STUDY OF STATICAL ANALYSIS ON INTEGRATED BUILDING OF STEEL STRUCTURES WITH WIND TURBINES

Abhijit Palit[1], Dr. Pankaj Singh[2]

[1]*Research Scholar, Department of Civil Engineering, Faculty of Engineering, SRK University, M.P. India*
[2]*Professor, Department of Civil Engineering, Faculty of Engineering, SRK University, M.P. India*

ABSTRACT

In this proposed work we have gone through the study of Structural Analyses of Wind Turbine Tower for small 5 kW Horizontal Axis Wind Turbine is presented. First, some standard graph aspects of the wind turbine tower are discussed: types, heights, and some other factors that can be viewed for the analysis of wind turbine tower. Wind turbine tower diagram is presented, highlighting its primary layout features.

Keyword: - *Wind Turbine Tower Design1, Wind Turbine Tower Load2, Finite Element Analysis3, Seismic Analysis4.*

---

1 INTRODUCTION

People have long used wind to travel across the oceans and round the world till the steam engine used to be invented. It promoted international buying and selling and led to the discovery of “new India". Nowadays, wind is used for generating electrical energy which is a vital aspect to contemporary each day lives. Indeed, it is increasingly getting greater famous than traditional strategies of producing electrical energy and there are right reasons for it. Traditional methods of producing electric power are based totally mostly on the use of fossil fuels such as coal, petroleum, or natural gas. One of the important contributors to greenhouse gases, carbon dioxide (CO2), is emitted in large extent in the use of such electricity sources. Many are worried with steeply inclining CO2 stages in the atmosphere as it is directly linked to international warming. In a file to limit the emission levels, many nations have signed a global agreement called the Kyoto Protocol. The Kyoto Protocol is a linked to the Unite Nations framework convention on local weather change. The predominant function of the Kyoto Protocol sets binding objectives for 37 industrialized countries and the European neighborhood for decreasing greenhouse fuel emissions. One of the methods to obtain this goal is to locate and develop approaches to harness easy alternative power sources such as wind. Finding and securing fossil fuels can be a mission as many other countries desire them and many of them are sourced from regions that are not pretty politically stable. Foreign dependency on fossil fuels has precipitated economic chaos before and there is no assurance that it will no longer take place again despite many efforts and measures to stop it. A suitable instance is the 1973 oil crisis when the participants of the Organization of Arab Petroleum Exporting Countries or the OAPEC (consisting of the Arab members of OPEC, plus Egypt, Syria and Tunisia) placed an oil embargo in response to the choice of the U.S. to resupply the Israeli military in the course of the Yom Kippur War. Wind is abundant in nature and there is no want to compete for it. Therefore, renewable power sources such as wind power and solar power have emerged as outstanding sources of choice electricity to step by step change fossil fuels. We can witness the shift globally. Still, some are skeptical about the use of wind as a strength source. Let's seem to be at some statistics about wind electricity as a power source, especially electricity. The wind strength usage and potential are swiftly growing in the manufacturing of electricity. The ability in electrical energy manufacturing from wind strength expanded from round 2.5 GW to 94 GW at the end of 2007, which corresponds to an annual increase of 25% [1]. One of the reasons that contribute to the speedy growth of wind strength utilization is its competitive cost. Wind energy has the lowest ordinary value of all renewable electricity

sources and now it is nearly competitive with traditional strength sources, even barring environmental credits. It is due to many investments and lookup for growing the technologies to harness the wind energy. The dramatic decrease in the price of electricity (COE) from wind over the past two decades is due to improvements in aerodynamics, materials, controls systems, electronics, and reliability that reduce maintenance costs [2].

