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BELTCON 4

Longitudinal Vibrations during Transient Operating Conditions of Belt Conveyors

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LONGITUDINAL VIBRATIONS DURING TRANSIENT OPERATING CONDITIONS OF BELT CONVEYORS

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SUMMARY

During transient operating conditions of belt conveyor systems complex vibrational phenomena occur under certain conditions in the upper and lower belts due to the continuous distribution of masses and elasticities. Introductorily these phenomena are analyzed with regard to their generation, their main parameters and their effects on the complete belt conveyor system. A brief presentation of a method explaining the transient operating conditions of belt conveyor systems by circulating elasto-mechanical travelling elastic waves (TEWs), and developed at the University of Hannover in the 70's, is given. This is followed by an analysis concerning the influences of the main parameters on the magnitude of the TEWs and thus on the transient stresses of the belt and on the other components of the system in its non-steady operating conditions. The analysis demonstrates that the rate of the drive unit's torque rise is a very important figure. Basing especially on this parameter recommendations for the optimization and calculation of the non-steady operating conditions of belt conveyors are given. In consideration of the experience concerning the practical design of these conveyors with regard to their elasto-mechanical dynamic behaviour, it is demonstrated that the complex finite element methods must not always be used for the calculation of the transient forces and velocities in the starting and stopping phases of belt conveyor systems. This applies especially to those conveyors where the rate of the drive and brake unit's torque rise is higher than 5 up to 10 times the travelling time of the TEWs in the lower strand. This is confirmed by the given presentation of experimental results concerning the dynamic behaviour of a long-distance belt conveyor system.

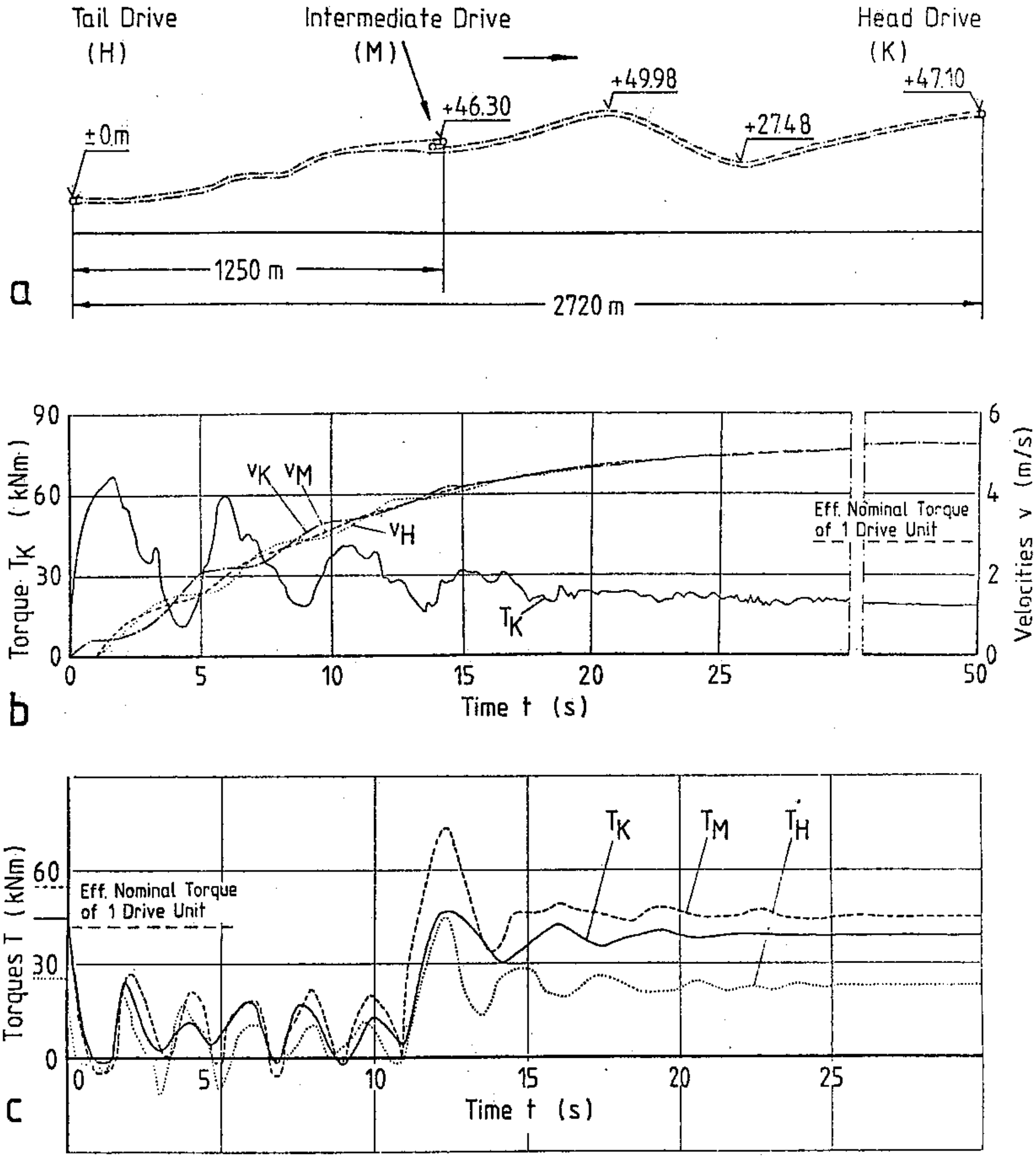


Figure 1 Dynamic behaviour of a slightly inclined and undulated uphill overland belt conveyor system with two head and two intermediate drive units as well as with one tail drive unit

a. Geometric profile of overland belt conveyor

b. Transient torque T_K at the head pulley and transient local belt velocities at the head (v_K), intermediate (v_M) and tail station (v_H) during starting of the unloaded conveyor

c. Transient torques at the pulleys of the head (T_K), intermediate (T_M) and tail station (T_H) during run down and during the following starting phase with reduced synchronous speed of the driving slip-ring motors

