IN-VENTO 2026
International Conference of the Italian Association for Wind Engineering
Bari, September 13th – 16th, 2026

BARI

Survey and analysis of wind-induced failures in lightweight metal structures in Italy

E. Maiorana [1], B. Briseghella [2]

[1]*University of the Republic of San Marino, Dogana, San Marino, e.maiorana@unirsm.sm*
[2]*College of Civil Engineering, Fuzhou University, Fuzhou, China, bruno@fzu.edu.cn*

SUMMARY
Steel structures characterized by high slenderness, low mass, and limited inherent damping are particularly sensitive to wind-induced dynamic actions. In recent years, numerous collapses of lightweight metal structures—such as canopies, scaffolding, cranes, stages, poles, and temporary installations—have been documented in Italy, revealing persistent shortcomings in design, detailing, assembly, and maintenance practices. These failures frequently occur under wind conditions that are not necessarily extreme in absolute terms but become critical when dynamic amplification, resonance phenomena, and fatigue effects are not adequately considered. A survey of documented collapse events over the last fifteen years is presented and discussed in relation to wind speed records and operational thresholds. The analysis highlights that structural damage is rarely attributable to static wind pressure alone, but rather to complex aeroelastic and fatigue-driven mechanisms that are often underestimated in lightweight systems.

Keywords: lightweight structures, wind-induced failures, tolerances.

1. INTRODUCTION

The analytical assessment of wind-induced structural response remains one of the most complex topics in structural engineering, particularly when dynamic effects govern the behavior of slender systems. For conventional massive structures, static wind pressure may provide a sufficiently accurate design approximation. However, when high slenderness ratios, low mass, and limited inherent damping are involved, this simplification becomes inadequate. In such cases, transverse and torsional oscillations induced by vortex shedding and aeroelastic coupling may dominate the structural response, leading to significant stress amplification and potential instability, as discussed in the general wind-loading framework proposed by Solari, 2017.

The importance of properly accounting for dynamic wind–structure interaction has been widely recognized for tall buildings and long-span bridges. Wind tunnel investigations and numerical analyses demonstrate that aerodynamic response is strongly influenced by cross-sectional geometry and Reynolds number effects, which modify flow separation and vortex formation mechanisms (Liu et al., 2023). In typhoon-prone regions, Low-Level Jets (LLJs) further alter boundary-layer wind profiles, significantly affecting the aerodynamic behavior and design requirements of high-rise buildings (Huang et al., 2026). Moreover, structural eccentricities may induce modal coupling and amplify Vortex-Induced Vibrations (VIV), influencing both structural safety and serviceability performance (Song et al., 2024). For long-span suspension bridges, parametric effects caused by atmospheric turbulence can substantially modify aerodynamic damping and stiffness, with direct consequences on extreme response and flutter stability (Barni et al., 2026). Although these studies primarily focus on large and complex structures, a comparable—if not greater—vulnerability can be observed in lightweight metal systems.

This category includes scaffolding, canopies, stages, barriers, poles, and temporary installations composed of thin-walled members and characterized by reduced mass per unit area. Despite their structural simplicity, such systems are often highly slender, and their transverse and torsional responses may far exceed longitudinal effects (Solari, 2017). In practice, these structures are frequently treated with simplified design approaches, even though their dynamic sensitivity may be pronounced. In addition to global dynamic amplification, fluctuating wind loading generates cyclic stresses that accumulate over time, producing fatigue damage.

The progressive degradation of mechanical properties under repeated loading has been quantified through fatigue-damage models that relate residual material properties to accumulated damage variables (Zheng et al., 2025). Welded joints, in particular, are highly susceptible to wind-induced fatigue due to stress concentration effects and intrinsic material degradation under cyclic loading. This vulnerability becomes critical when combined with assembly imperfections, insufficient bracing, or inadequate anchorage systems. Indeed, flexible structural failures caused by below-design wind events behave in ways not typically accounted for in conventional building design (torsional galloping, vortex-induced vibrations, and rain-wind-induced vibrations).