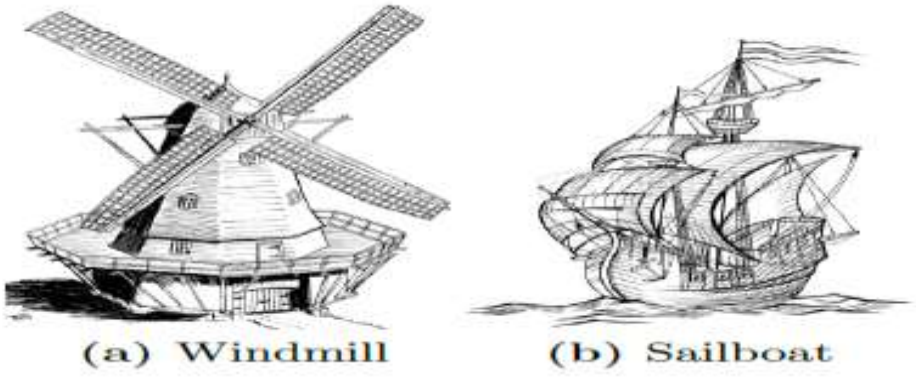

Figure 1.1: Traditional use of wind turbines

The wind turbine tower performs an essential role in in addition decreasing the value of wind energy. It can be finished by using the most fulfilling format of the tower, and placing the turbine at greater elevations where extra wind can be captured.

1.1.1 Minimizing Cost: Among the prices of the wind turbine system, the wind turbine tower cost may additionally represent as lots as 20% of an entire megawatt-scale horizontal axis wind turbine and 10% of the whole price of power [2]. It actually cost an extra around 10 lakhs on common to amplify the height with the aid of 10 m. Optimally designed towers and basis structures are key to limit the value of the wind turbine system. Tower optimization and advanced structural analyses are lively lookup areas.

1.1.2 Challenge of Putting It Higher: The wind turbine tower holds the wind turbine at the indispensable elevation and supports all the masses that the wind turbine experiences.

There are increasing needs for a greater tower because the wind pace is greater and more uniform at greater elevation (less boundary layer, wind shear). The wind turbine would be capable to capture more wind strength at higher height. But a greater peak effects in greater masses imposed on the tower. The venture is to make a safe shape with a lifelike value with the extra constraints imposed with the aid of transportation and installation.

1.2 Small Wind Turbine (SWT) System

The International Electro-technical Commission (IEC) is the world's leading agency that prepares and publishes worldwide requirements for all electrical, electronic and associated technologies, jointly recognized as electro science [3]. Small-scale wind generators have special traits and graph needs compared with large turbines.

A need for the standardization and format tips for the new class of wind turbine emerged. The IEC installed a popular IEC61400-2: Design Requirements for Small Wind Turbine, which deals with security philosophy, pleasant assurance, and engineering integrity and specifies requirements for the security of Small Wind Turbines (SWT) such as design, installation, upkeep and operation underneath distinct exterior conditions. Its purpose is to furnish the gorgeous level of safety in opposition to damage from dangers from these systems at some point of their planned lifetime [4]. Although this trendy establishes useful graph guidelines, it is slowly adopted by using industry due to the fact it is tough and high-priced to apply [5]. So, when situations allowed, the IEC trendy used to be employed for a diagram or an analysis in this project.

According to the Small Wind Turbine (SWT) is labeled as having a rotor swept location smaller than 200 m^2 (16 m in diameter) generating at a voltage under 1600 V AC or 2100 V DC. Additionally, the popular states that if the rotor swept location are larger than 2 m^2, then all the support buildings shall be protected as a part of the SWT system. The support buildings refer to the wind turbine tower and foundations and they are vital structure elements as their dynamic characteristics and load carrying capacities at once have an effect on the overall performance of the wind turbine.

It is really useful to seem at the modern-day diagram practices and developments of the small wind turbine machine as a whole before discussing the graph of particular component. Wind Energy - The Facts is a collection of technical articles about wind mills that have been prepared by using the main wind turbine

industry experts. The current fashion in the layout of a standard horizontal-axis SWT is reviewed and summarized [5]:

(a) Rotor blades:

In general, three blades are popular for the SWT.

- Design closer to decrease height working velocity which offers decrease noise emission.
- Typical sketch rotor-tip speed to wind speed ratio is 5:1.
- Rotor diameter is much less than 10 m. Trend is toward large rotors.

(b)Tower:

Height is between 12 to 24 m, The trend is closer to a taller tower, using a steel tubular structure.

(c).Generator:

- Synchronous permanent magnet generator
- Use uncommon earth permanent magnet as a substitute than ferrite magnet for gold standard magnetic properties.

(d).Regulation control for gust events:

- Use of yawing or furling - The rotor is grew to become out of the wind passively, through aerodynamic forces
- Alternative technique - mechanical brake, dynamic brake, stall control, pitch control.