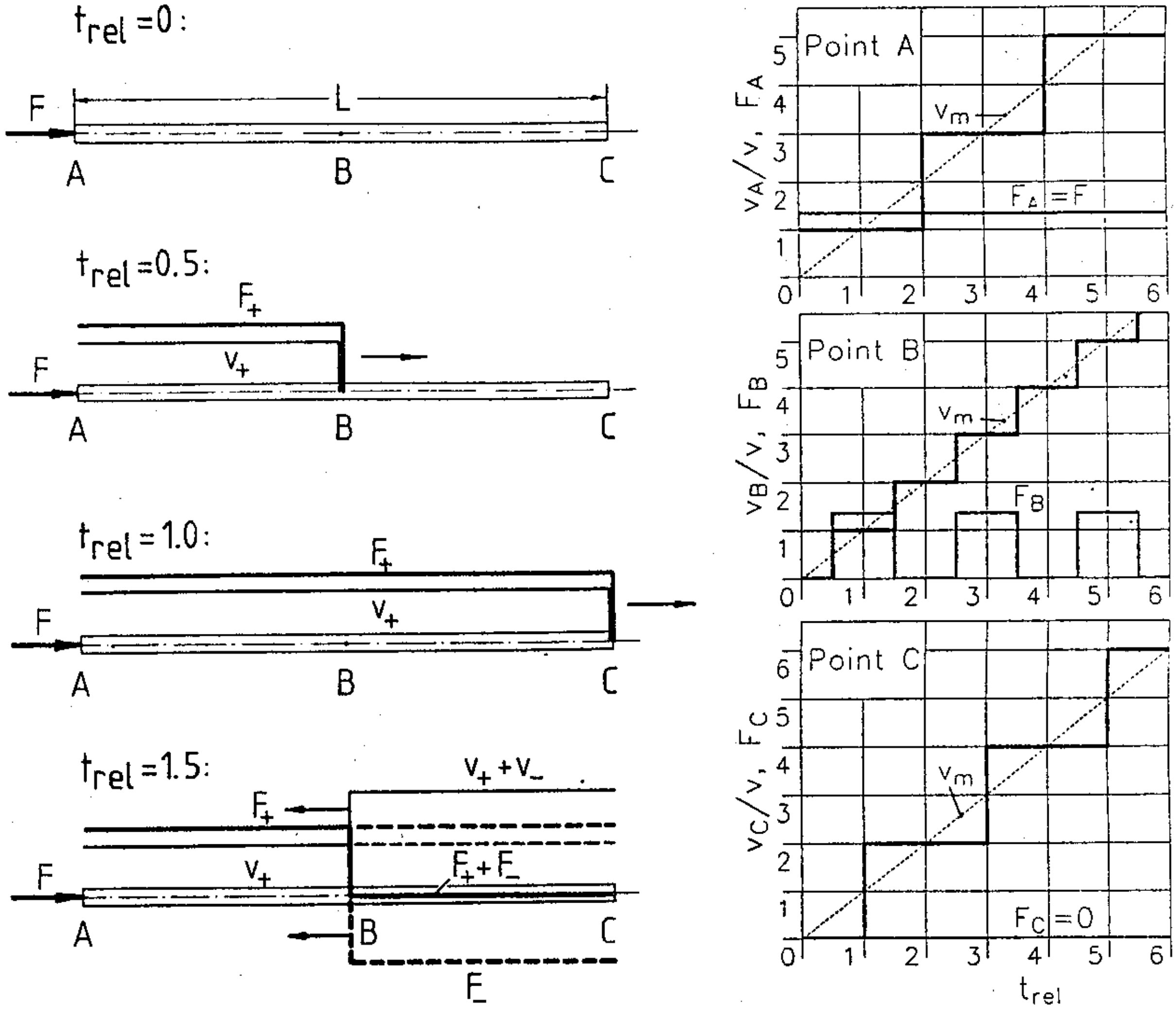


Figure 2 Transient forces and velocities during the acceleration phase of a long rod with continuously distributed mass and elasticity and with neglected friction under the influence of the force F, which is induced as a step-function at the end A of the rod

Left: Travelling elastic waves (forces F_+, F_- and velocities v_+, v_-) and their reflection at the end C of the rod

Right: Local transient forces F_x and velocities v_x at the points x = A, B, C caused by the wave couple F_+, v_+

t_{rel}: Time t related to the travelling time of the elastic waves which is needed to cover the length L of the rod