Lessons learned from these failures will enable a relatively better design of flexible structures sensitive to wind and will also enable the development of appropriate theories for forensic engineers (Cheruku, 2022). Furthermore, the development of plastic buckling zones and formation of plastic hinges, considering geometric and material nonlinearity, are the dominant factor in wind-induced failure and collapse of steel reticulated shell cooling towers (Zhao et al., 2024).

Cold-formed light steel structures are especially susceptible to extreme winds because of the light weight of the building and its components. Research on this topic has been conducted around the world for several decades. There are still some problems that need to be further studied on limit states about claddings, purlins, and mainframes. Moreover, it is necessary to make a precise prediction for the response of real light steel structures under extreme wind loads. Performance-based wind engineering methodologies for cold-formed light-frame steel construction is currently unavailable. Performance goals, limit states levels, time-dependent reliability theory, and fragility analysis for the cold-formed steel structural systems exposed to wind hazard could also be the significant research points to be studied in the future (Yang and Bai, 2017).

Current European standards, including EN 1991-1-4 and the Italian Technical Standards for Construction (D.M. 17/01/2018), prescribe the consideration of dynamic effects whenever resonance with gust energy is possible. Recent studies have also emphasized the necessity of dynamic analyses for steel roofing systems subjected to strong gust events, especially under foehn wind conditions (Radoń et al., 2026).

In operational practice, for example in tower cranes, safety manuals clearly define service and out-of-service wind speed thresholds to prevent instability and collapse (Bianchini, 2011).

An area where significant problems are occurring is the installation of photovoltaic panels. Among available technologies, single-axis solar trackers with horizontal mounting are the most cost-effective for energy production. However, cost-driven reductions in structural stiffness have increased vulnerabilities, leading to catastrophic failures caused by aeroelastic phenomena. These instabilities arise beyond a critical wind speed, but a unified criterion to define this threshold remains absent (Carbajosa et al., 2025).

In this context, the present study investigates the vulnerability of slender lightweight metal structures subjected to wind gusts. Through the analysis of documented collapse events and meteorological data, the paper aims to identify recurring failure mechanisms and to emphasize the need for improved dynamic assessment procedures, fatigue-oriented verification criteria, and enhanced resilience strategies in light of increasingly frequent extreme weather phenomena.

Unlike previous studies focused on individual failure mechanisms or specific structural typologies, the present work provides a unified forensic interpretation of wind-induced collapses in lightweight metal structures, demonstrating that failure is predominantly governed by dynamic amplification and system-level vulnerability rather than by exceedance of static design wind loads.

2. COLLAPSE OF LIGHT METAL STRUCTURES

In order to assess the real vulnerability of lightweight metal structures to wind action, a survey of documented collapse events occurring between 2011 and early 2026 was conducted. The information was collected from publicly available online sources, including news reports and technical communications. Although the absence of an official centralized database represents a limitation in terms of completeness and statistical accuracy, the number and frequency of recorded events provide a meaningful qualitative overview of the phenomenon.

2.1. Cases of collapse of metal structures

The collected cases involve a wide range of structural typologies, including scaffolding systems, canopies, temporary stages, cranes, roofs, poles, railings, barriers, and small-span pedestrian structures. These systems share common characteristics: reduced structural mass, thin-walled steel members, limited redundancy, and, in many cases, temporary installation conditions. Their weight per unit area is significantly lower than that of conventional steel bridges or permanent buildings, which increases their sensitivity to dynamic wind excitation. Table 1 lists wind-induced collapses that occurred from 2011 to early 2026, primarily due to strong winds. For information, significant events affecting foreign countries have also been included.

Fig. 1 shows the number of collapses per year. As said, the limitations of the survey include the lack of an official database for recording events, and there may be a highly plausible correlation between the real economy and the presence of, for example, scaffolding, and therefore the likelihood of their collapse. There are also cases of barriers and panels knocked down by the wind but immediately repaired without further damage or made safe before significant damage occurred (Fig. 2).