1.3. Project Status

The wind turbine nacelle was once designed by my team of postgraduate civil engineering students for their senior tasks. The rotor, which consists of carbon per blades and an aluminum hub, used to be developed and manufactured by way of two civil engineering graduate students. The foundation plan and site soil analysis have been finished with the aid of a team of civil engineering college students and school members and organizations who specialize in geotechnical engineering. A civil engineering student is currently working on the computational useful resource modeling of the wind turbine site place to determine the excellent spot to install future wind turbines.

1.4 Historical Potential

The wind turbine first came into being as a horizontal axis windmill for mechanical strength generation, used because 1000 AD in Persia, Tibet and China. Transfer of mechanical windmill technology from the Middle East to Europe took area between 1100 and 1300, accompanied via further improvement of the science in Europe. During the nineteenth century many tens of lots of modem windmills with rotors of 25 meters in diameter were operated in France, Germany and the Netherlands, most of the mechanical electricity used in enterprise was once based on wind energy. Further diffusion of mechanical windmill technology to the U finite States took vicinity all through the nineteenth Century. The earliest recorded (traditional) windmill dates from the 12 months 1191 at the Abbey of Bury St Edmunds in Suffolk. It changed animal electricity for grinding grain and different farm things to do like drawing water from well, the recognition of wind generators expanded noticeably and they quickly dotted the landscape. The creation of DC electric powered power in 1882, and introduction of 3-phase AC strength production in the early 1890s, provided a technological basis for setting up wind turbines that generated electricity. The Danish scientist and engineer Poul La Cour is the most widely recognized pioneer of electricity generation the use of wind power. In 1891 in Askov, Denmark he brought a 4 shuttle sail rotor plan producing about 10kW of DC electric power. He also applied the DC current for water electrolysis, and utilized the hydrogen fuel for gasoline lamps to light up the local faculty grounds. La Cour's efforts commenced research, development and commercialization of wind electricity in Europe and for this reason Europe received its leadership position in wind electricity generation. Though less diagnosed than La Cour, Charles F. Brush in 1888 delivered in Cleveland Ohio the first routinely operating wind turbine generator, a 12kW, 17-meterdiameter machine, operated for 2

The figure below shows the power versus R.P.M plots for 3 blades, $\psi = 0^0$, $\beta_0 = 4^0$, V_0= 10 m/sec, $R = 46m$, $Chord = 10\ mm$

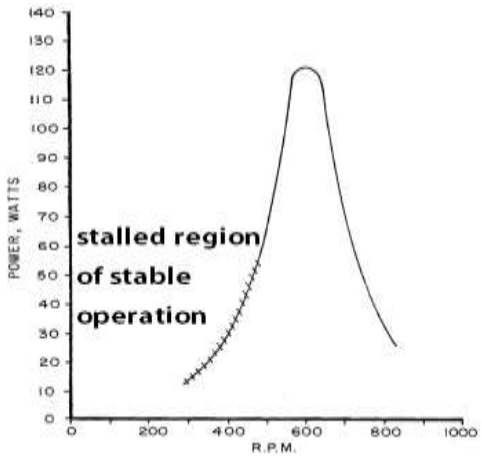

Figure 1.2: Power vs RPM plots

1.5 Formal Description of Blade Problem

Rotating wings have been analyzed as beams with a variety of boundary conditions. Depending on the targeted construction, these beams may additionally be hinged at the root, pinned, or some combination. The outer area free. The simplest rotating winds, are of a rectangular format shape and a single material. For example, extruded aluminum blades are now commercially handy in a variety of sizes. These are the simplest to analyze it will always be viable to discover a set of axes which definitely uncouples the bending deflections in one path from those in the other. These are by means of definition the important axes. They will have the identical orientation for all sections and all loads and moments can be resolved about them.

2. LITERATURE SURVEY

A. Jagadeesh has organized a file on wind strength development in two states of Andhra Pradesh and Tamilnadu along with achievable limitations encountered with the aid of a variety of wind challenge developers. This paper has recognized the troubles confronted and indicated the feasibilities for upcoming initiatives over subsequent two decades. S. Gomathinayagam ,Executive director of CWET has explained the boom of Indian wind industry. He has made a few recommendations to designers and developers, such as selecting the turbine dimension w.r.t the seasonal versions and consequently function web site resolution in most of Indian topographies.