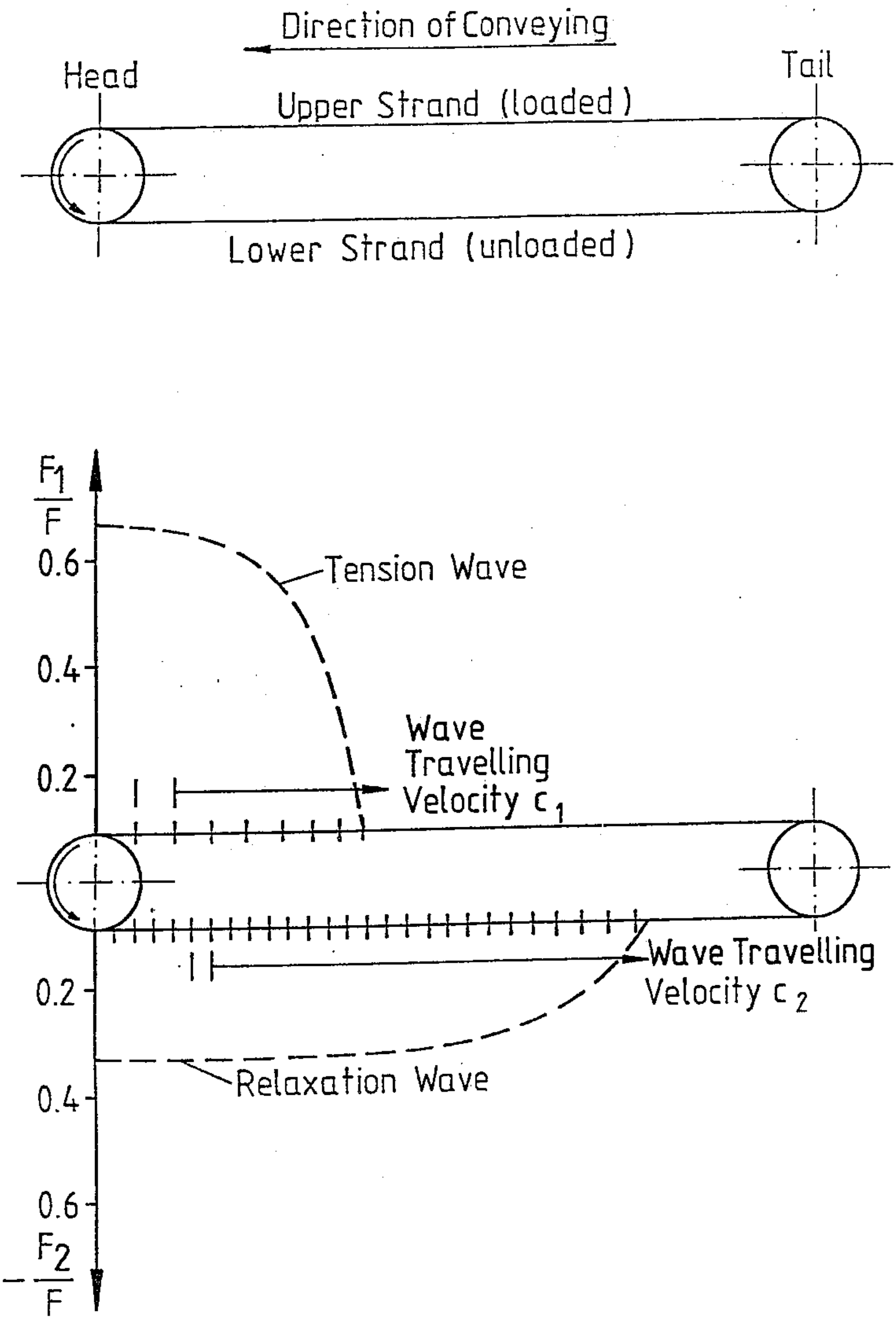


Figure 3 Transient local tensioning and relaxing belt forces in the upper and lower strand of a horizontal loaded conveyor with winch take-up when starting, due to travelling elastic waves which are caused by the head drive's torque, assumed to be generated as a step-function
(Assumed ratio of effective masses per unit length in the upper and lower strand: $\mu_1/\mu_2 = 4$)

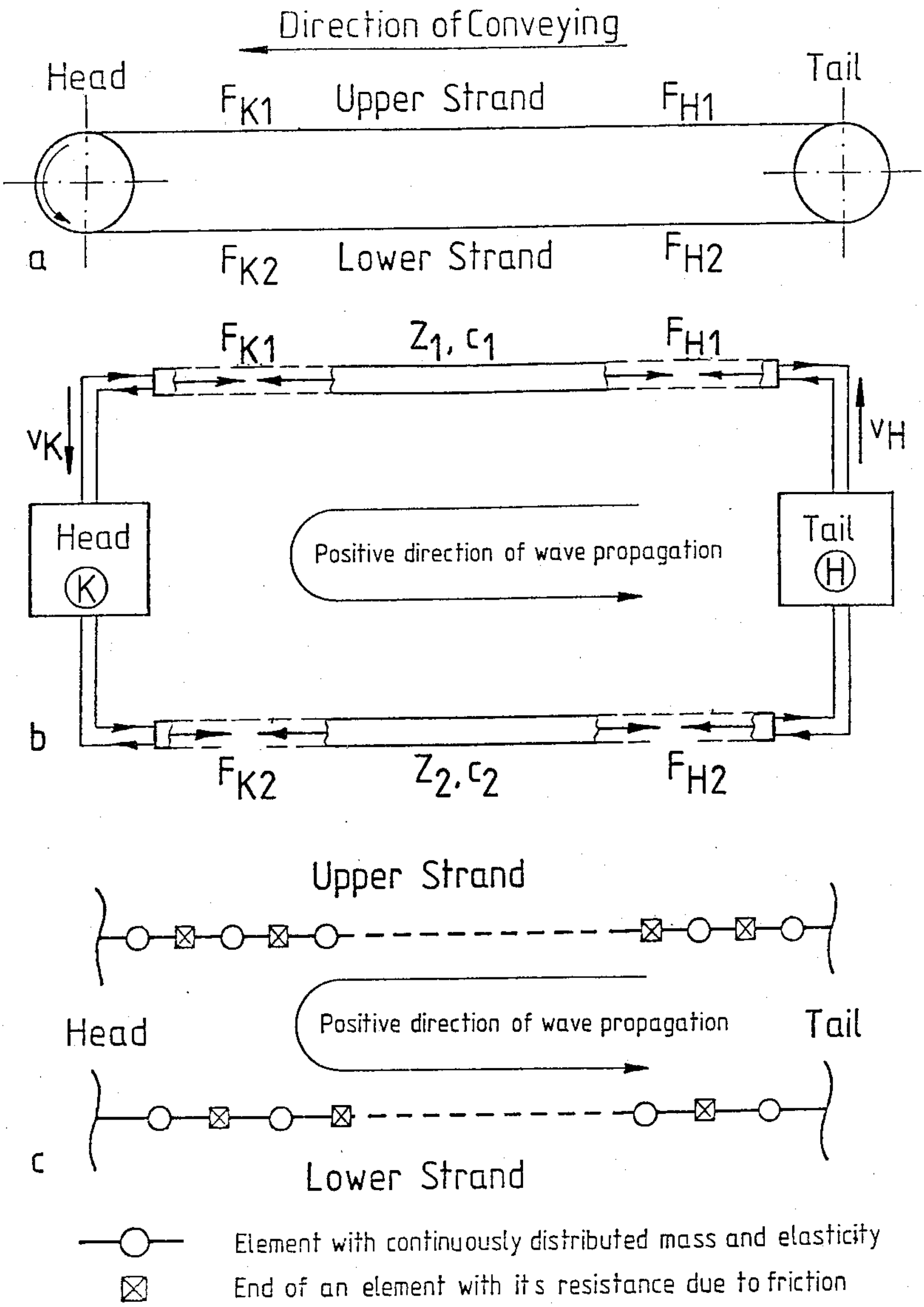


Figure 4 Horizontal belt conveyor with head drive and winch take-up as well as with return pulley

a. System of the belt conveyor under investigation

b. Mechanical model with transient belt forces F and velocities v at the head and tail station