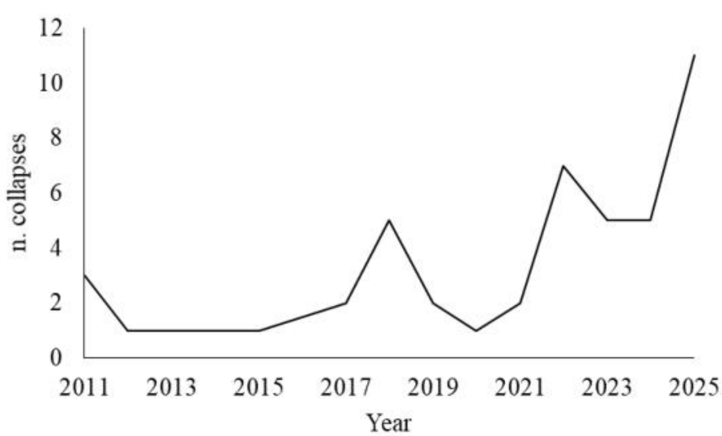


Figure 1. Number of catastrophic events between 2011 and 2026

Table 1. Collapse of lightweight metal structures from 2011 to early 2026

n.	date	place	typology	causes collapse	$v_{b,0}$
1	06/02/2026	Fiano Romano (Roma)	canopy	strong wind	27
2	29/01/2026	Messina	pole	strong wind	28
3	04/01/2026	Castelli Romani	railing	strong wind	27
4	16/12/2025	Guaíba (Brasile)	statue	strong wind (25 m/s)	
5	10/11/2025	Filippine	suspension bridge	strong wind (56 m/s)	
6	21/10/2025	Parigi (Francia)	crane (3)	strong wind	
7	31/08/2025	Agnone Cilento (SA)	stage	strong wind	27
8	30/06/2025	Milano	sign	strong wind	25
9	21/06/2025	Lecco	ferris wheel	failure	25
10	31/05/2025	Torino	crane	strong wind	25
11	09/05/2025	Messico	stage	assembly error	
12	28/01/2025	Roma	crane	strong wind	27
13	19/01/2025	Lanusei (NU)	roof	strong wind	28
14	17/01/2025	Aci San Filippo (CT)	roof	strong wind	28
15	23/05/2024	Messico	stage	strong wind	
16	16/04/2024	Cinisello Balsamo (MI)	roof	strong wind	25
17	01/04/2024	Aversa (CE)	scaffolding	strong wind	27
18	20/01/2024	Lecce	scaffolding	strong wind	27
19	19/01/2024	Ponte San Nicolò (PD)	scaffolding	strong wind	25
20	02/12/2023	Teramo	crane	strong wind	27
21	29/08/2023	Maiorca (Spagna)	canopy	strong wind	
22	23/07/2023	Fiume (Croazia)	crane	strong wind	
23	06/04/2023	Santa Margherita Ligure (GE)	crane	strong wind	28
24	17/01/2023	Napoli	scaffolding	strong wind	27
25	22/11/2022	Viterbo	scaffolding	failure	27
26	18/08/2022	Boara (FE)	scaffolding	strong wind	25
27	13/08/2022	Valencia (Spagna)	stage	strong wind	
28	06/07/2022	Verona	stage	strong wind	25
29	27/06/2022	Bassano del Grappa (VI)	stage	strong wind	25
30	17/04/2022	La Spezia	scaffolding	strong wind	28
31	27/02/2022	Empoli (FI)	scaffolding	assembly error	27
32	18/12/2021	Torino	crane	strong wind	25
33	06/12/2021	Viterbo	canopy	strong wind	27
34	23/11/2020	Portico di Caserta (CE)	crane (3)	assembly error	27
35	11/07/2019	Taranto	wind turbines	strong wind	27
36	26/02/2019	Pescopagano (PZ)	crane	strong wind	27
37	29/10/2018	Roma	scaffolding	strong wind	27
38	22/10/2018	Jesolo (VE)	stage	failure	25
39	05/07/2018	Bellaria (RN)	roof	strong wind (28 m/s)	25
40	25/02/2018	Venezia	pole	strong wind	25
41	16/01/2018	Corigliano Calabro	canopy	strong wind	27
42	04/01/2018	S. Teresa di Riva (ME)	stage	strong wind (28 m/s)	28
43	18/12/2017	Porto Alegre (Brasile)	stage	strong wind	
44	22/05/2017	Bari	scaffolding	strong wind	27
45	02/11/2015	Piedimonte Matese (CE)	canopy	strong wind	27
46	10/01/2014	Pescara	stage	strong wind	27
47	17/07/2013	Genova	stage	strong wind	28
48	05/03/2012	Reggio Calabria	stage	failure	28
49	12/12/2011	Trieste	stage	assembly error	30
50	19/08/2011	Hasselt (Belgio)	canopy	assembly error	
51	14/08/2011	Indianapolis (USA)	pole	strong wind	

