

Ropes, Cables and Chains: Theory and Applications 23 September 2004, University College Northampton

The seminar was organized jointly by the Institute of Physics Stress and Vibration Group and the Lift Technology Section of the School of Applied Sciences, University College Northampton. The objective was to introduce the delegates to modern methods in the analytical, computational and experimental analysis of tension members such as ropes, cables and chains across a number of engineering disciplines, including transport, marine and civil engineering.

The meeting was attended by over forty delegates representing the elevator and the power transmission industries as well as academic institutions. A number of leading manufacturing companies from within the UK and overseas were represented. A diverse range of topics featured in the seminar presentations. Presenters and topics included:

Professor Mathew Cartmell from the Department of Mechanical Engineering at the University of Glasgow gave a talk on *The Rigid Body Dynamics of the Motorized Momentum Exchange Tether (MMET) on Circular and Elliptical Earth Orbits*. The presentation described how the Momentum Exchange Tether has gone through a continuous cycle of invention and re-invention since Tsiolkovsky's proposal of 1895 for a space elevator based on a hanging cable system. Subsequently, the author introduced his MMET system for space vehicle propulsion as a possible competitor in future propulsion technology for interplanetary freight exchange between Earth and Mars and summarized the latest developments in this project.



Mr. Rory Smith of ThyssenKrupp Elevator Corporation presented *Elevator Suspension Ropes Constructed of Aramid Fibers*. In this talk the development of a Kevlar elevator suspension system was described. The speaker explained the research process, failure modes of the rope and its characteristics as well as the design of the suspension system components. The details of the first commercial lift installation using these components were discussed.



Dr. Jack Hale of the School of Mechanical and Systems Engineering at the University of Newcastle upon Tyne discussed *The Latest Measurement Techniques on High Speed Roller Chains*. Chains find diverse engineering applications ranging from high speed power transmission systems to systems for compensation of tensile forces over the traction sheave in mid- and high-rise building elevators. This presentation explained the kinematics and dynamics of a moving chain. This was followed by a presentation of current state of the art developments in chain load measurement technology.



Professor Robin Tucker of the Department of Physics at the University of Lancaster presented *Cosserat Methods and the Fluid-Structure Interaction in Cable Stayed Bridges*. The Cosserat equations offer a versatile tool for modelling dynamics of complex systems. Professor Tucker demonstrated the application of this technique in the prediction of the dynamical behaviour of undersea marine risers responding to vortex induced vibration and in the analysis of the motion of cables in cable stayed bridges that are excited to vibrate in light-wind rain conditions.



Dr. John MacDonald from the Engineering Research Centre, University of Bristol gave a presentation entitled *Dynamic cable-Deck Interaction of Cable-Stayed Bridges*. The presentation demonstrated various types of vibration problems of both the bridge decks and inclined cables. It was shown that various types of dynamic interaction can take place between these two components, including the occurrence of combined cable and deck linear modes, the effects of cable wind loads on the overall bridge response and potentially serious non-linear interactions for specific frequency ratios.



Mr. Michael Pohle of Datwyler AG delivered a talk on *Elevator Flat Traveling Cables and Compensation Weight*. Datwyler AG developed a robust design of elevator travelling cables as well as a plastic compensation system for high rise applications. High material requirements for no-twisting, low deflection and high flexibility had to be satisfied in this design. The presentation gave a comprehensive overview of the construction principles and the testing methods.



Dr. Stefan Kaczmarczyk of the School of Applied Sciences at the University College Northampton addressed the problem of *Resonance Phenomena in Tension Member Systems with Time-Varying Characteristics*. The length variations of ropes and cables in traction drive elevator installations and various hoist systems result in the change of the mass, stiffness and damping characteristics. Consequently, transient resonance phenomena arise during the operation of such installations. The presentation discussed the methods to predict these phenomena and gave examples describing the dynamic behaviour of ropes and cables in typical vertical transport installations.



The presentations can be found at: <http://groups.iop.org/SV/AE/Ropes.htm>.

A panel discussion about direction for future research in the area of analysis and design of rope, cable and chain systems took place after the presentations. The issue of suppression of adverse dynamic behaviour of such systems emerged as an important problem. It was pointed out that traditional methods of active vibration control are difficult to implement within long moving continua systems. Current emphasis is on boundary control methods and an active suspension system for a car in elevator systems have been considered and implemented by some elevator companies. However, a number of delegates indicated that a holistic approach is needed to treat the suspension rope - car system as an integral system so that suppression of vibration at one area will not cause problems elsewhere.



It has also become evident that new material technologies made an impact on the design and construction of ropes and cables. Non-steel solutions that include composite elements such as Kevlar ropes as well as flat plastic belts and cables emerged as a way forward. Thus, the cross-disciplinarity combining the fields of nonlinear structural dynamics,

vibration control, structural health monitoring, artificial intelligence, and materials science emerged as a rising trend.

It was proposed that a forum comprising representatives from various industries (elevator, power transmission, and textile) and academic institutions should be created to discuss the problems concerning the theory and applications of various tension members. The discussion indicated a strong support for future seminar and/or conference events of this kind.



Overall, the meeting was very successful and it was agreed that the possibility of staging an annual conference on rope/cable problems with both invited keynote speakers and technical contributed papers should be considered.