c. Finite element model of the upper and lower strand

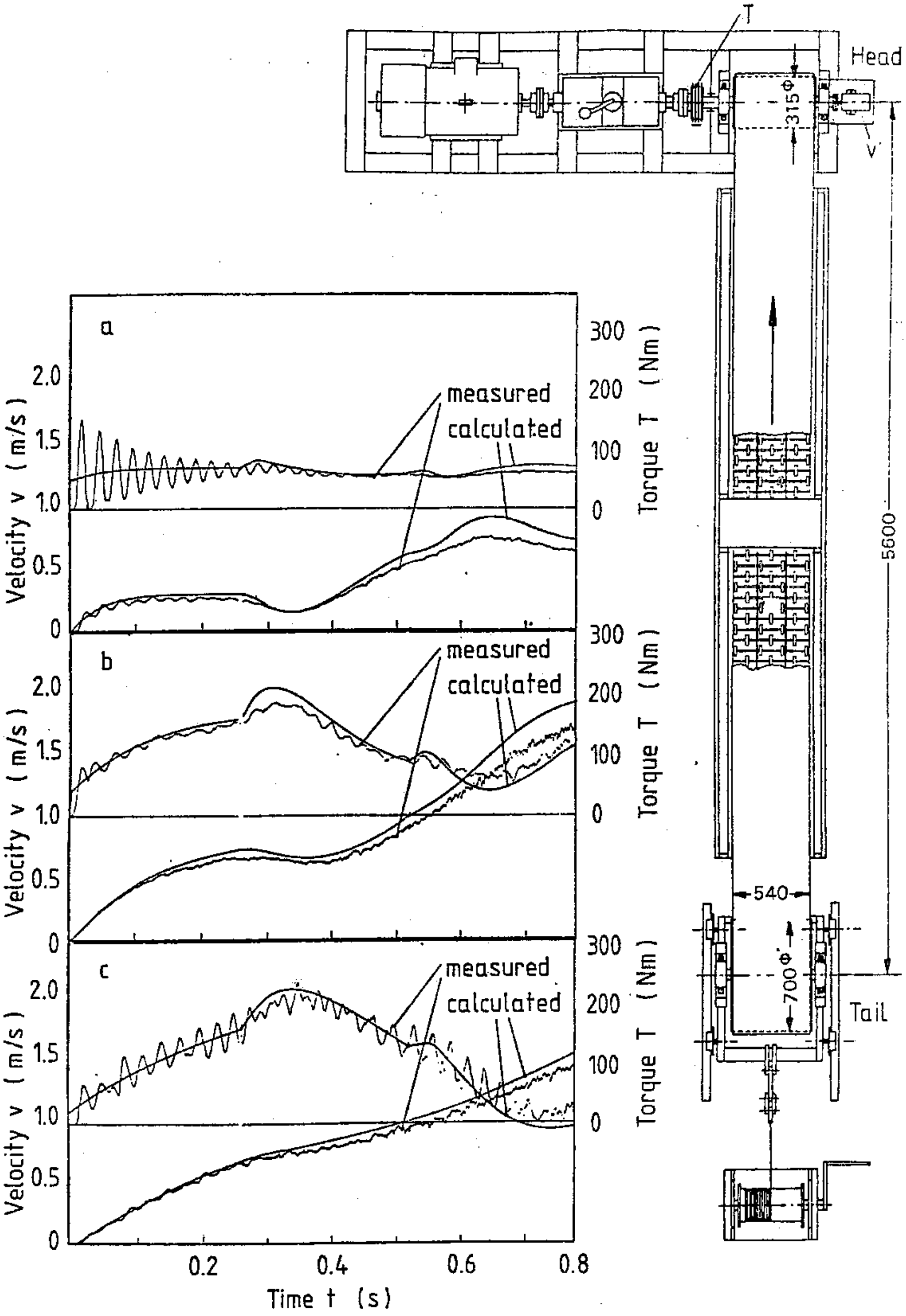


Figure 5 Test stand for the experimental investigation and for the modelling of the dynamic behaviour of belt conveyor systems with some test results concerning torque T and velocity v at the head pulley versus time

