# DESIGN AND ANALYSIS OF WIND TURBINE BY USING POLYMER NANO COMPOSITE MATERIALS

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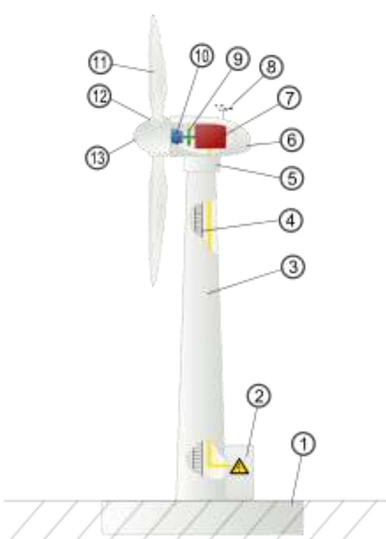
***ABSTRACT:** Wind is a form of solar energy and is a result of the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and the rotation of the earth. Wind is the movement of air from an area of high pressure to an area of low pressure. Humans use this wind flow, or motion energy, for many purposes: sailing, flying a kite, and even generating electricity. In fact, Ancient mariners used sails to capture the wind and explore the world. Farmers use windmills to grind their grains and pump water. In this thesis, the wind turbine blade modeling in CREO parametric software and analyzed for its strength using Finite Element analysis software ANSYS. Structural, modal and fatigue analysis will be done in ANSYS on the different materials (s2 glass, Kevlar, e-glass epoxy, galvanized iron) win turbine blade material galvanized iron replace with s2 glass, Kevlar, e-glass epoxy at different speeds of the turbine rotor.*

## I.INTRODUCTION

**Wind turbine design**

An example of a wind turbine, this 3 bladed turbine is the classic design of modern wind turbines




Wind turbine components : 1-Foundation, 2-Connection to the electric grid, 3-Tower, 4-Access ladder, 5-Wind orientation control (Yaw control), 6-Nacelle, 7-Generator, 8-Anemometer, 9-Electric or Mechanical Brake, 10-Gearbox, 11-Rotor blade, 12-Blade pitch control, 13-Rotor hub.

**Wind turbine design** is the process of defining the form and specifications of a wind turbine to extract energy from the wind. A wind turbine installation consists of the necessary systems needed to capture the wind's energy, point the turbine into the wind, convert mechanical rotation into electrical power, and other systems to start, stop, and control the turbine.

This article covers the design of horizontal axis wind turbines (HAWT) since the majority of commercial turbines use this design.

In 1919 the physicist Albert Betz showed that for a hypothetical ideal wind-energy extraction machine, the fundamental laws of conservation of mass and energy allowed no more than 16/27 (59.3%) of the kinetic energy of the wind to be captured. This Betz' law limit can be approached by modern turbine designs which may reach 70 to 80% of this theoretical limit.

In addition to aerodynamic design of the blades, design of a complete wind power system must also address design of the hub, controls, generator, supporting structure and foundation. Further design questions arise when integrating wind turbines into electrical power grids.

**Aerodynamics**

Main article: Wind turbine aerodynamics

The shape and dimensions of the blades of the wind turbine are determined by the aerodynamic performance required to efficiently extract energy from the wind, and by the strength required to resist the forces on the blade.

Wind rotor profile

The aerodynamics of a horizontal-axis wind turbine are not straightforward. The air flow at the blades is not the same as the airflow far away from the turbine. The very nature of the way in which energy is extracted from the air also causes air to be deflected by the turbine. In addition the aerodynamics of a wind turbine at the rotor surface exhibit phenomena that are rarely seen in other aerodynamic fields.

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**Power control**

The speed at which a wind turbine rotates must be controlled for efficient power generation and to keep the turbine components within designed speed and torque limits. The centrifugal force on the spinning blades increases as the square of the rotation speed, which makes this structure sensitive to overspeed. Because the power of the wind increases as the cube of the wind speed, turbines have to be built to survive much higher wind loads (such as gusts of wind) than those from which they can practically generate power. Wind turbines have ways of reducing torque in high winds.

A wind turbine is designed to produce power over a range of wind speeds. All wind turbines are designed for a maximum wind speed, called the survival speed, above which they will be damaged. The survival speed of commercial wind turbines is in the range of 40 m/s (144 km/h, 89 MPH) to 72 m/s (259 km/h, 161 MPH). The most common survival speed is 60 m/s (216 km/h, 134 MPH).

