© 2016 IJRTI | Volume 1, Issue 3 | ISSN: 2456-3315

High Altitude Cable Bridge

Vinayak.Gourannavar[1], Chinmay.S.M[2],
Department of Civil Engineering,
[1,2] Girijabai Sail Institute of Technology, Karwar, Karnataka, India.581345
E Mail vinayakscaz@gmail.com, chinmaysmcc@gmail.com

Abstract**—***The construction of the multi-stay cable-stayed bridges are well known since 19th century. There are many examples for such bridges,but in most of the other locations we cannot build other types of bridges due to its horizontal & vertical distance. Among several types, cable-stayed bridges are most popular type for its long spans & for its economical structures, because they can be continued for longer spans up to 3000 meters. This work involves designing of cable stayed bridge for high altitude applications in order of 400 m. As the design of bridge is for higher altitudes where wind velocity will be high,thedesign encompasses utilization of wind turbines for power generation to utilize such freely available natural wind resource. This paper studies wind turbines mounted on bridge to generate electricity which can be utilized for lightings & other purpose for the bridge. This study also considers the aerodynamic design of bridge for such high altitude winds & also to generate the electricity at that high altitude level.*

IndexTerms**—***Aerodynamic design, Cable-stayed bridge,High altitude bridge, Power generation, Wind turbines, Wind velocity.*

I. INTRODUCTION.

AllThe Cable-stayed bridges have become very popular over the last forty years because of their economic structural efficiency and their aesthetics design. Cables stay are critical structural components in cable-stayed bridges. Nowadays, cable-stayed bridges are increasingly built because they can span distance far longer than any other types of bridges. Cable-stayed bridges offer magnificent architectural appearances due to its smaller diameter of cables, minimum overhead structure and wide choice of the design methods. A typical cable-stayed bridge is a continuous girder with one or two towers erected above piers in the middle of the span, cables are attached diagonally to the girder to provide additional support. Cable-stay bridges have a simple and best look. In this study of the cable-stayed bridges, higher altitude up to 300 meters or more can be seen, bridge up to the span length of 400 meters for single pylon span superstructure has designed & studied aerodynamically for the power generation at higher altitude which may be the height up to 300 meters[2].

In general cable-stayed bridges, the superstructure can be supported by one or two planes or several lines of cables, to achieve the increase span length and to make it more efficient to the nature for future bridges, accurate procedures & calculations need to be developed that can lead to understanding and a realistic prediction of the structural response to not only for the wind and earthquake loads but also for the traffic loads.The design of bridge is for higher altitudes where wind velocity will be high, arrangement of wind turbines have made for power generation, to utilize such freely available natural wind resourcewind turbines have mounted on bridge to generate electricity which can be utilized for lightings & other purpose for the bridge. This study also considers the aerodynamic design of bridge for such high altitude winds & also to generate the electricity at that high altitude level.

II. STRUCTURAL ASSESSMENT& STRUCTURAL STUDIES TO BE FOCUSED ON.

Structural Assessment.

The bridge takes the form of a multi-span cable-stayed bridge. Having multiple spans there are no back stays as with most cables-stayed bridges to anchor the pylons to a rigid support. Instead adverse loads on one span directly interact with the next as the pylons bend to accommodate this. Due to the height of bridge it is important that the pylons have a relatively low bending stiffness compared to the other piers. If this is not the case and large bending moments may be transferred to the pier, huge bending moments would result at the base of the piers. Considering the poor bedrock & hard strata of limestone containing major cavities the piers are founded on, this would possibly cause problems for the bridge super structure. The shapes of the pylons seem to be significant in reducing the bending moment transferred to the piers against wind & traffic loads. The longitudinal A-frame appears to inspire the resolution of moments into vertical forces. With the uttered that the deck is of steel. Avoiding such cracking during the launch would mean pre-stressing the deck, in advance using tendons and also completely erecting the pylons and cables prior to launch, efficiently pre-stressing the deck superstructure. This would prove time consuming and the steel deck was considered the more efficient option. As a result the deck needs to be able resist any associated buckling loads with the predicted compressive loads which may not have been such a concern as with a concrete deck.