a. $m_{Krel} = 2.25$; $Z_{Krel} = 0.32$

b. $m_{Krel} = 0.70$; $Z_{Krel} = 0.04$

c. $m_{Krel} = 7.5$; $Z_{Krel} = 1.26$

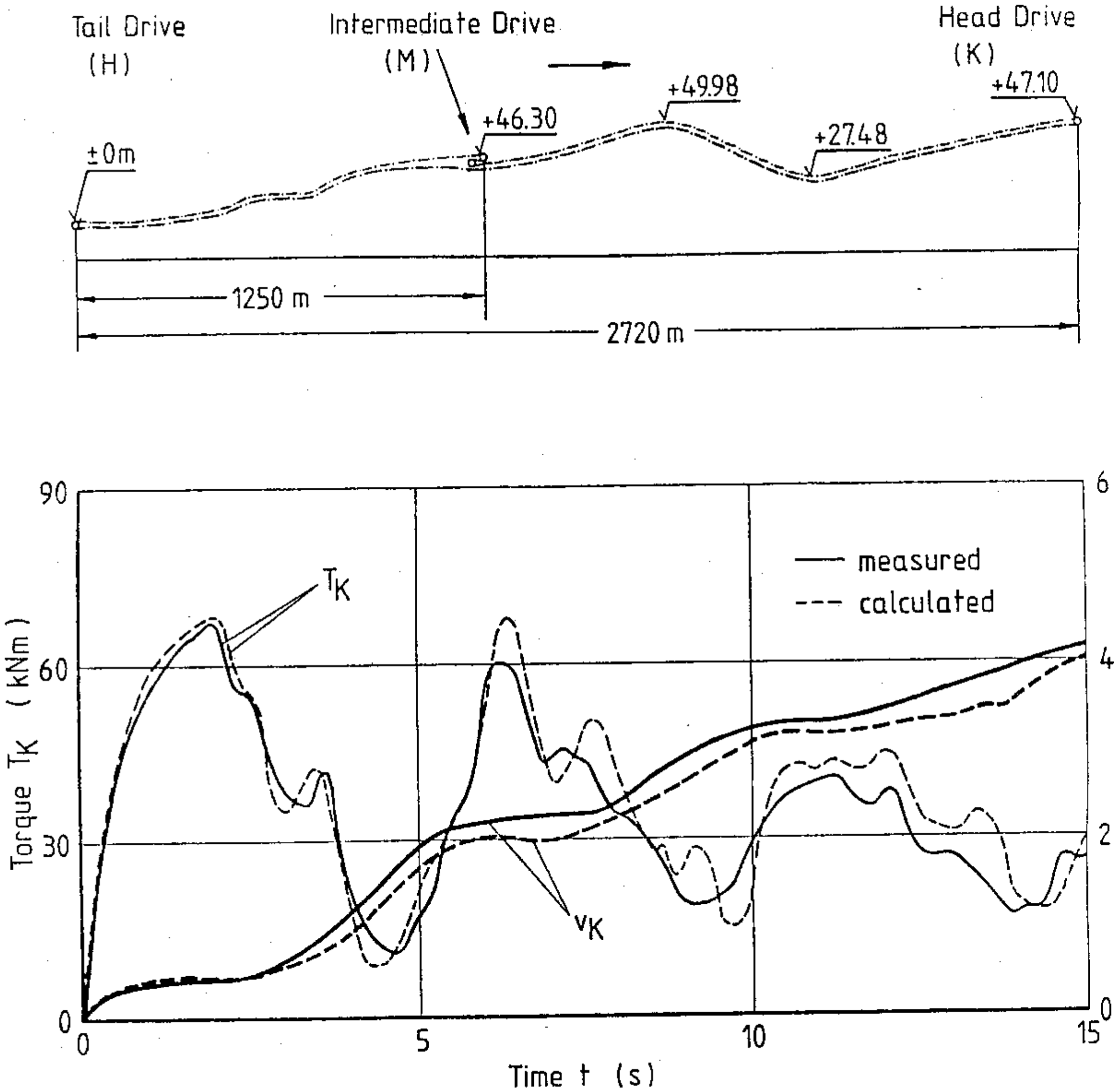


Figure 6 Comparison between the measured and calculated transient torque T_K and velocity v_K at the head pulley of a slightly inclined and undulated uphill overland belt conveyor system with two head and two intermediate drive units as well as with one tail drive unit

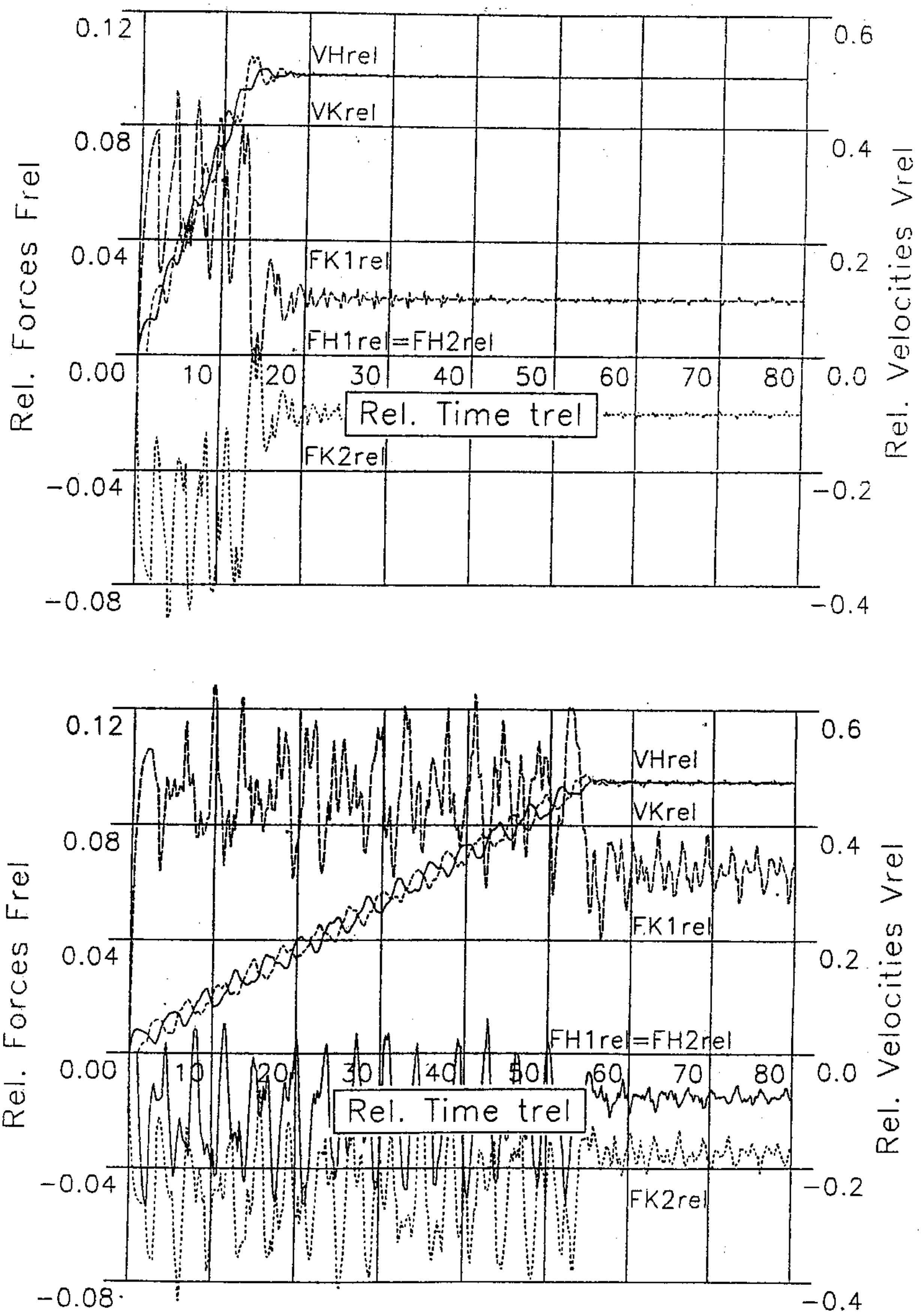
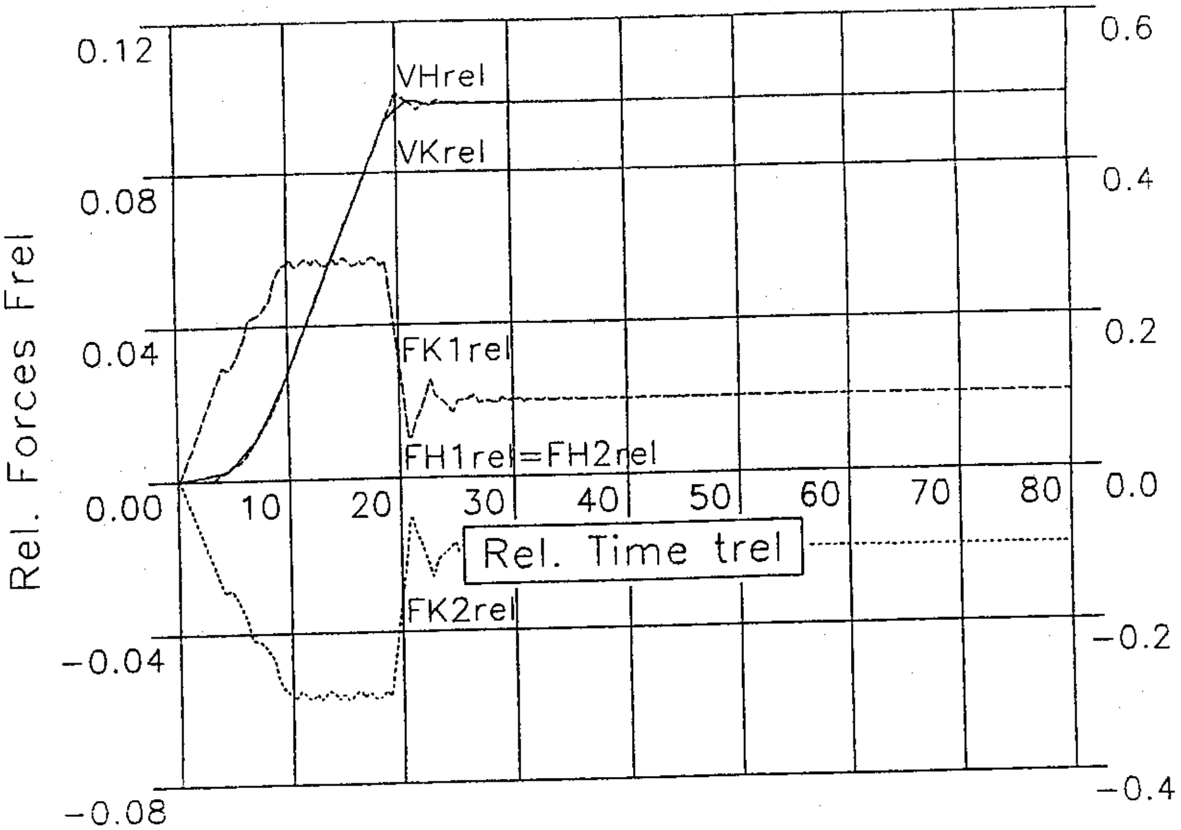


