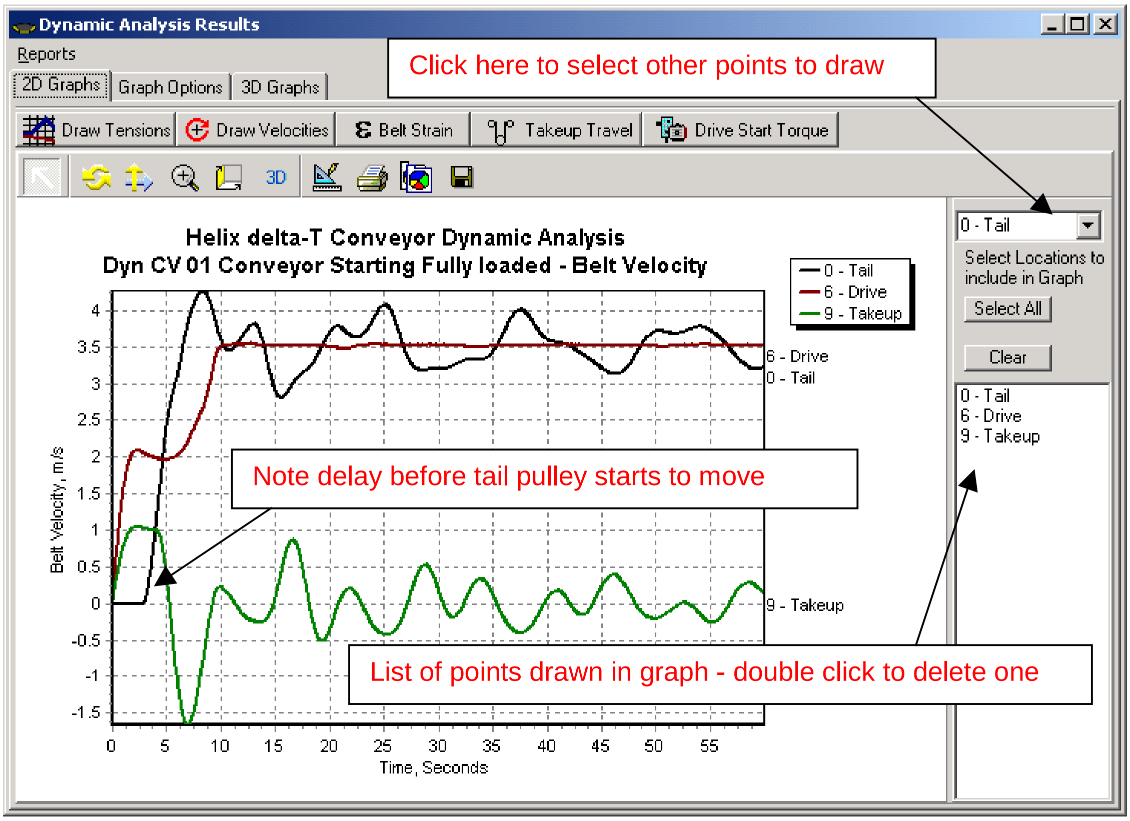
Wound Rotor Motor Torque Speed curve

Example of Wound Rotor Motor Torque Speed curve is shown above and Velocity ramp shown below.



Dynamic Analysis Calculation Results

The Dynamic calculations are performed at the click of a few buttons and then the results may be viewed and printed. The results are presented in the form of 2D and 3D graphs.