Structural Studiesto Be Focused On.

- Geology.
- Testing bored pile foundations.
- Design of the pier and deck.
- Meteorological records.
- Wind load & wind pressure.
- High performance concrete design.
- Seismicity.
- Maintenance and operation.
- User's behavior.
- Building methods.
- Construction management.
- Cost analysis.
- Hydraulic studies.
- Archaeology.

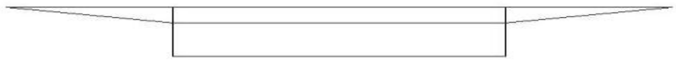
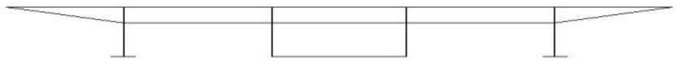
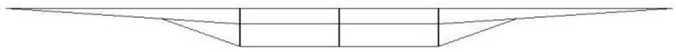
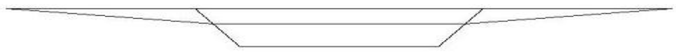
III. DESIGN DATA PREPARATION AND MODELING.

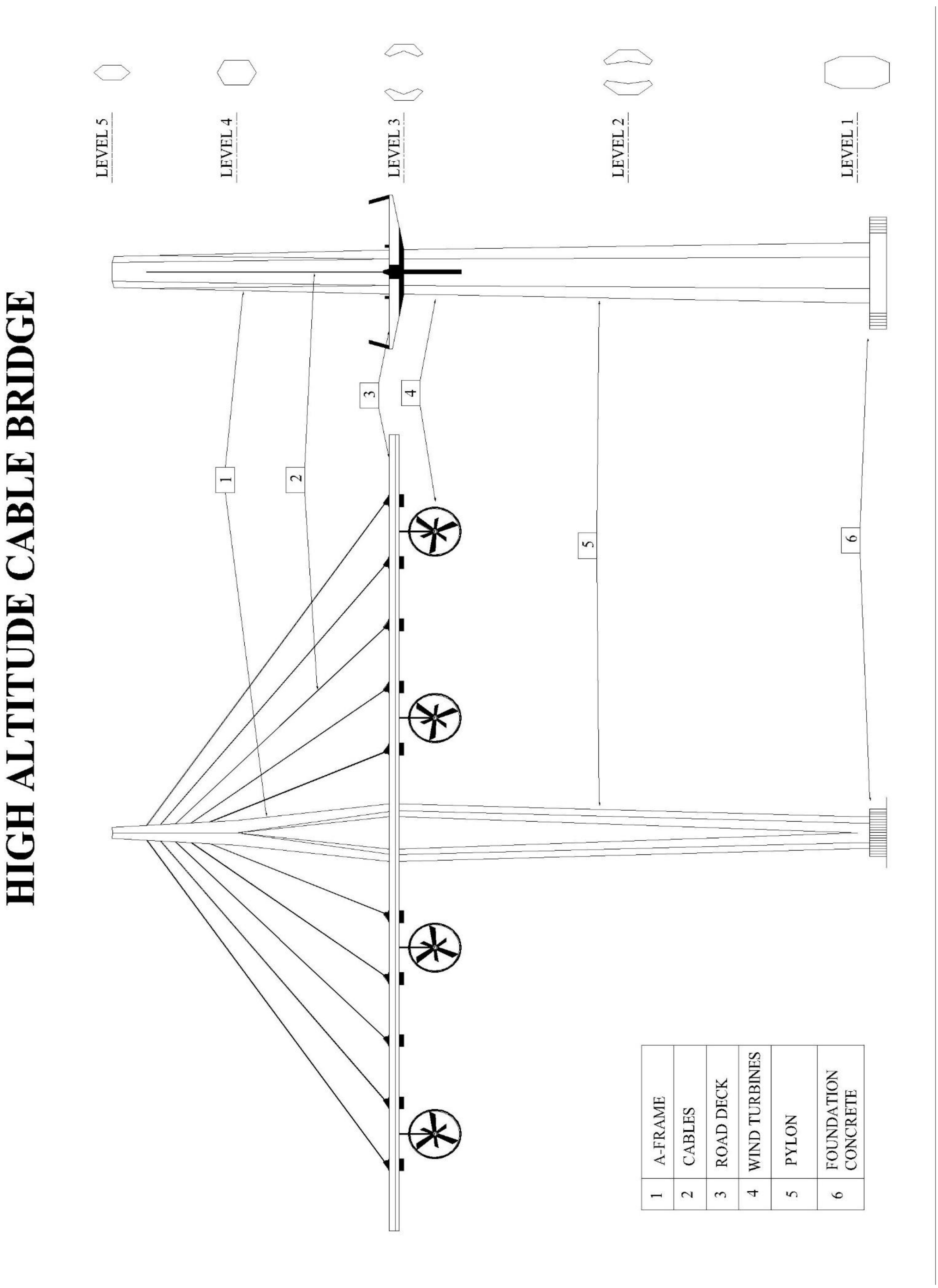
Design Data Preparation.

