

ASCE 7 Triggers for Requiring Wind Tunnel Studies/Tests	Date: June 01, 2016
ABSTRACT: <p>This white paper is intended to establish an understanding of circumstances when ASCE 7, Chapters 27 to 30 methods for evaluating building characteristics under wind loading may require the use of ASCE 7's Chapter 31 (Wind Tunnel Procedure) design wind pressures.</p> <p>(Section or Chapter Number References below are specifically from the ASCE Standard 7-10 Edition)</p>	Task Group Members: <i>Scott Douglas, P.E, S.E., Chair</i> <i>Russell Larsen, P.E., S.E.</i> <i>Don Scott, P.E, S.E</i> <i>Scott Beard, P.E, S.E.</i> <i>Larry Liu, P.E., S.E.</i> <i>Steve Pfeiffer, P.E., S.E.</i> <i>Tony Tschanz, P.E, PhD</i>
COMMITTEE MISSION STATEMENT: <ul style="list-style-type: none">• <i>Provide guidelines for wind design and analysis issues that are not straightforwardly given in the Standard.</i>• <i>Provide guidance for wind design and analysis for conditions and techniques which are not in the Standard.</i>• <i>Participate in ICC/ASCE 7 code and standard processes to monitor/testify on wind design and analysis issues.</i>	

The recommendations in this White Paper represent the opinion of the Task Group and the SEAW Wind Engineering Committee. It is intended for use as a design aid reference by engineers and building officials in conjunction with their own judgement and the actual project design criteria and assumptions.

I. INTRODUCTION:

ASCE 7 Sections 27.1.2, 29.1.2, and 30.1.2 limit the applicability of each chapter to buildings that are regular in geometry, and which are not subject to unusual responses or dynamic effects under the wind loading cases listed therein. Sections 27.1.3, 29.1.3 and 30.1.3 allow the procedure to take into account load magnification effects caused by gusts in resonance with along-wind vibrations of flexible buildings or other structures. This is accomplished by the use of a calculated gust factor, G_f , defined in Section 26.9.5.

In contrast, Chapter 28 considers gust effects through the G_{Cp} and Ps_{30} values tabulated in Figures 28.4-1 and 28.6-1, respectively.

ASCE 7 Section C26.2 identifies the following structural attributes as indicators to determine if a building has unusual response characteristics:

1. A natural frequency below 1 Hz.

2. A height to width ratio greater than 4.

The Structural Engineers Association of Washington (SEAW) Wind Engineering Committee feels that other characteristics of a building are better indicators to consider if a wind tunnel investigation is warranted or required for the building design.

II. RECOMMENDATIONS:

The SEAW Wind Engineering Committee believes that the 1 Hz threshold criterion stated in ASCE 7 Commentary Section C26.2 is insufficient to determine when a building is susceptible to dynamic effects under wind loading. The committee instead recommends using the enclosed guideline, Figure 1, to determine when further wind engineering investigation of a structure is warranted. Figure 1 evaluates calculated dynamic characteristics of the structure to determine if the structure may be susceptible to unusual responses under wind loading. Further investigation may be required if a structure is not compliant with ASCE 7 Sections 27.1.2.2, 29.1.2.2 or 30.1.2.2, and does not meet the criteria identified in Figure 1. Such investigation may require a design utilizing recognized literature or a wind tunnel investigation per ASCE 7 Chapter 31.

III. COMMENTARY:

ASCE 7 Chapters 27, 29, and 30 limit the applicability of wind load determination to:

- Buildings that are regular in geometry
- Buildings that are not subject to dynamic effects (such as across wind loading, vortex shedding, or instability due to galloping or flutter)

Sections 27.1.3, 29.1.3, and 30.1.3 further define the basic limitation requirements for each Method. Each section specifically states:

*“The provisions of **this chapter take into consideration** the load magnification effect caused by gusts in resonance with along-wind vibrations of **flexible buildings**. Buildings not meeting the requirements of Section (27.1.2, 29.1.2, or 30.1.2), or having unusual shapes or response characteristics shall be designed using recognized literature documenting such wind load effects or shall use the wind tunnel procedure specified in Chapter 31.”* (Emphasis ours.)

Commentary Section C26.2 discusses the definition of “*Buildings and Other Structures, Flexible.*” The Commentary states in Section C26.2, “*When buildings or other structures have a height exceeding four times the least horizontal dimension, or when there is reason to believe that the natural frequency is less than 1 Hz (natural period greater than 1 s), the natural frequency of the structure should be investigated.*” Unfortunately, a first mode frequency below 1 hertz is often used by design engineers as a test to determine if a wind tunnel investigation is necessary. However, Sections C26.2 and C26.9 indicate that load magnification effects in flexible structures are already accounted for by the gust effect factor, G_f , meaning a wind tunnel investigation may not be necessary unless other building complexities which could cause unusual response characteristics are present.

In order to facilitate the evaluation of buildings likely to experience unusual response under wind loading, the SEAW Wind Engineering Committee has developed the flow chart shown in Figure 1. The series of “check tests,” if triggered, indicate that the response of the structure is beyond the

scope limits inherent to ASCE 7 Chapters 27, 29, or 30, and that a wind tunnel study should be performed.

Figure 1 was developed based upon past experience of factors that influence the dynamic wind loading response of building structures. Due to the complex wind-structure interactions that generate wind design pressures, the checks within Figure 1 should be viewed as characteristic indicators representative of structures that can exhibit wind response beyond the scope of ASCE 7 Methods. Note that the checks within Figure 1 are specifically developed to identify exceptions to the **design** level pressures generated from ASCE Methods and do not identify buildings that may be susceptible to wind generated occupant discomfort or serviceability concerns. With regard to the fourth check of Figure 1, the expected stiffness of the structure during a **design wind event** should be used when establishing the lowest natural frequency (longest period). Consideration of the true levels of cracking and material stiffness within a concrete structure is advised. Additionally, the normalized velocity is based upon the ultimate basic wind speed presented in ASCE 7 Figure 26.5-1 and/ or as denoted by “ V_{ult} ” according to the 2012 International Building Code, Section 1609.3.

Figure 1 - Flowchart
Triggers for Further Wind Engineering Investigation for Primary Lateral Force-Resisting System

June 2016