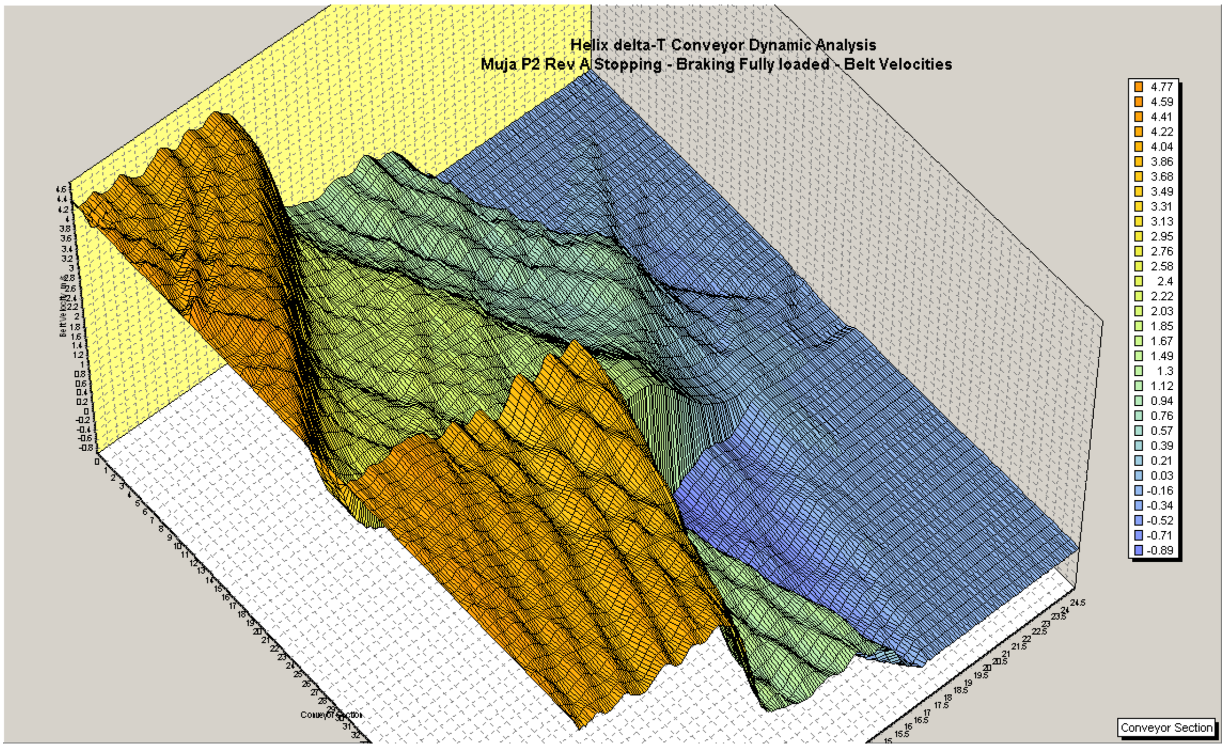


Sample for 2D Belt Velocity Graph shown above

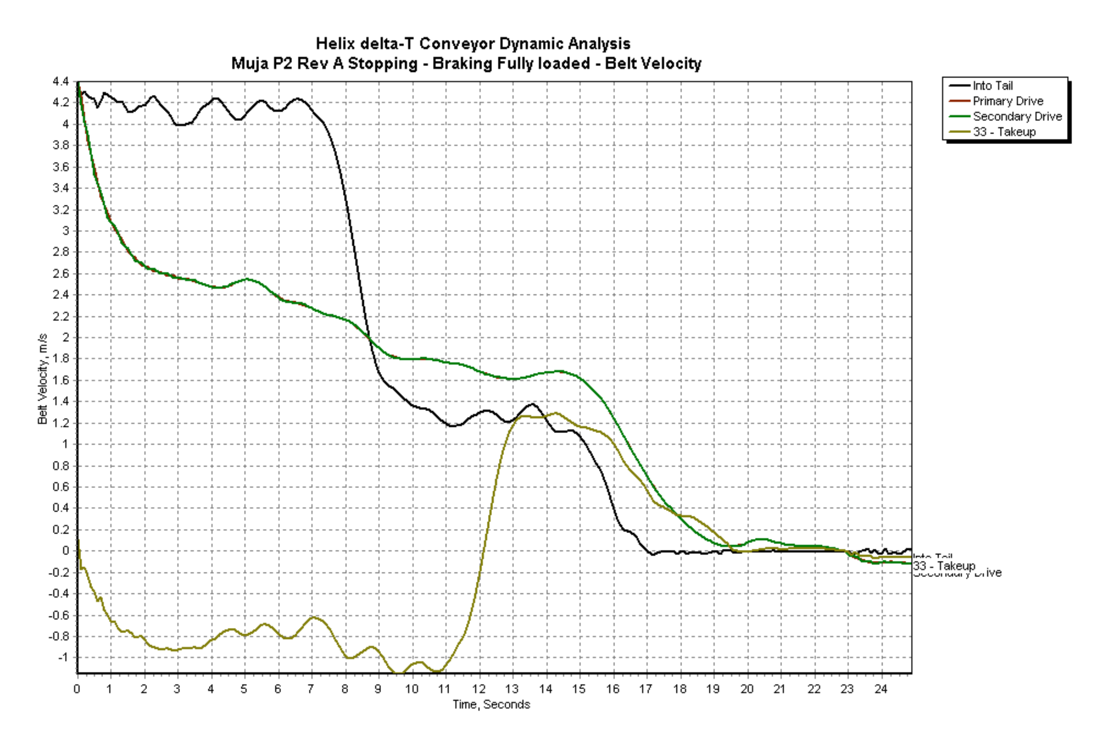
Any point along the conveyor can be graphed by selecting from a drop down list of points. 3D graphs show all points.

