

Wind turbulence and cranes

EDUARDO ESTELLES from Glasgow, Scotland-based energy and weather monitoring specialist Logic Energy, explains wind turbulence and why it should be monitored

A crane is essentially a metallic structure and, like all structures, it has elements and joints that can only tolerate a certain amount of force before they fail. Of course, the forces required to cause failure are extremely high for a metallic crane which is built to hoist equipment weighing many tonnes. However, there is another form of structural failure, called fatigue failure, that can occur at much lower effort levels.

Fatigue failure can occur when machinery is subject to strong cyclical forces. These forces are very dangerous, since they can damage mechanical devices at a much lower load than is normally tolerated. Tower cranes experience these forces when exposed to turbulent wind and they are added to any load present if the crane is operating.

All structures, including tower cranes, have a natural frequency at which they tend to vibrate in response to external forces. If turbulent wind produces a variable force close to the natural frequency of a crane, vibration increases dramatically. This behaviour is called resonance, and it can occur even with relatively light loads.

Since turbulent wind can cause resonance and fatigue failure in tower cranes, it must be kept under watch in construction projects where these cranes are used. Wind

monitoring solutions tend to focus only on wind speed and direction, overlooking turbulence in many cases.

What is wind turbulence?

In simple terms, we can define wind turbulence as the degree of randomness in wind movement. We tend to associate turbulence with a high wind speed, but this is not always the case. Low-force winds that change a lot can be considered turbulent even if they aren't strong. The opposite also applies: wind can be strong and not necessarily turbulent, if its speed is steady.

Turbulence in the wind is invisible but it would appear as random vortices in all directions if it could be seen. Any wind that displays this movement pattern is considered turbulent, regardless of its strength.

When wind speed is measured it is possible to calculate an average speed value. Then, if wind turbulence is present, it appears as ongoing variation above and below the average speed. A turbulent 30 mph wind feels very different from a stable 30 mph wind, even if the average speed is the same in both cases. This is why a fast and accurate measurement system is required to detect turbulence.

Quantifying wind turbulence

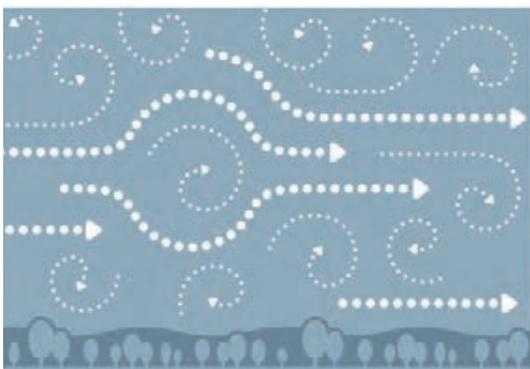
As discussed above, the average wind speed value does not tell us anything about turbulence. Instead, we must analyse how much the wind speed changes above and below the average value.

As an example, let's assume the average wind speed is 30 mph. If the actual wind speed ranges from 27 to 33 mph, it will be perceived as steady – there is little variation. On the other hand, if wind speed ranges from 15 to 45 mph it will be perceived as very turbulent as there is drastic variation. However, the average wind speed is 30 mph in both cases so the average value does not tell us anything about turbulence.



Since turbulent wind can cause resonance and fatigue failure in tower cranes, it must be kept under watch. Here ALE is using a tower crane to erect a wind turbine in Thailand (see the *wind turbine erection* feature on p25 for more info)

Turbulence intensity (TI) is the percentage variation of wind speed above and below the average value. Continuing with the example above, in the first case the wind speed varies by 3 mph above and below the average value of 30 mph, so we have a TI of only 10 percent. In the second case it changes by 15 mph above and below the average, so we have a TI of 50%. »



Turbulence in the wind would appear as random vortices in all directions

Also note that turbulence intensity is relative. The variation of 3 mph is only 10 % at 30 mph. However, if we have another site where the average wind speed is 12 mph, the 3 mph variation represents 25 %.

The importance of monitoring

Construction companies must manage multiple projects with different site conditions, and this includes the wind. Although weather monitoring is always important, it is critical when tower cranes are in operation, since they are susceptible to harsh weather.

If a monitoring system only tracks average wind speed, and the same value is displayed for two construction sites, it can give the wrong impression that wind conditions are the same. On the other hand, if the first site has 5 % TI and the second has 50 % TI, the difference is evident. In this case, project managers can suspend crane operation in the second site until the wind calms down.

When it comes to safe crane operation, average wind speed only tells part of the story. Keep in mind that cranes are vulnerable to strong winds, but they can also be affected by turbulence even at moderate wind speeds.

Safe operation is extremely important when dealing with tower cranes, since accidents are almost always severe. Consider



Prevention is the best solution, says Eduardo Estelles, who recommends construction managers use a reliable wind monitoring system such as Windcrane

all the damage caused if an operational tower crane collapses due to turbulent wind. First, human consequences are very likely; construction workers and bystanders can suffer injuries or may even lose their lives. Second, the tower crane could be damaged beyond repair, along with any equipment it was lifting when the accident occurred. Third, if the crane falls towards the structure being built, damage is certain; portions of the building may collapse, along with the crane. Adjacent buildings can also suffer damage, in

which case severe lawsuits can be expected.

It is not an exaggeration to say that a crane accident can mean bankruptcy for a construction company. This article does not intend to scare readers but being aware of the potential consequences of crane accidents is important. Prevention is the best solution so with a reliable wind monitoring system, such as the Windcrane system that measures turbulence intensity, construction managers can suspend crane activities because of potentially dangerous weather. ■



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