Figure 7 Calculated transient belt forces F_{rel} and belt velocities v_{rel} at the head and tail end of a horizontal conveyor with head drive, winch take-up and return pulley when starting unloaded (top) and loaded (bottom)

Parameter $T_{Arel} = 0$



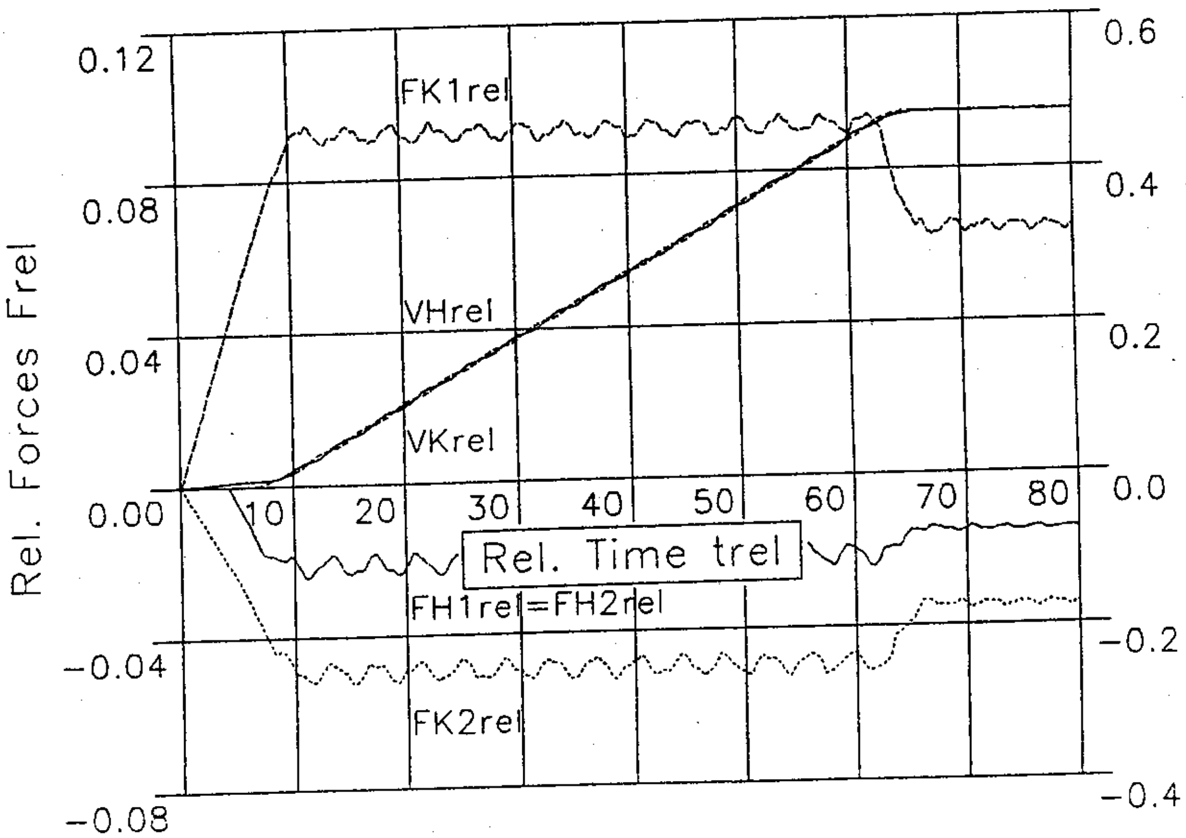


Figure 8 Calculated transient belt forces F_{rel} and belt velocities v_{rel} at the head and tail end of a horizontal conveyor with head drive, winch take-up and return pulley when starting unloaded (top) and loaded (bottom)