If the rated wind speed is exceeded the power has to be limited. There are various ways to achieve this.

A control system involves three basic elements: sensors to measure process variables, actuators to manipulate energy capture and component loading, and control algorithms to coordinate the actuators based on information gathered by the sensors.[2]

**Stall**

Stalling works by increasing the angle at which the relative wind strikes the blades (angle of attack), and it reduces the induced drag (drag associated with lift). Stalling is simple because it can be made to happen passively (it increases automatically when the winds speed up), but it increases the cross-section of the blade face-on to the wind, and thus the ordinary drag. A fully stalled turbine blade, when stopped, has the flat side of the blade facing directly into the wind.

A fixed-speed HAWT (Horizontal Axis Wind Turbine) inherently increases its angle of attack at higher wind speed as the blades speed up. A natural strategy, then, is to allow the blade to stall when the wind speed increases. This technique was successfully used on many early HAWTs. However, on some of these blade sets, it was observed that the degree of blade pitch tended to increase audible noise levels.

Vortex generators may be used to control the lift characteristics of the blade. The VGs are placed on the airfoil to enhance the lift if they are placed on the lower (flatter) surface or limit the maximum lift if placed on the upper (higher camber) surface.[3]

Furling works by decreasing the angle of attack, which reduces the induced drag from the lift of the rotor, as well as the cross-section. One major problem in designing wind turbines is getting the blades to stall or furl quickly enough should a gust of wind cause sudden acceleration. A fully furled turbine blade, when stopped, has the edge of the blade facing into the wind.

Loads can be reduced by making a structural system softer or more flexible.[2] This could be accomplished with downwind rotors or with curved blades that twist naturally to reduce angle of attack at higher wind speeds. These systems will be nonlinear and will couple the structure to the flow field - thus, design tools must evolve to model these nonlinearities.

**Blade materials**

Several modern wind turbines use rotor blades with carbon-fibre girders to reduce weight.

In general, ideal materials should meet the following criteria:

- wide availability and easy processing to reduce cost and maintenance
- low weight or density to reduce gravitational forces
- high strength to withstand strong loading of wind and gravitational force of the blade itself
- high fatigue resistance to withstand cyclic loading
- high stiffness to ensure stability of the optimal shape and orientation of the blade and clearance with the tower
- high fracture toughness
- the ability to withstand environmental impacts such as lightning strikes, humidity, and temperature.

## II. LITERATURE REVIEW

The study is an effective traffic accident modeling in minimizing the accident rates depending on road factors and finding the impact of highway geometric elements. Hence, a literature survey was carried out in the field of accident causative factors and accident prediction and optimization modeling and presented as below.

### 2.1 Accident Causative Factors Overview

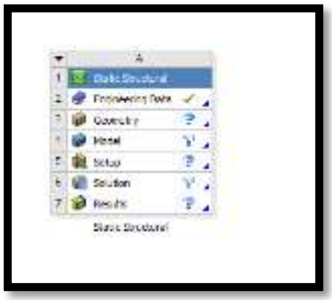
Feng-Bor Lin (1990) studied on flattening of horizontal curve on rural two lane highways and found that horizontal curves on highways are on average more hazardous than tangent sections. As their curvatures increase, horizontal curves tend to have higher accident rates. He suggests that the differences between the 85th percentile speeds and the safe speeds have no statistically significant relationships with the accident rates. In contrast, the magnitudes of speed reduction, when vehicle moves from a tangent section to a curve, have a significant impact on traffic safety. Such speed reductions on horizontal curve with gentle grades are strongly correlated with the curvatures of the curves. Therefore, curvatures can be used as a safety indicator of the curves.

## III. MATERIALS AND METHODOLOGY

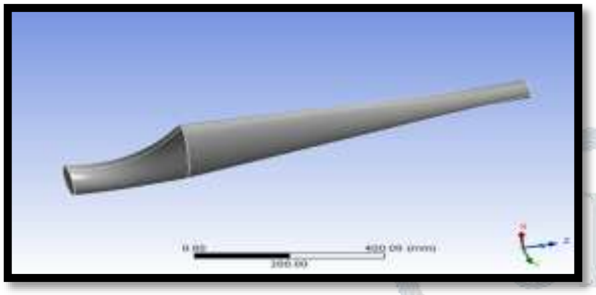
Accident analysis has been carried out in order to determine the effects of different geometric elements of the highway with accident rate of the same highway. These geometric elements are horizontal radius, deflection angle, horizontal arc length, super elevation, rate of change of super elevation, vertical gradient, vertical curve length, K-value and visibility/sight distance. Finally, these geometric elements are statistically analyzed and considered for model development which are statistically significant.