Emergency Stopping - Muja Fully Loaded Conveyor

Muja Conveyor 3D Graph of Belt Velocities - Stopping Fully Loaded

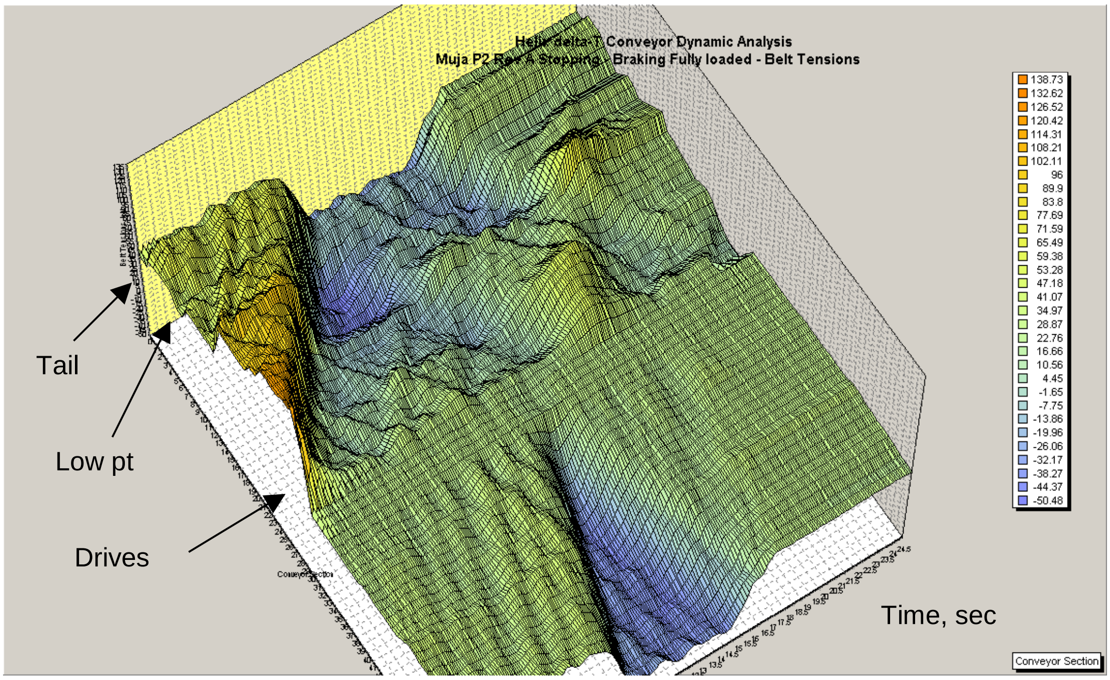


Muja Conveyor - 2D Graph Belt Velocities Stopping fully Loaded



Drive velocity drops rapidly but Tail continues to move at about 4.2 m/s for 7 seconds then drops down 1.3m/s.