Figure 2. Barriers and panels subjected to wind and collapsed.

Table 1 shows that 82% of the collapses are attributed to strong winds, 10% to assembly errors and 8% to (operational/configurational) failure. Since a significant fraction of failures occurs at wind speeds comparable to or lower than design reference values, it is possible that failure is governed by dynamic amplification rather than static exceedance.

3. ANALYSIS OF THE CAUSES OF THE COLLAPSES

The predominant triggering factor in the surveyed events is strong wind, often described as gusts, downbursts, or uplift phenomena. In several cases, wind speeds were reported in the range of 25–30 m/s or higher, corresponding to storm or high-storm conditions.

However, collapses were not exclusively associated with extreme wind intensities. Some failures occurred under wind velocities that, while significant, were not extraordinary when compared with regional design reference values. This suggests that dynamic amplification, resonance effects, or fatigue-related deterioration may have played a decisive role. In addition to wind intensity, failures emerge from the interaction of:

- Structural vulnerability (insufficient bracing or global instability, particularly in scaffolding and stage structures, connection failures, especially in welded joints subjected to cyclic stresses);
- Execution deficiencies (assembly errors, including improper tightening of bolts, incomplete bracing systems, or incorrect installation sequences, inadequate anchorage to the ground or supporting structure, leading to overturning or uplift);
- Aerodynamic amplification (for the presence of tarpaulins or protective panels, which increased aerodynamic pressure through the so-called "sail effect");
- Dynamic excitation (material degradation or fatigue accumulation, particularly in systems exposed for prolonged periods).

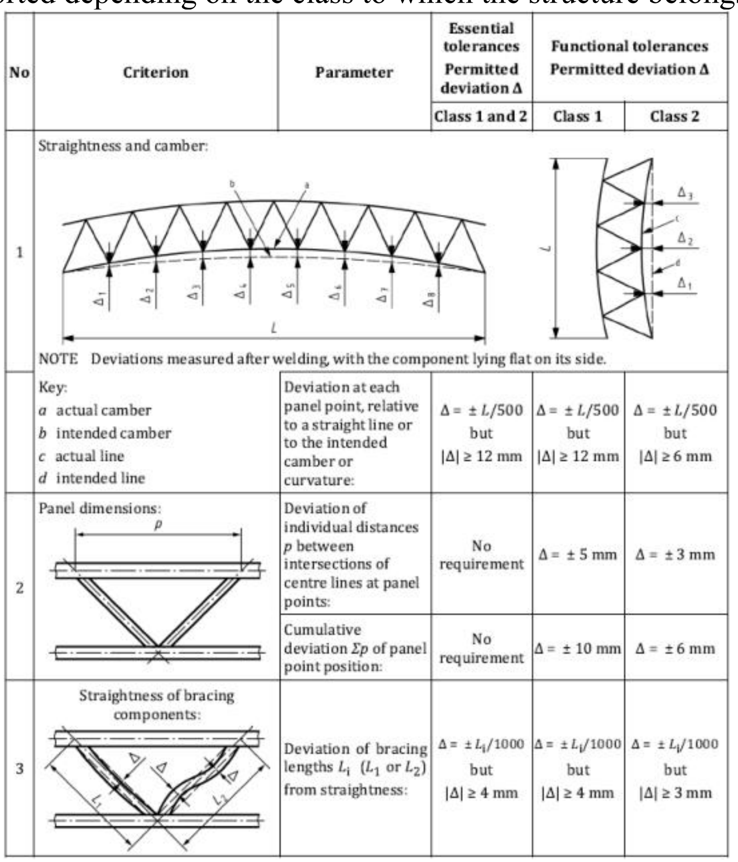
Nevertheless, the recurrence of wind-induced failures suggests that these prescriptions are not always adequately implemented or verified, particularly in temporary or lightweight installations. Over the past fifteen years, numerous collapse events involving lightweight metal structures have been reported, often associated with strong gusts, downbursts, uplift phenomena, design errors, or assembly deficiencies. These repeated incidents indicate that structural damage is rarely attributable to static wind pressure alone; instead, complex dynamic mechanisms—including vortex shedding, flexural–torsional instability, uplift effects, and fatigue accumulation—play a decisive role. While the collapse of scaffolding is related to the presence of tarps, the crane collapses, that represent a significant subset of the recorded events, have more complex causes

