Effect of low-rise building geometry on tornado-induced loads

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Introduction

Description of simulated tornado

Maximum horizonal wind speed Tornado vortex diameter Swirl ratio

Model description, instruments, conventions

Building models
Instrumentation
Procedure and conventions

Results

The effect of cave height
The effect of roof pitch
The effect of the ratio plan dimension

Conclusions

Challenges to quantify tornado-induced loads:

► Lack of research facilities capable of determining tornado-induced loads (pressures, forces, etc.)

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Challenges to quantify tornado-induced loads:

- Lack of research facilities capable of determining tornado-induced loads (pressures, forces, etc.)
- Absence of full-scale data
- Lack of interest in tornado-resistant design

How to overcome these challenge:

▶ Iowa State University (ISU) tornado simulator

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- ► Full-scale data from several recent tornados

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- Iowa State University (ISU) tornado simulator
- ► Full-scale data from several recent tornados
- Pressures obtained form the ISU simulator are verified

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Maximum horizontal wind speed

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- Fact 4: Maximum horizonal velocity of the tornado generated by ISU Simulator is 11.7 m/s

Description of simulated tornado

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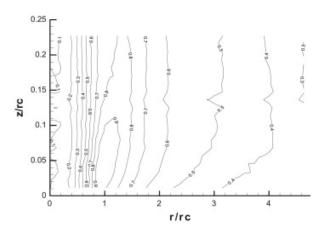
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Choose target full-scale wind speed to be 74 m/s

Velocity scale $\lambda_{\rm V}=11.7/74=1/6.3$

Maximum horizonal wind speed

Contour plot of normalized tangential velocity



Tornado vortex diameter

Tornado vortex diameter

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Definition

Radius of the core r_c : radius of the maximum wind near the ground

Fact 1: r_c of F2 tornado is between 45 to 225 m

Fact 2: r_c of simulated tornado is $0.56 \,\mathrm{m}$

Choose r_c of target full-scale tornado to be $56 \,\mathrm{m}$

Length scale is 1:100

Swirl ratio

Swirl ratio: definition

Definition Swirl ratio *S*:

$$S = \frac{\pi V_{\theta \max} r_c^2}{Q}$$

 r_c : core radius

 $V_{\theta \rm max}$: maximum tangential wind speed

Q: inflow rate of the vortex measured at $r = r_c$

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Swirl ratio

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└─Description of simulated tornado └─Swirl ratio

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Swirl ratio

Description of simulated tornado

How to choose swirl ratio

- Fact 1: Data from full-scale tornados indicates $S \ge 2.0$
- Fact 2: Best fit of full-scale data with numerical simulation when $S \ge 2.0$

Choose the swirl ratio S to be 2.6

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