## STATIC ANALYSIS OF WIND TURBINE BLADE

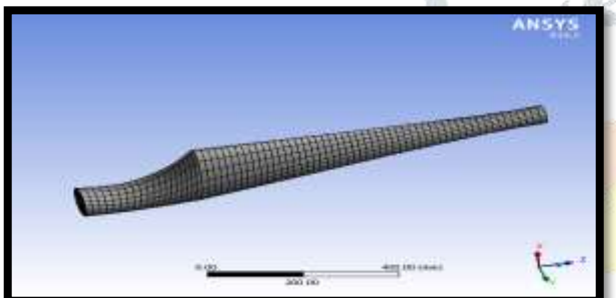
Open ANSYS>Open work bench 14.5>select static structural >double click on it.

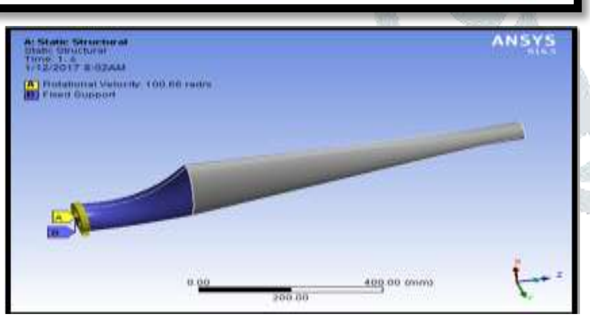


**Imported Model from CREO**



**Meshed Model**

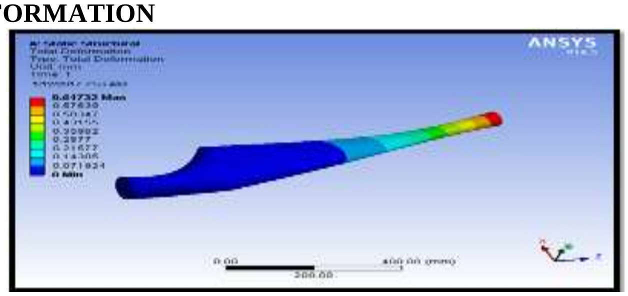




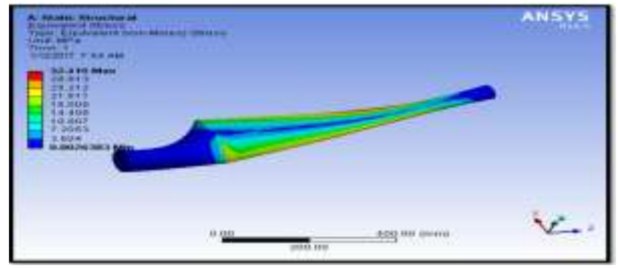
**WIND TURBINE SPEED = 7m/s**

**MATERIAL – GALVANIZED IRON**

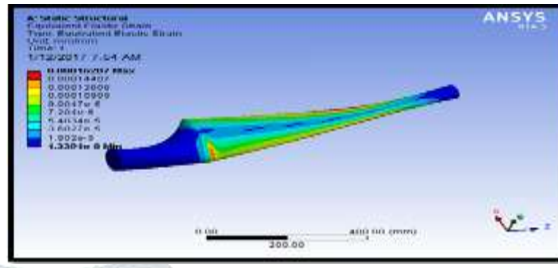
**DEFORMATION**



**STRESS**



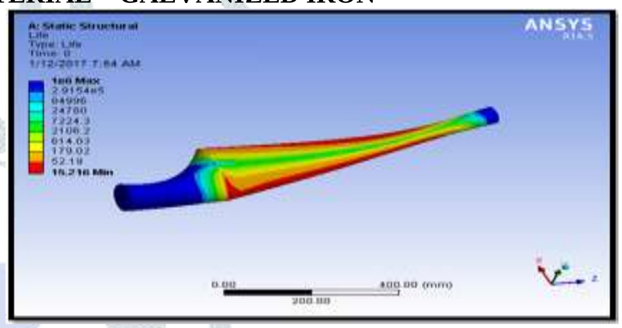
**STRAIN**



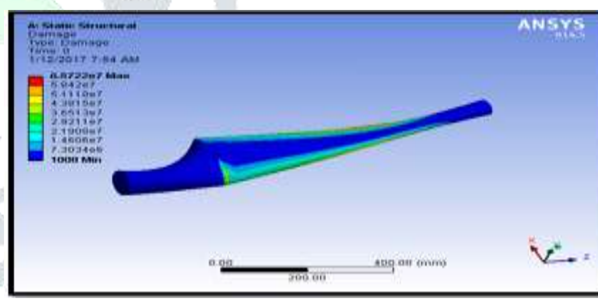
## FATIGUE ANALYSIS OF WIND TURBINE BLADE