Khalid et al. carried out monetary feasibility through the use of an industrial wind turbine generator and performed monetary analysis. They have taken conceivable websites of Malaysia for the forecasting studies. They cited that annual energy production from a wind turbine is the critical component for the willpower of the viability of a particular web site for wind energy development. Net present value, Internal Rate of Return and Payback period are evaluated.

Dalabeeh et al have demonstrated the techno-economic evaluation of wind power technology for chosen locations in Jordan. They viewed Weibull parameter primarily based wind strength calculation expanded with technology hours. Capacity thing and LCOE estimations are performed for some wind turbine models.

All the above papers inspired the want for wind resource evaluation and web page decision for feasibility studies. After the web site selection, it is crucial to operate wind energy practicable estimation at the new site. Wind speed and wind electricity density be estimated at the chosen site in order to dimension the turbine and in consequence project.

A wind resource evaluation marketing campaign like other technical initiatives requires careful and coordination guided by a clear set of objectives. It frequently receives restrained through slim budgets and schedules. Ultimate success of WRA programme depends upon the satisfactory of the statistics obtained, assembled assets, siting & size techniques, trained staff, excessive fantastic instrumentation & equipment, fabulous information analysis and modeling techniques.

M. Goel et al described one of the first of its sort boundary layer experiments taken up with the aid of authorities of India in 1980's. The expreiments have been carried out to study the atmospheric boundary layer process across the monsoon trough. MONTBLEX observatory towers included surface towers, sodar observations, tethered balloons etc. to set up an operational forecast center. Indigenously designed meteorological gadgets were used. Wind profiles and temperature profiles have been additionally studied up to some extent.

Ignacio et al as phase of ANEMOS assignment mounted quite a number wind monitoring stations in Europe. ANEMOS venture worked more than 20 years in the region of wind energy predictions. As phase of the interaction between lookup institutions and companies, they are now proving latest wind power prediction technology for TSOs, utilities or market machine operators in Australia, the US, the UK, Ireland, Canada, Denmark, Greece, France, Spain, and Portugal. R. Echidna et al defined the wind resource evaluation methods adopted for Adamou and North Cameroon provinces. The recorded values via this programme are daily, monthly and annual mean wind speeds and wind power reachable used to be determined.

Jason et al , presented the kingdom of the enterprise and practices adopted in quite number countries. They have listed out challenges confronted via research communities in WRA analysis. A few of these cutting-edge challenges are – Limited get entry to public data, Validation & Benchmarking methods now not described properly, etc. They have emphasized the importance of having Measure – Correlate- Predict methodology to be accompanied by all industry companions worldwide. They have described an excessive stage model for Distributed wind aid assessment & analysis for more than a few tiers of wind projects.

U.S. Department of Energy and NREL in collaboration with worldwide partners have formed a group and launched SWERA programme (Solar and Wind Energy Resource Assessment) to furnish data on renewable electricity assets for countries and areas around the world. This is now reachable as a free downloadable aid to builders and researchers.

3. RESEARCH GAP

The structural design of a wind turbine supporting structure must provide adequate strength and stiffness; it is need to analysis of same. Here are the few problems that are frequently occurring in wind turbine which need to addresses.

To withstand extreme loads from the highest wind speeds which may occur?

To guarantee fatigue strength/life of all components including support structure.

To provide adequate dynamic behavior and control of deflections by avoiding resonance situations through well balanced natural frequencies in relation to rotation frequency ranges; the vibrational behavior of a wind turbine can be kept under control only when the stiffness and mass parameters of all its components are carefully matched;

Maximum Deflection of blades and tower must be checked so that no contact can occur between the blades and the tower; also, resonance between rotor frequencies and tower Eigen frequencies must be avoided**.**

4. CONCLUSION

For the dynamic analysis, the frequency extraction was once carried out in order to acquire the natural frequencies and the mode shapes of the tower. Using the results, the response spectrum evaluation and the transient dynamic analysis, which are primarily based on the modal superposition method, have been performed in order to see the structure's response for earthquakes that are probable to manifest at the wind turbine set up site.