Parameter T_{Arel} = 10

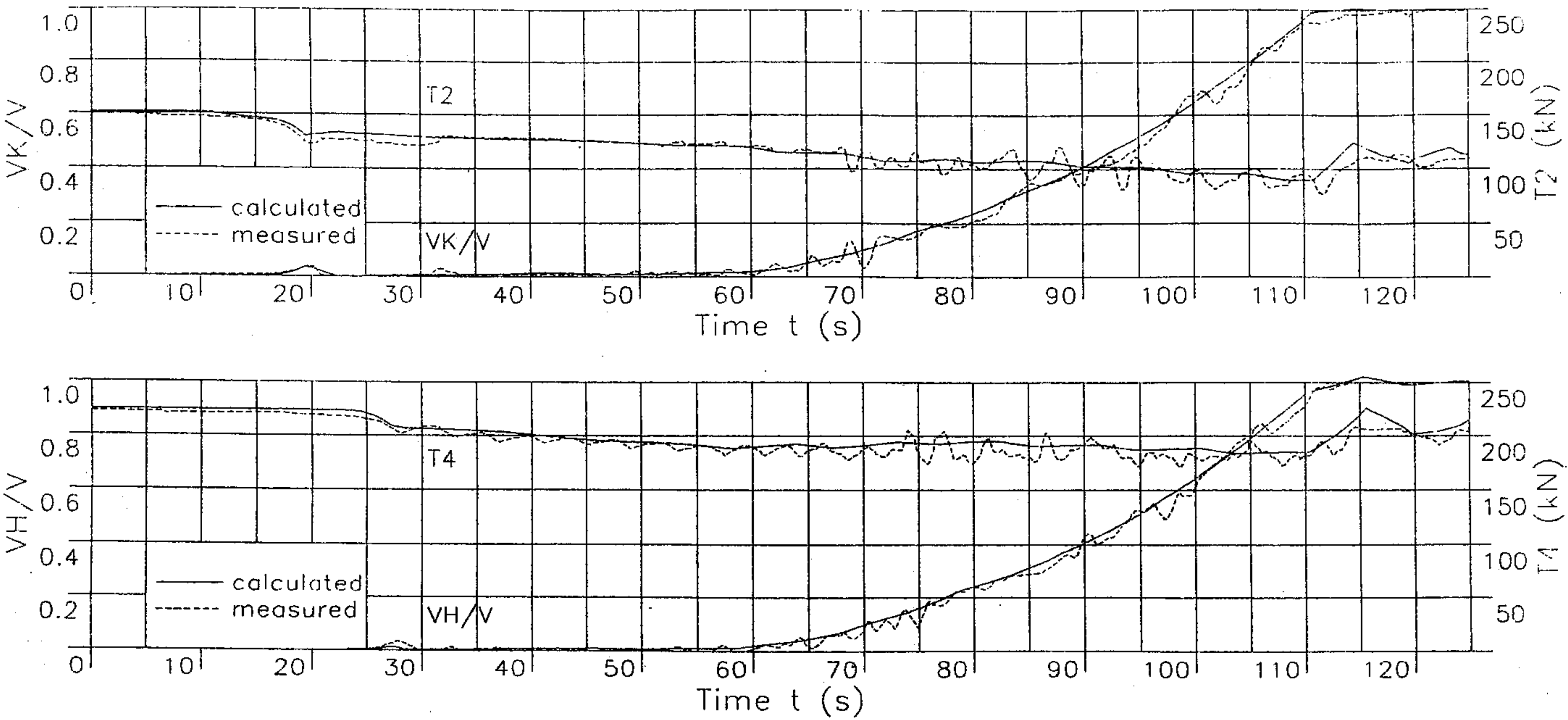


Figure 9 Transient belt velocities v and slack side tensions at the tail (top) and front station (bottom) of an undulated long-distance downhill belt conveyor system with two head drives and with one tail drive when starting unloaded