**WIND TURBINE SPEED = 7m/s**

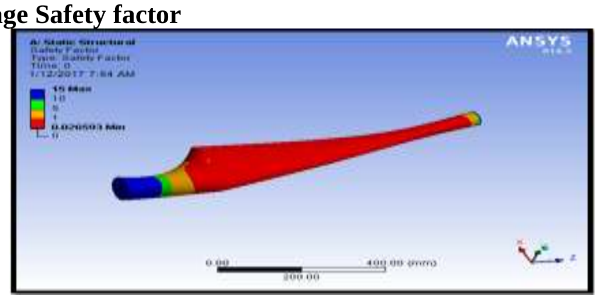
**MATERIAL – GALVANIZED IRON**



**Life**



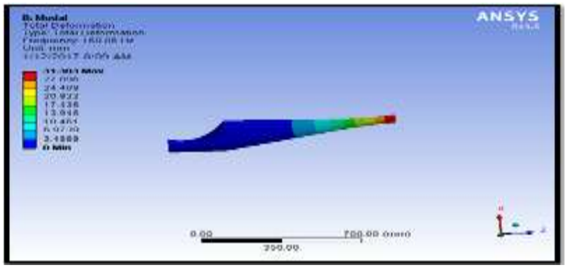
**Damage Safety factor**



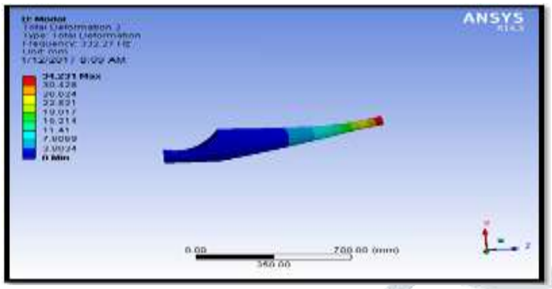
## MODAL ANALYSIS OF WIND TURBINE BLADE

**MATERIAL – GALVANIZED IRON**

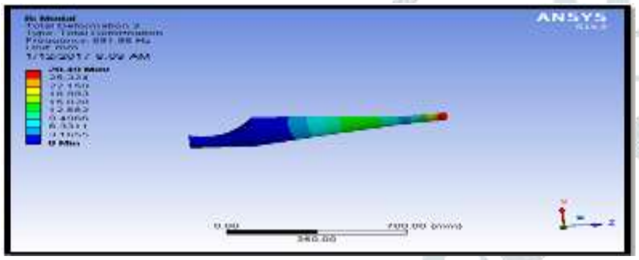
**Deformation -1**



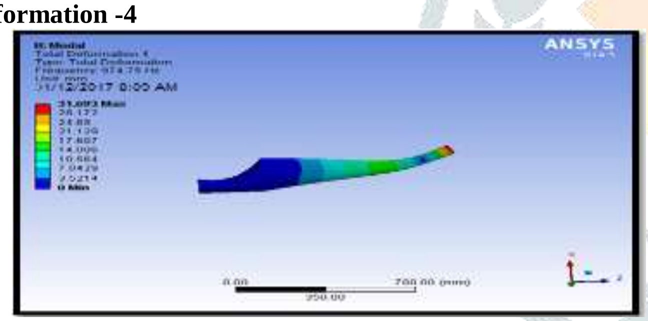

**Deformation -2**



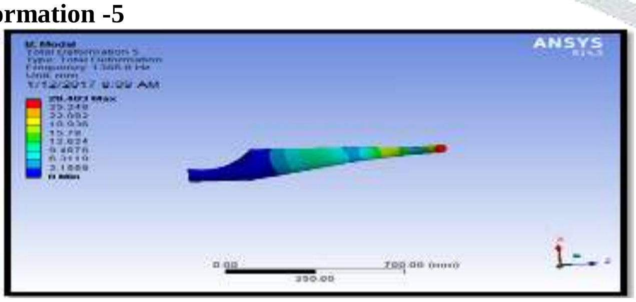

**Deformation -3**




**Deformation -4**




**Deformation -5**

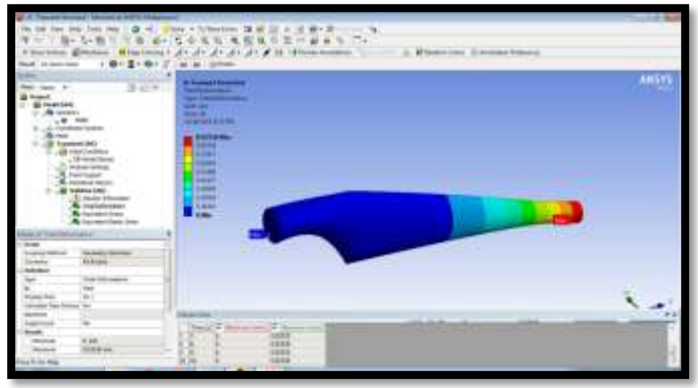



**TRANSIENT ANALYSIS OF WIND TURBINE ROTOR BLADE**

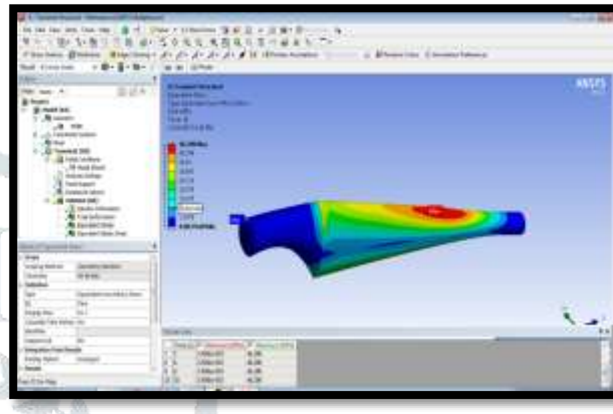
**MATERIAL- GALVANIZED IRON**

**Time at 10sec**

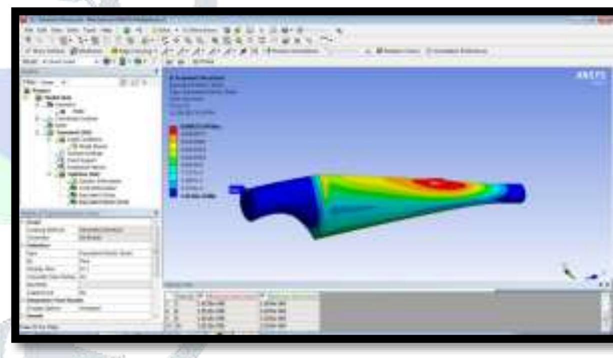
**Deformation**



**Stress**



**Strain**



**Static analysis results**

| Speed m/s | Material | Deformation(mm) | Stress (MPa) | Strain |
|---|---|---|---|---|