Although operational manuals clearly define service wind speed limits and prescribe specific out-of-service configurations (Bianchini, 2011), several incidents indicate either unexpected gust intensification or non-compliance with operational safety procedures. Similarly, temporary stages

and event-related structures frequently exhibit vulnerability due to rapid assembly, limited redundancy, and the addition of non-structural elements that substantially increase exposed surface area.
The annual distribution of collapse events shows variability over time, with certain years characterized by a higher concentration of incidents. However, the interpretation of these data must consider possible external influences, such as fluctuations in construction activity levels or reporting bias. Furthermore, numerous minor incidents—such as barriers or temporary elements displaced by wind and immediately restored—are unlikely to be systematically documented, suggesting that the actual frequency of wind-induced structural distress may be underestimated. Overall, the surveyed cases highlight a recurring pattern: lightweight metal structures, particularly when temporary or insufficiently detailed, are highly susceptible to dynamic wind effects.
For lightweight systems, the combination of slender geometry, low mass ratio, limited damping, and vulnerable connection details creates conditions in which even moderate gust events may lead to disproportionate structural consequences for vortex-induced and aeroelastic instabilities. These observations reinforce the need for improved dynamic verification procedures, stricter assembly control, and enhanced fatigue-oriented design criteria for lightweight metal systems.

3.1 Geometric tolerances

The EN 1090-2:2018 standard contains useful indications for the geometric-dimensional verification of the straightness tolerances of the components of lattice girder which could be used, together with the other requirements for the periodic verification of the structures.
Fig. 3 shows, as an example, one of the many tables in Annex B where the permitted deviations in straightness are reported depending on the class to which the structure belongs.



No	Criterion	Parameter	Essential tolerances Permitted deviation Δ	Functional tolerances Permitted deviation Δ	
			Class 1 and 2	Class 1	Class 2
1	Straightness and camber: NOTE Deviations measured after welding, with the component lying flat on its side.				
	Key: *a* actual camber; *b* intended camber; *c* actual line; *d* intended line	Deviation at each panel point, relative to a straight line or to the intended camber or curvature:	$\Delta = \pm L/500$ but $\lvert\Delta\rvert \geq 12$ mm	$\Delta = \pm L/500$ but $\lvert\Delta\rvert \geq 12$ mm	$\Delta = \pm L/500$ but $\lvert\Delta\rvert \geq 6$ mm
2	Panel dimensions:	Deviation of individual distances *p* between intersections of centre lines at panel points:	No requirement	$\Delta = \pm 5$ mm	$\Delta = \pm 3$ mm
		Cumulative deviation Σp of panel point position:	No requirement	$\Delta = \pm 10$ mm	$\Delta = \pm 6$ mm
3	Straightness of bracing components:	Deviation of bracing lengths L_i (L_1 or L_2) from straightness:	$\Delta = \pm L_i/1000$ but $\lvert\Delta\rvert \geq 4$ mm	$\Delta = \pm L_i/1000$ but $\lvert\Delta\rvert \geq 4$ mm	$\Delta = \pm L_i/1000$ but $\lvert\Delta\rvert \geq 3$ mm