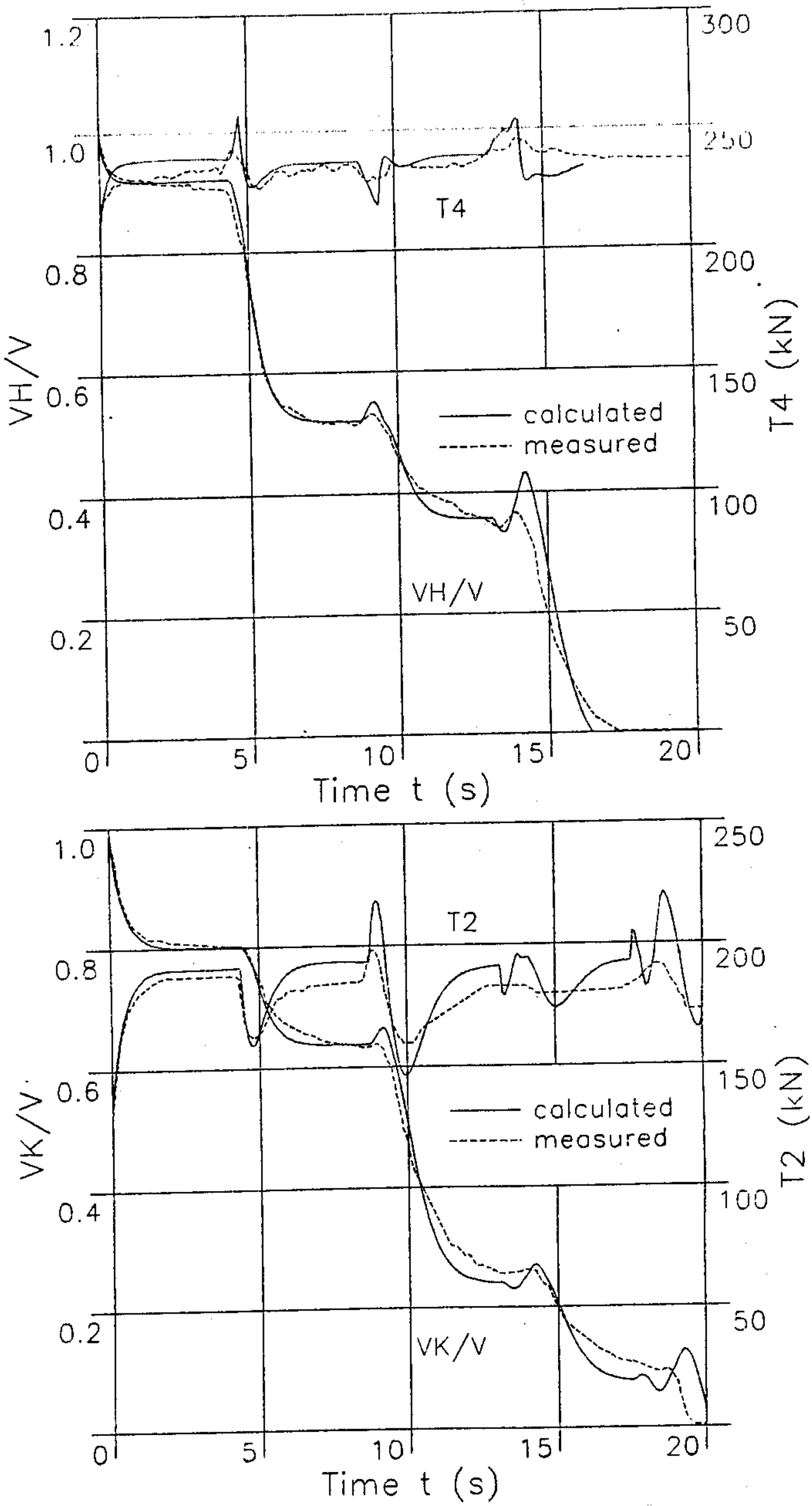


Figure 10 Transient belt velocities v and slack side tensions at the tail (top) and front station (bottom) of an undulated long-distance downhill belt conveyor system with two head drives and with one tail drive when running down unloaded

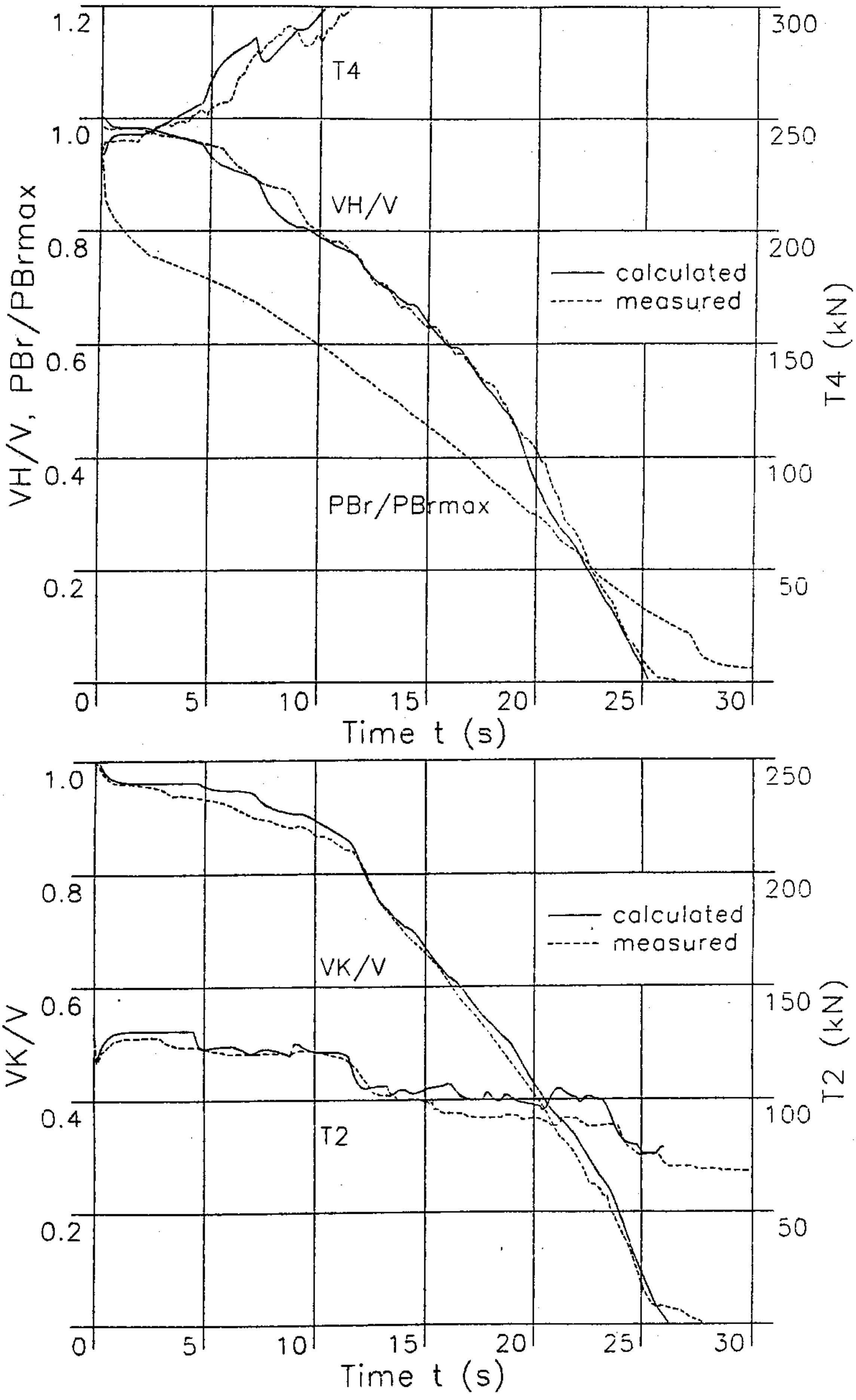


Figure 11 Transient belt velocities v and slack side tensions at the tail (top) and front station (bottom) of an undulated long-distance downhill belt conveyor system with two head drives and with one tail drive when braking loaded.