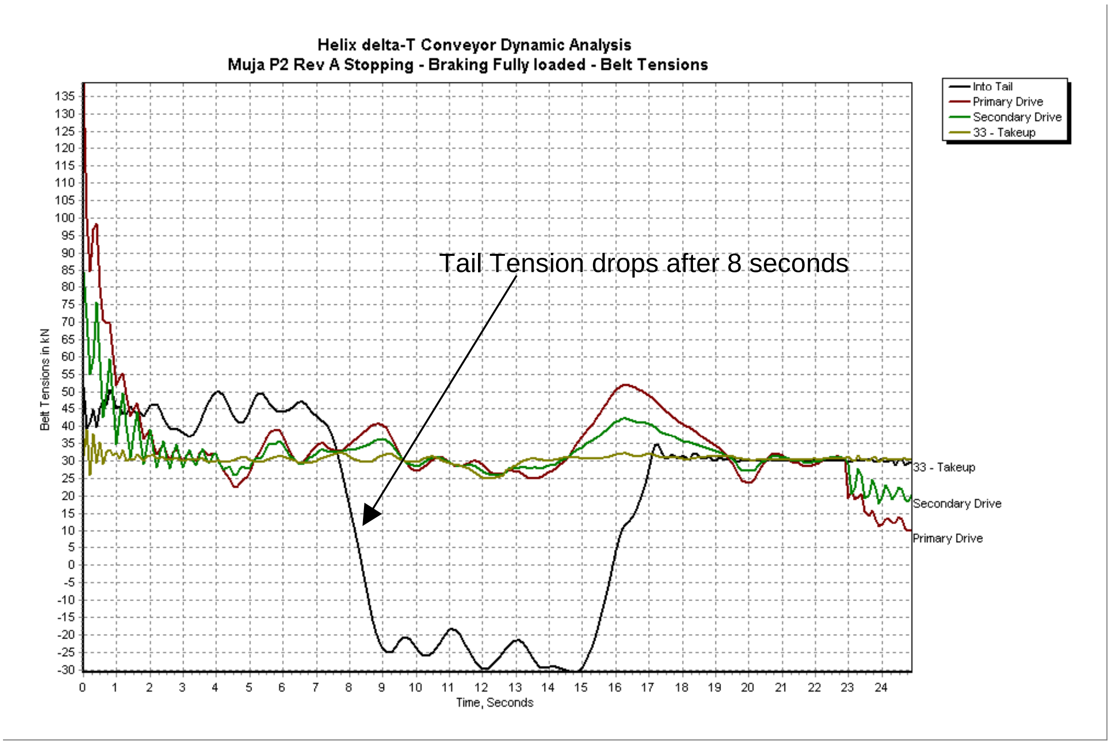
Muja Conveyor - 3D Graph Belt Tensions Stopping Fully Loaded



Notes:

- Drive is midway along left bottom axis
- Time axis is along right hand side axis, zero at bottom left, 24 seconds at RHS
- Tail pulley is at far left against yellow wall of graph
- Tensions drop immediately at the drive
- Tension at the Tail remains close to running tension for about 8 seconds and then drops rapidly to negative values - belt slip was observed at the tail brake on site after 8 seconds