Figure 3. Table B.12 – Manufacturing tolerance – Lattice components [14]

4. REFERENCE SPEED FOR CRANE OPERATION

On the other hand, the catastrophic effects of wind load on crane stability are well known, and the user manuals indicate the atmospheric conditions under which the machine should be taken out of service (Solari, 2017). With reference to wind speed, construction site operations are generally suspended for wind speeds equal to or greater than 72 km/h (20 m/s), known as the "limit service speed"; at this speed, the corresponding specific pressure is 250 N/m^2, or 25 kg/m^2. At the end of service or in any case before leaving the crane, the hook must be raised under the arm and the arm must be left free to rotate under the pressure of the wind. Assembly and disassembly operations must be carried out in the absence of wind. The maximum permitted speed is 10 km/h (2.7 m/s). Furthermore, while in the absence of wind the surface area of the lifted loads is not subject to limitations, as the wind speed increases the exposed surface area undergoes a proportional reduction: near 20 m/s the exposed surface area must be less than 1 m^2, with 10 m/s winds, it must be less than 2 m^2. Table 2 provides a scale for defining wind strength, the corresponding name, speed, and effect; a speed of 20 m/s corresponds to a "wind storm", grade 8.6. It should be noted that the operational logic of cranes is different from that of scaffolding/stages which do not have such rigid protocols.

Table 2. Correlation between wind speed degree and effect

Wind strength		Speed	
grade	denomination	m/s	km/h
0	calm	0 – 0.2	1
1	light	0.3 – 1.5	from 1 to 5
2	light wind	1.6 – 3.3	from 6 to 11
3	light breeze	3.4 – 5.4	from 12 to 19
4	moderate breeze	5.5 – 7.9	from 20 to 28
5	fresh breeze	8.8 – 10.7	from 29 to 38
6	strong wind	10.8 – 13.8	from 39 to 49
7	very strong wind	13.9 – 17.1	from 50 to 61
8	wind storm	17.2 – 20.7	from 62 to 74
9	storm	20.8 – 24.4	from 75 to 88
10	high storm	24.5 – 28.4	from 89 to 102

4.1.Regional wind monitoring network

For the purposes of environmental monitoring and meteorological forecasting, Italy is equipped with an extensive network of automatic weather stations that continuously record wind speed and direction through calibrated anemometric systems. In the Veneto region alone, approximately 300 monitoring stations are operated by the Regional Agency for Environmental Prevention and Protection (ARPAV), providing a reliable and spatially distributed dataset for wind characterization. To obtain a representative assessment, the data from a reference station may be considered. In this study, the Legnaro station (no. 111), located near Padua, is selected as a case example. The analysis focuses on characteristic wind parameters, comparing recorded mean, peak, and gust wind speeds ($v_{average}$, v_{max} and v_{blast}) with the standard reference base wind speed at sea level ($v_{b,0}$), limit service value ($v_{limit\ service}$) and the operational service limit ($v_{operational\ service\ limit}$). The temporal evolution and mutual relationship among these velocity parameters during the last fifteen years are illustrated in Fig. 4.

Fig. 5 illustrates, for the period from 2011 to 2025, the frequency with which recorded wind speeds exceeded two critical operational thresholds: the operational service limit (v > 2.7 m/s), exceeded on average per month, and the limit service speed (v > 20 m/s), in the year.

