Damping in tall buildings – uncertainties and solutions

Rob SMITH
Associate
Arup
London, UK
rob-j.smith@arup.com

Rob Smith graduated from Oxford University and has worked as a structural engineer for 13 years. He leads the tall buildings team within Arup's Advanced Technology Practice.

Michael WILLFORD
Director
Arup
London, UK and
San Francisco, USA
michael.willford@arup.com

Michael Willford has worked in the field of structural dynamics for over 30 years. He is an Arup Fellow and Global Leader of Arup's Advanced Technology and Research Practice

Summary

In the design of tall buildings, the dynamic response in wind is a dominant consideration. The damping of the building has a major influence on the dynamic response, and the structural engineer has to make an informed decision as to an appropriate value to assume for design.

This paper reviews available measured data on the damping of tall buildings and compares against values in common usage. It is found that damping ratios commonly assumed in design are inappropriate and unconservative.

The paper describes the consequences of over-estimation of damping at the design stage, and illustrates the benefits of incorporating robust supplementary damping systems to reduce dynamic response, to reduce uncertainty and to improve economy in design.

Keywords: damping; wind; seismic; dampers; high-rise buildings; risk; occupant comfort.

1. Introduction

The predicted dynamic response of tall buildings in wind is particularly sensitive to assumptions about the intrinsic damping made by the structural engineer. It is evident that current practice overestimates the damping in the many buildings of 200m+ now being constructed worldwide, and the need for more reliable damping predictions is imperative.

The consequences of overestimation of damping during design include higher lateral accelerations increased lateral deflections and higher forces in structural members (reduced factor of safety and potential structural damage and fatigue in extreme winds).

2. Damping measurements

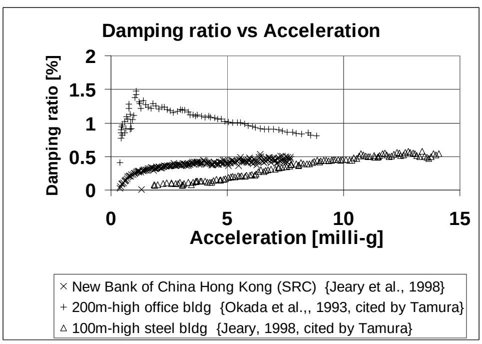

Figure 1 - Variation of damping with amplitude

2.1 Variation of damping with amplitude

Figure 1 shows three examples of the variation of damping with amplitude. It can be seen that the peak damping ratio occurs at relatively low amplitudes and does not necessarily increase at “ultimate” (design) loading levels as is commonly assumed.

https://doi.org/10.2749/222137908796225618
Distributed by structurae

2.2 Variation of damping with building height

Figure 2 shows a dataset of damping values assumed in the design of tall buildings compared to the measured values..

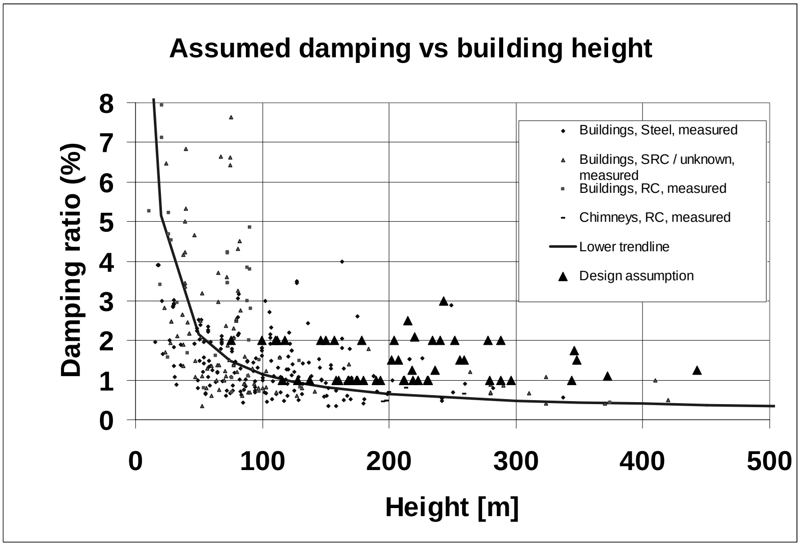

Figure 2 - Comparison between measured and assumed damping

3. Conclusions and recommendations

3.1 Conclusions

- There is a clear trend for the intrinsic damping of tall buildings to reduce with height.
- Structural designers and wind tunnel testing laboratories frequently assume higher values of damping for design than the measurements support. This is unconservative.
- There is little evidence to suggest that damping will increase between typical serviceability amplitudes (1-10 year return period wind) and the design wind load.
- There is little difference in the measured damping of steel and concrete frame buildings above 250m in height.
- Viscous dampers and similar components are an effective way of reducing both the dynamic response and the risk of unconservative structural design.

3.2 Recommendations

Structural engineers and wind loading specialists should either:

- Assume damping ratios consistent with measurements – typically 0.5% - for buildings above 250m in height.
- Incorporate supplementary damping systems, preferably robust systems which can improve the economy and performance of tall buildings.