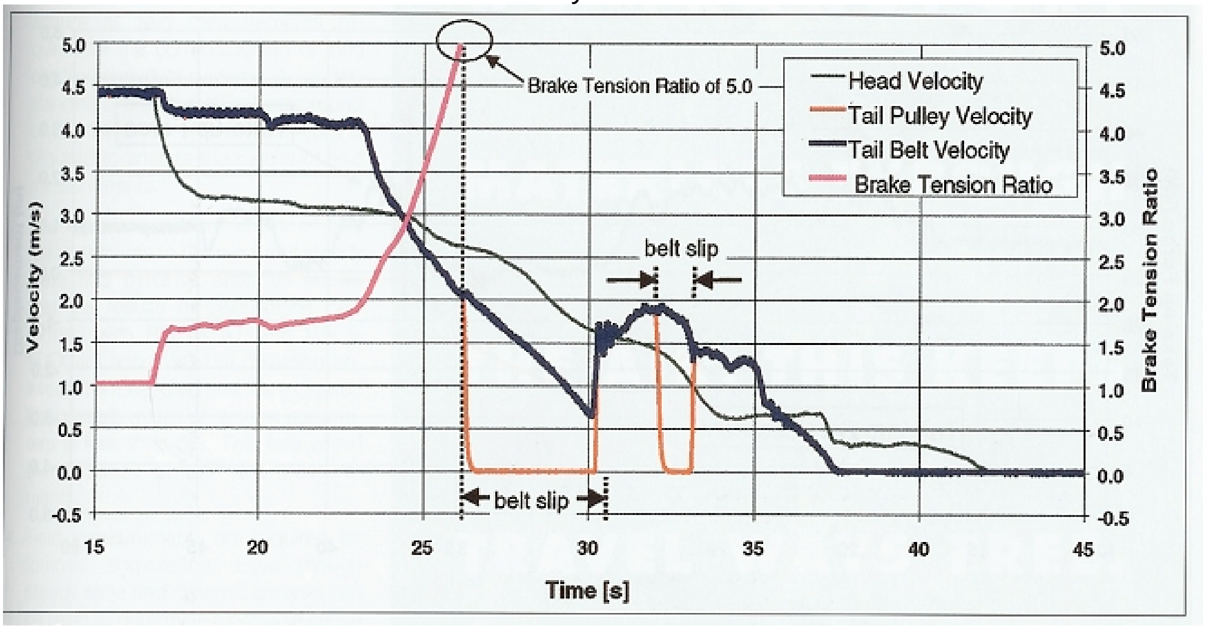
Muja Conveyor Stopping Fully Loaded - 2D Graph of Belt Tensions



The 2-D graphs show various sections of the 3D graphs in more detail. Note the tension at the drives drops rapidly as soon as the driving torque is removed. The tension at the tail remains as it was during running for about 7 to 8 seconds and then drops rapidly to 'negative' values (indicating takeup needs increasing), before recovering again 17 seconds after the drives were switched.

Muja Conveyor - Actual measurements of belt velocity - stopping full

The following graphs, reproduced from the Bulk Solids Handling article, show the belt velocities at the drives and the Tail of conveyor.



From the measurements shown in the above graph the following can be seen:

1. The Drives are switched off at the 17-second time.
2. The drive velocity drops quickly from 4.4 to about 3 m/s.
3. The tail continues to move at 4.2 m/s for about 7 seconds and then drops down
4. 8 Seconds after drives were stopped, the Tail pulley stops whilst the belt continues to move, indicating belt slip. Ie the brake stops to pulley, but because the belt tension has dropped too low, the belt slips.
5. The Tensions at the tail increases sufficiently after 14 seconds to a level where the pulley starts to move again.
6. The whole conveyor is at rest after 24 seconds or so.

Conclusion

The following conclusions can be drawn from the above:

1. The information provided by the Static or Rigid body calculations did not predict the low tensions at the tail and low point of the conveyor during stopping fully loaded.
2. The Dynamic Analysis belt tension graphs show the low tension occurring at the tail 8 seconds after drives are switched off. From this one could predict that the belt would slip at the Tail drive after 8 seconds and this was in fact measured on site.
3. The Helix delta-T Dynamic Analysis program accurately predicted the low tension and belt slip encountered and measured on site in practice.