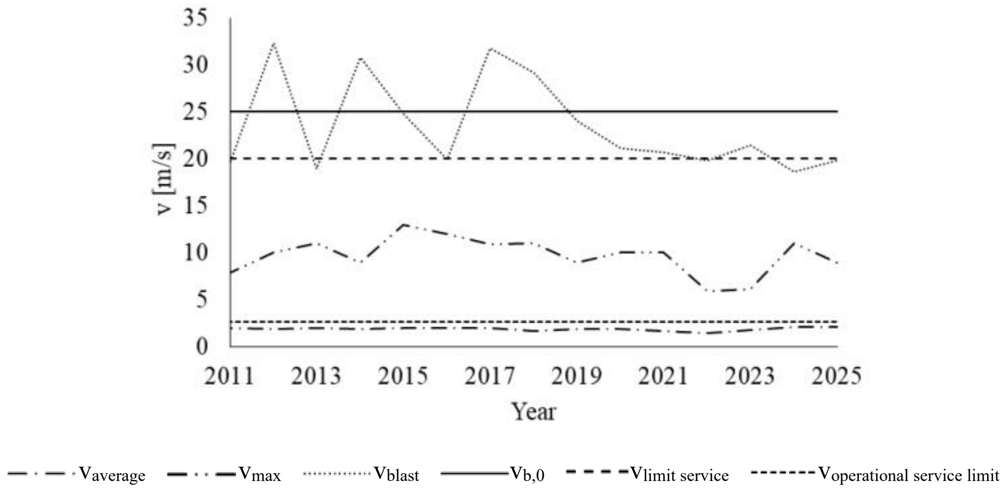


Figure 4. Speed vs. base year

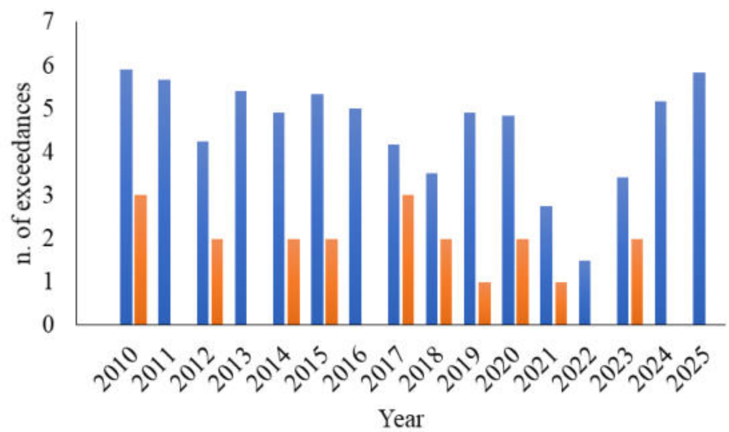


Figure 5. Number of times the operational service limit (v > 2.7 m/s) on average per month and the limit service speed (v > 20 m/s) in the year was exceeded.

On average, the assembly wind speed threshold is exceeded approximately five times per month, while the maximum service speed is surpassed about once per year. The most severe recorded gust during the examined period reached 32.3 m/s and occurred in September 2012 at 4:05 PM. The windiest months correspond to the spring and autumn seasons.

Considering the safety factors adopted for SLU and SLE combinations checks, from a design point of view it would appear that no further modifications are necessary.

However, dynamic effects due to the wind together with a very narrow tolerance with respect to the co-cause with other factors, can be very critical, even for structures with a very limited-service life. Despite clear operational thresholds, recorded wind exceedances are frequent, indicating that lightweight structures regularly operate near critical dynamic regimes.

5. CONCLUSIONS

The evidence collected over the past fifteen years clearly shows that lightweight metal structures are particularly vulnerable to wind-induced actions, especially when characterized by high slenderness, low mass, and limited damping capacity. The survey of documented collapses highlights a recurring pattern in which strong wind gusts—often in combination with design deficiencies, inadequate bracing, assembly errors, or insufficient anchorage—trigger dynamic phenomena that are frequently underestimated in ordinary design practice. The analysis confirms that the failure mechanisms are rarely attributable to static wind pressure alone. Instead, oscillatory effects such as vortex shedding, flexural–torsional coupling, uplift, and fatigue accumulation in critical details—particularly welded joints and bolted connections—play a decisive role in structural collapse.

The evidence suggests that current design practices, when based primarily on static wind pressure, are not structurally conservative for lightweight systems, even when code-compliant.