| 7 | Galvanized iron | 0.64732 | 32.415 | 0.00016207 |
| | S2 glass | 0.6443 | 11.12 | 0.0001614 |
| 10 | Galvanized iron | 2.5723 | 128.81 | 0.00064405 |
| | S2 glass | 2.5608 | 44.191 | 0.00064138 |

| | Deformation(mm) | Stress (MPa) | Strain |
|---|---|---|---|
| Kevlar | 1.9104 | 5.931 | 0.00047831 |
| e-glass epoxy | 0.011203 | 2.015 | 0.000002798 |

**Fatigue analysis results**

| Speed m/s | Material | Life | | Damage | | Safety factor | |
|---|---|---|---|---|---|---|---|
| 7 | Galvanized iron | 15.216 | 1*e6 | 1000 | 6.572e7 | 0.026593 | 15 |
| | S2 glass | 181.31 | 1*e6 | 1000 | 5.515*e6 | 0.077515 | 15 |
| 10 | Galvanized iron | 0.01 | 1*e6 | 1000 | 1*e32 | 0.006692 | 15 |
| | S2 glass | 0.01 | 1*e6 | 1000 | 1*e32 | 0.019506 | 15 |

| | Life | | Damage | Safety factor |
|---|---|---|---|---|
| | Max. | Min. | | |
| Kevlar | 1×e6 | 925.48 | 1.0805e6 | 0.014534 |
| e-glass epoxy | 1×e6 | 24.940 | 40096 | 0.42779 |