Further information can be obtained from Helix Technologies at:

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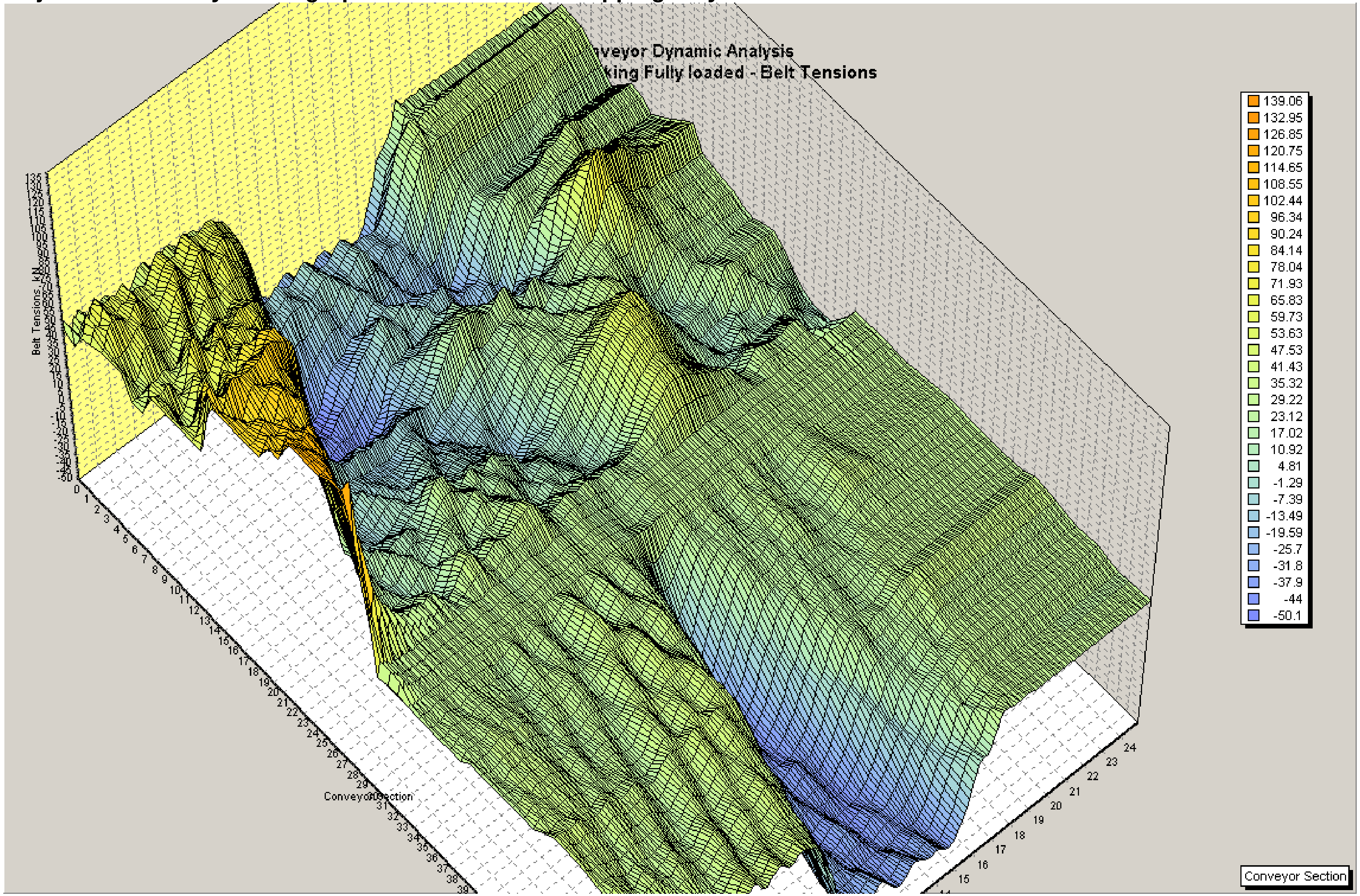
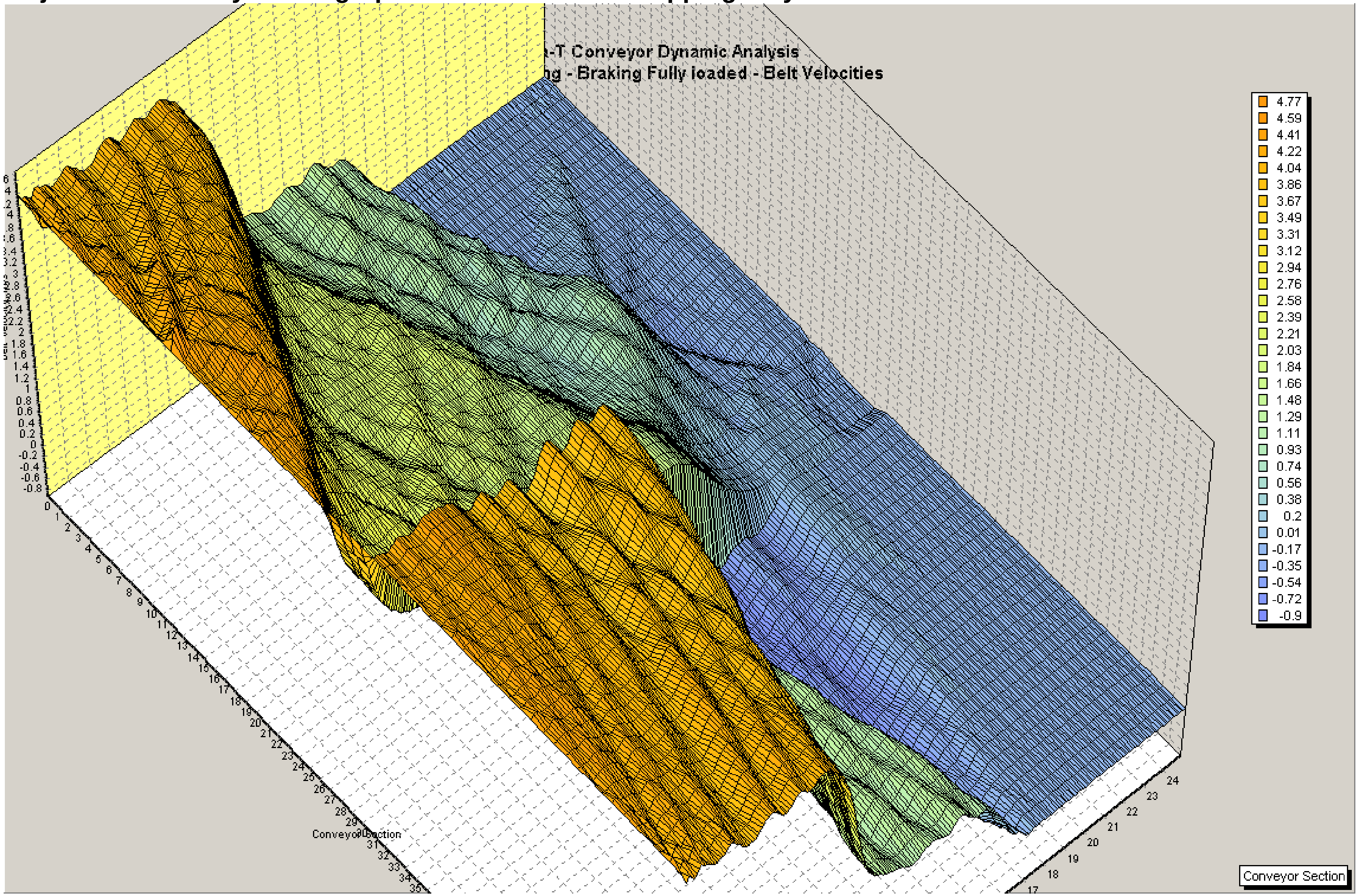
Muja 6.1 km conveyor - 3D graph of Belt Tensions stopping fully loaded