The progressive deterioration of mechanical properties under cyclic loading further increases the fragility of these systems over time, especially when inspection and maintenance are inadequate. Meteorological data show that wind speeds exceeding operational and serviceability thresholds are not exceptional events. Even in regions not traditionally classified as extreme-wind areas, gusts beyond assembly limits occur several times per month, while service-limit speeds may be exceeded annually. In the context of climate change and the increasing frequency of intense atmospheric phenomena, these occurrences are likely to become more critical. The findings underline the necessity of adopting a more rigorous dynamic approach in the design and verification of slender lightweight structures, in accordance with current standards, whenever resonance or fatigue phenomena may arise. Particular attention should be paid to bracing systems, connection detailing, anchorage design, and the aerodynamic effects introduced by temporary elements such as tarpaulins or protective panels. Finally, the absence of a comprehensive and official database of wind-induced collapses represents a significant limitation for systematic risk assessment.

Establishing structured monitoring and reporting procedures would improve statistical reliability, support the calibration of predictive models, and enhance the resilience of lightweight metal structures. Greater awareness, stricter control during assembly, and improved fatigue-oriented design criteria are essential steps toward reducing future catastrophic events.

ACKNOWLEDGEMENTS

The University of the Republic of San Marino is gratefully acknowledged for the support in the framework of the Research Project PRIU2024: "Progettazione Sostenibile e Tecnologie Avanzate per il Settore delle Costruzioni: Caratterizzazione e Analisi di Materiali e Sistemi Strutturali Innovativi ed Ecocompatibili".

REFERENCES

Barni, N., Øiseth, O., Peterson, Ø.W. and Mannini, C. (2026). Long-term wind-induced response of suspension bridges including static response, flutter stability, and parametric effects of turbulence. Journal of Wind Engineering & Industrial Aerodynamics 271, 106365.

Bianchini, G. (2011). Manuale della sicurezza per l'uso delle gru a torre, I quaderni della SEB (Scuola Edile Bresciana).

Carbajosa, C., Hernández-Badillo, C., Cárdenas-Rondón, J.A., Marín-Coca, S. and Martíz-Cava A. (2025). Self-excited critical wind speed and uncertainty determinations. Renewable Energy 255, 123640.

Cheruku, S. (2022). Wind-induced failures of flexible structures. In Forensic Engineering, 403-410.

D.M. 17/01/2018. Aggiornamento delle «Norme tecniche per le costruzioni». Supplemento ordinario alla "Gazzetta Ufficiale" n. 42 del 20 febbraio 2018 - Serie generale.

EN 1090-2:2018. Execution of steel structures and aluminium structures. Part 2: Technical requirements for steel structures.

Huang, X., Hu, G., Gong, J., Yuan, C., Li, C., Huang, Z. and Li, L. (2026). Wind tunnel investigation of high-rise building aerodynamics under typhoon wind profiles featuring low-level jets. Journal of Wind Engineering & Industrial Aerodynamics 271, 106366.

Liu, Y.J., Fu, J.Y. and He, Y.C. (2023). Effects of Reynolds number on wind effects toward a super-tall building with curved cross-section. Journal of Building Engineering 64, 105660.

Radoń, U., Zabojszcza, P. and Szaniec, W. (2026). Dynamic response of the steel roof covering to strong gusts of foehn wind. Advances in Science and Technology Research Journal 20(2), 402-416.

Solari, G. (2017). Wind Loading of Structures: Framework, Phenomena, Tools and Codification. Structures 12, 265-285.

Song, J., Hu, G., Pan, X., Zou, L., Shen, L. and Lei, X. (2024). Investigation on vortex-induced vibrations of square-sectioned high-rise buildings with various structural eccentricities. Engineering Structures 319, 118828.

Yang, N., Bai, F. (2017). Damage analysis and evaluation of light steel structures exposed to wind hazards. Applied Sciences 7(3), 239.

Zhao, X., Zhao, L., Qian, J. and Chen, Y. (2024). Wind-induced collapse mode and mechanism of super-large hyperbolic steel reticulated shell cooling tower with stiffening rings. Engineering Structures 321, 118985.

Zheng, X.-W., Deng, Y., Li, X.-L. and Gardoni, P. (2025). Fatigue damage assessment of wind-excited tall steel buildings with the effect of crosswind responses and uncertain variables. Journal of Building Engineering 116, 114689.