

Vibration Response of a Monumental Stair: Design & Validation

**Sebastian MENDES, Ph.D.,
P.E.**

Project Engineer

Thornton Tomasetti

New York City, USA

smendes@thorntontomasetti.com

Dr. Mendes has over five years of engineering experience and performed the test program for measuring the stair vibration response.

Michael BAUER, P.E.

Vice President

Thornton Tomasetti

New York City, USA

mbauer@thorntontomasetti.com

Mr. Bauer has designed numerous monumental stairs in NYC and developed tools used at Thornton Tomasetti for analysis of stair vibration.

Zhi ZHANG, Ph.D.

Senior Engineer

Thornton Tomasetti

New York City, USA

zzhang@thorntontomasetti.com

Dr. Zhang has one year of engineering experience and assisted with the test program for measuring the stair vibration response.

Travis TEST, P.E.

Associate

Thornton Tomasetti

New York City, USA

ttest@thorntontomasetti.com

Mr. Test has over ten years of engineering experience and was project engineer for the staircase and support structure.

Contact: smendes@thorntontomasetti.com

1 Abstract

Monumental stairs are a common feature in buildings throughout New York City, as they provide both a practical means of egress and an aesthetic impact. It is often desired to make these stairs appear as light as possible, and as a result they are especially susceptible to excessive human-induced vibrations. While not a strength limit state, stair vibrations must nonetheless be limited to satisfy tolerance criteria for human comfort. The updated second edition of AISC Design Guide 11 includes new guidance for prediction and evaluation of stair vibration, including recommendations for finite element analysis. Thornton Tomasetti has developed a tool for analysis of stair vibration based largely on these recommendations, and numerous monumental stairs have been designed using this approach. One such stair is located in the NewYork-Presbyterian David H. Koch Center. Following its completion, a test program was implemented to measure the dynamic properties and response of the stair and compare with the design predictions. This paper describes the structural design of the stair and overviews the analytical approach used to predict the stair vibration response. The test program employed to measure the actual vibration response of the completed stair is also described, and the predicted and experimental vibration responses are compared.

Keywords: monumental stair; human-induced vibrations; vibration response

2 Introduction

Monumental stairs are purposely situated in prominent areas of buildings, such as atriums and

lobbies, and serve as much an aesthetic function as a practical utility. From a structural standpoint, the foremost difference between conventional stairs and monumental stairs is that the latter emphasizes much longer spans between floors while relying