REFERENCES

[1] The European Wind Energy Association, \Economics of wind," in Wind Energy, The Facts (WindFacts), 2009.

[2] D. Malcolm, \Windpact rotor design study: hybrid tower design," tech. rep., National Renewable Energy Laboratory (NREL), April 2004.

[3] International Electro technical Commission (IEC), \homepage." http://www. iec.ch.

[4] International Electro technical Commission (IEC) Technical Committee 88: Wind Turbines, International Standard IEC61400-2, Wind turbines, Part 2: Design requirements for small wind turbines. IEC, 2nd ed., 2006.

[5] The European Wind Energy Association, \Technology," in Wind Energy, The
Facts (WindFacts), 2009.

[6] K. S. Dahl and P. Fuglsang, \Riso-r-1024 (en): Design of the wind turbine airfoil family riso-a-xx," tech. rep., Riso National Laboratory, December 1998.

[7] Ginlong Technologies, Wind Turbine Permanent Magnet Generator/ Alternator
Ginlong Technologies GL-PMG-3500.

[8] A. Martinez, F. Martinez, D. Nevarez, and Z. Taylor, \Wind turbine nacelle
senior project." Cal Poly, San Luis Obispo, 2009.127

[9] B. Edwards, \Composite manufacturing of small wind turbine blades," Master's
thesis, Cal Poly, San Luis Obispo, 2009.

[10] F. Knox and A. Valverde, \Wind turbine foundation design." Cal Poly, San Luis Obispo, 2010.
[11] J. Manwell, J. McGowan, and A. Rogers, Wind Energy Explained: Theory, de-sign, and application, ch. 6 Wind Turbine Design. John Wiley Sons Ltd., 2nd ed.,2009.
[12] B. A. Babcock and K. E. Conover, \Design of cost-e_ective towers for an advanced wind turbine," Wind Energy, vol. 15, 1994.
[13] P. Gipe, \Wind turbine tower trends."
[14] Det Norske Veritas, Riso National Laboratory, Guidelines for Design of Wind
Turbines, 2nd ed., 2002.
[15] L. Global Energy Concepts, \Windpact turbine design scaling studies technical area 3 - self-erecting tower and nacelle feasibility," tech. rep., National Renewable Energy Laboratory (NREL), March 2001.
[16] A. Huskey and D. Prascher, \Validation of aero elastic model of nordtank 500/37," tech. rep., Riso National Laboratory, November 1997.
[17] G. C. Larsen and P. Volund, \Validation of aero elastic model of vestas v39,"
tech. rep., Riso National Laboratory, April 1998.
[18] A. Huskey and D. Prascher, \Tower design load verification on a 1-kw wind
turbine, tech.rep" National Renewable Energy Laboratory (NREL), January 2005.
[19] Dassault Systemes, Abaqus Analysis User's Manual, 2009.
[20] B. S. Taranath, Wind and Earthquake Resistant Buildings: Structural Analysis and Design, ch. 2 Seismic Designs. Marcel Dekker, 1st ed., 2005.
[21] Bellcore, Network Equipment-Building System (NEBS) Requirements: Physical Protection (GR-63-Core, section 5), 1995.
[22] E. Wilson, \Dynamic analysis using response spectrum seismic loading," CSI
Tech Report, vol. 15, 1994.
[23] Strand7, Use of Damping in Dynamic Analysis, 2011.
[24] I. Prowell and P. Veers, \Assessment of wind turbine seismic risk: Existing literature and simple study of tower moment demand," tech. rep., Sandia National
Laboratories, March 2009.
[25] International Electro technical Commission (IEC) Technical Committee 88: Wind Turbines, International Standard IEC61400-1, Wind turbines, Part 1: Design requirements. IEC, 3rd ed., 2007.
[26] R. D. Cook, Finite Element Modeling for Stress Analysis. John Wiley and Sons, Inc., 1995.
[27] N. Bazeos, G. Hatzigeorgiou, I. Hondros, H. Karamaneas, D. Karabalis, and
D. Beskos, \Static, seismic and stability analyses of a prototype wind turbine steel tower," Engineering Structures, vol. 24, 2002.
[28] R. Huston and H. Josephs, Practical Stress Analysis in Engineering Design,
ch. 20 Flanges. CRC Press, 3rd ed., 2009.