**Transient analysis result table**

| Material | Time (sec) | Deformation(mm) | Stress (MPa) | strain |
|---|---|---|---|---|
| Galvanized iron | 10 | 0.92536 | 46.298 | 0.00023149 |
| | 25 | 1.1296 | 56.508 | 0.00028254 |
| | 30 | 1.3547 | 67.755 | 0.00033877 |
| S2 glass | 10 | 2.7165 | 16.16 | 0.00068959 |
| | 25 | 3.3246 | 19.766 | 0.00084113 |
| | 30 | 3.9984 | 23.756 | 0.0010078 |
| Kevlar | 10 | 3.2456 | 9.9938 | 0.00080597 |
| | 25 | 4.8929 | 15.039 | 0.0012129 |
| | 30 | 9.0996 | 27.886 | 0.0022489 |
| e-glass epoxy | 10 | 0.058449 | 1.0453 | 0.000014518 |
| | 25 | 0.087253 | 1.5604 | 0.000021672 |
| | 30 | 0.15823 | 20.8294 | 0.000039298 |

**MODAL ANALYSIS RESULTS TABLE**

| Material | Mode shapes | Deformation (mm) | Frequency (Hz) |
|---|---|---|---|
| Galvanized iron | 1 | 31.383 | 169.06 |
| | 2 | 34.231 | 332.27 |
| | 3 | 28.49 | 591.96 |
| | 4 | 31.693 | 974.75 |
| | 5 | 28.403 | 1385.8 |
| S2 glass | 1 | 30.999 | 169.58 |
| | 2 | 33.806 | 333.22 |
| | 3 | 28.135 | 594.14 |
| | 4 | 31.284 | 977.53 |
| | 5 | 28.041 | 1390.4 |
| Kevlar | 1 | 42.966 | 98.181 |
| | 2 | 46.869 | 192.98 |
| | 3 | 39.008 | 343.72 |
| | 4 | 43.401 | 566.14 |
| | 5 | 38.894 | 804.8 |
| e-glass epoxy | 1 | 10.936 | 0 |
| | 2 | 10.145 | 0 |
| | 3 | 7.5078 | 0.00048882 |
| | 4 | 5.1499 | 0.000592 |
| | 5 | 7.8663 | 0.00071079 |

**V.CONCLUSION**

In this thesis, the wind turbine blade modeling in CREO parametric software and analyzed for its strength using Finite Element analysis software ANSYS. Structural, modal and fatigue analysis will be done in ANSYS on the different materials (S2 glass, galvanized iron) win turbine blade material galvanized iron replace with S2 glass, Kevlar and e-glass epoxy at different speeds of the turbine rotor. By observing the static analysis the stress, deformation and strain values are increased by increasing the speed of the wind turbine rotor. The stress values are less for used e-glass epoxy material. By observing the fatigue analysis the safety factor values are more for used E- glass material. Modal analysis the deformation and frequency values are better performance e-glass epoxy. By observing the transient analysis the stress values are less for e-glass epoxy material than galvanized iron, Kevlar and s2 glass. So it can be conclude be e-glass epoxy material is the better material for wind turbine blade.

**VI. REFERENCES**

**REFERENCES**

**DESIGN AND ANALYSIS OF WIND TURBINE BY USING POLYMER NANO COMPOSITE MATERIALS**

Vasupalli Ramudu


**[1]** NitinTenguriaet.al."Design and Finite Element Analysis of Horizontal Axis Wind Turbine blade" International Journal of Applied Engineering Research, Dindigul Volume 1, No 3, 2010 ISSN 09764259. [2] Mr. Jesus Vega Fuentes,et.al. "Design of wind turbine blades of a power of 1000 watts for domestic use." 978-1-61284- 1325-5/12, 2012 IEEE.

**[2]** Mr.V. DíazCasás, et.al. "Automatic Design and Optimization of Wind Turbine Blades" International Conference on Computational Intelligence for Modeling Control and Automation, and International Conference on Intelligent Agents, Web Technologies and Internet Commerce 0-7695-2731- 0/06,IEEE. [4] Arvind Singh Rathore et al., "Design and Analysis of Horizontal Axis Wind Turbine Rotor"., International Journal of Engineering Science and Technology (IJEST) Vol. 3 No.11 November 2011 ISSN : 0975-5462.

**[3]** Jialin Zhang, et.al. "Design and Research of High-Performance Low-Speed Wind Turbine Blades. "November 2011.IEEE.