Muja 6.1 km conveyor - 3D graph of Belt Velocities stopping fully loaded



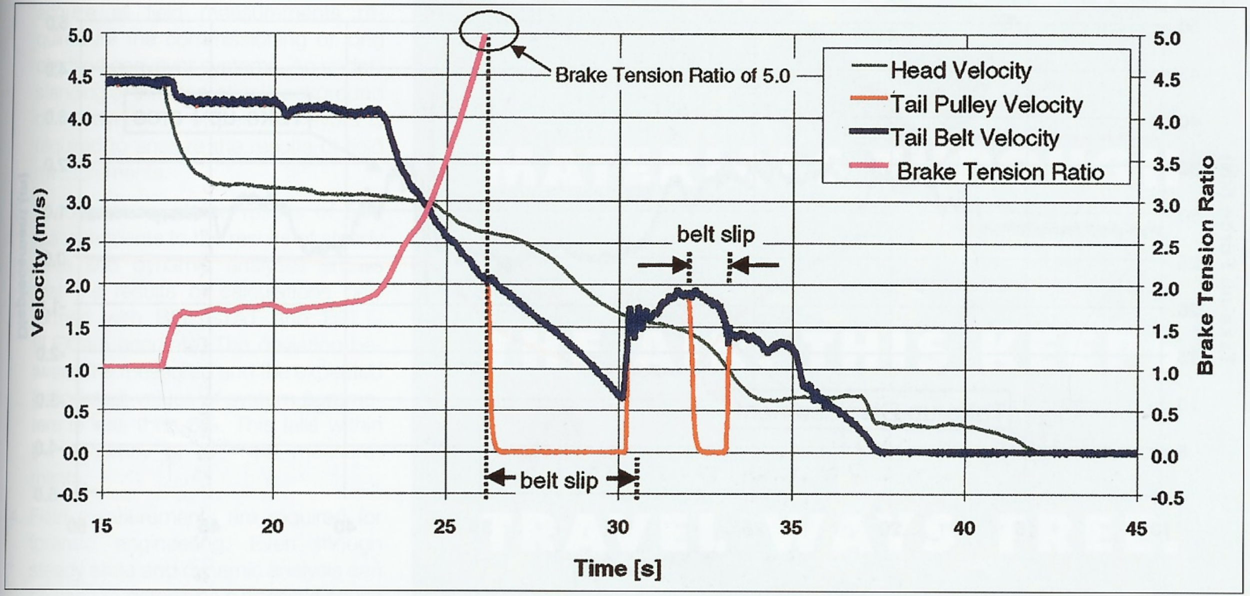


Fig. 17: Belt speed at the head and the tail of the conveyor, and the tension ratio on the brake pulley during an emergency stop.

arrives too late regardless of brake size. The disadvantage of having the brake at the tail pulley is that the tension in the return strand of the belt can also be very low during an emergency stop. These low tensions may yield a very high tension ratio over the brake pulley, which could result in belt slippage. In practice, the tension ratio is limited by the friction between the belt and the pulley, and the wrap angle. The belt will start to slip on the pulley as soon as the maximum tension ratio is reached. A capstan was installed at the take-up for this reason. The function of a capstan is to limit the take-up motion thereby not allowing the belt to relax. This results in a relatively high tension level in return strand of the belt. The capstan is designed to increase the belt tension by 22.5 kN. The pre-tension of the belt is 30 kN.

During commissioning, it was observed that the belt slipped on the brake pulley during an emergency stop. The belt and brake pulley (Fig. 17), the tail brake torque (Fig. 18), and the take-up tension (Fig. 19) were measured to determine the cause for the slippage. Fig. 17 shows the belt speed at the head and the tail of the conveyor during an emergency stop. The green line shows the belt speed at the head, the blue line the belt speed at the tail and the red line shows the (angular) speed as measured on the brake pulley. The belt starts to slip on the brake pulley about 9 seconds after initiation of the emergency stop. Fig. 18 shows the brake torque during the emergency stop. From this figure it can be seen that the torque applied by the brake was 6 to 8 kNm instead of the design value of 10 kNm. The brake therefore did not cause the slippage problem since the tension ratio decreases with decreasing brake torque. Fig. 19 shows the variation in take-up force and take-up displacement during an emergency stop. This figure shows that the capstan increased the belt tension only by 4 to 5 kN instead of the design value of 22.5 kN. This implies that

Fig. 18: Brake torque during an emergency stop