Dynamic Design of modular escalator systems

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Abstract

To reduce the design effort and to optimize the material use for long-span escalator systems, the structural system of a modular escalator design has been investigated under dynamic aspects to avoid human induced vibrations on the staircase. The analysis included a theoretical and experimental assessment of the dynamic response of escalators due to human induced vibrations and allowed to derive a realistic loading function which reflects the typical processes for the use of those facilities.

The following paper presents the results of the dynamic analysis of several types of the modular escalator system and introduces the resulting loading characteristics which have to be considered for the dynamic design. Furthermore theoretical and experimental results will be compared including the achieved reduction by a TMD system. Finally the vibration control measures and the design criteria, as well as the design challenges will be presented.

Keywords: TMD; long-span escalator; dynamic vibration analysis; vibration control measures;

1 Introduction

The use of a modular escalator design gives the opportunity to span over long distances with very efficient use of material and little design effort to adapt the system for these various spans. In some cases it is not possible to provide horizontal support and low natural frequencies can occur in the range of persons walking frequency. These vibrations can lead to discomfort for the users.

In order to apply the modular design also to long-span escalators while maintaining an acceptable vibration level, investigations on an existing 22 m long escalator were carried out. These investigations included experimental vibration tests to determine the relevant natural frequencies and the corresponding mode shapes, as well as the in-situ values of the structural damping and the resulting dynamic response to human induced vibrations of the structure.

In addition a FEM analysis was performed. The results were verified with the experimental results and used to predict the dynamic response to various loadings as well as for the assessment of the vibration reduction that can be achieved with the application of Tuned Mass Damper (TMD) systems. Also the FE model was used to optimize the TMD systems to be installed.

Based on these investigations a laterally effective TMD system has been developed and installed to the escalator structure. The application approach will be presented herein as well as the experimental results after the devices were installed.

2 Vibration measurements

2.1 Mode shapes

In order to identify the critical mode shapes an ambient modal analysis was performed on a 22 m long escalator. Therefore, a total of 36

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