For the necessary design data preparation, quantifiable properties and design data are effectively taken into account. To develop a safe and effective long-span cable stayed bridge, it is very important that modeling of proposed bridge is conceded within the defined structural stipulations and plans.

- The bridge has 4 main components i.e. pylon, road deck, A-frame (mast), high tensioned cables.
- This bridgetower pyloncan be constructed up to a height of 300 meters for the single pier support &weights about 100 tons.
- Steel deck i.e. formation of road way can be up to width of 30 meters & weighs 6,000 tons approx. entailing a 2x2 lane highway with a 3 meter shoulder about its length can be placed up to 400 meters, about its height is 3.5 metersfor the single pier support.
- The longitudinal A-frame (mast) peaks about 100 meters above deck.
- Approximately it requires 12,000 m3 of concrete for foundation.
- Since the road way is to be constructed at a higher altitude, we have designed the components of bridge structure as aerodynamic, wind screens are provided to protect the vehicles which is of 4 meter in height.

Modelling.

TYPES OF MAIN GIRDER	
Type	Deck cross-section
Twin girder	
Single Rectangular Box Girder	
Central Box Girder	
Single Twin Cellular Box Girder With Slopping Strut	
Single Trapezoidal Box Girder	
Twin Rectangular Box Girder	
Twin Trapezoidal Box Girder	


HIGH ALTITUDE CABLE BRIDGE
LEVEL 5
LEVEL 4
LEVEL 3
LEVEL 2
LEVEL 1
1 A-FRAME
2 CABLES
3 ROAD DECK
4 WIND TURBINES
5 PYLON
6 FOUNDATION CONCRETE

IV. DESIGN LOADS & DESIGN COMPONENTS.

Design Loads.

The applied loads on the proposed bridge model are dead loads, super imposed dead loads, live traffic loads, wind load, temperature load, and other load. After then, structural responses of proposed bridge are studied under these loads.

- *Dead Loads.*

The dead load is mainly just the steel deck. The fixings for the cables and also the cables themselves may be counted as dead loads as well as the pylons. The cornice and wind screen can also be considered as dead load, so by removing these will extremely affect the aerodynamics of the deck.

- Super Imposed Dead Loads.

When the bridge will be constructed the loads were added after the key structure (dead load) will be completed. The black top surfacing, concrete and steel crash barriers, handrails and all drainage can be taken as super imposed dead loads. These are all considered as permanent but can theoretically be removed.

- *Live Traffic Loads.*

The Bridge currently has two lanes of traffic and a narrow hard shoulder in each way. The total width of carriageway is 30 meters including the steel crash barriers on the outside. Braking from trucks can triggers the horizontal loading on the deck with a force of 8kN/m being presumed as acting along one notional lane. Accidental skidding from vehicles is taken as the causing a point load of 250kN. This can act in any direction in one of the notional lanes which is associated with the loading. Collision with the steel parapets on the outside and concrete ones on the inside should be considered. With the parapets present it is exceptional that vehicles will impact the pylons and the cables & decks. Nevertheless due to the size and cost of the project this may have been considered. The height of the bridge familiarizes another collision loading in the form of impact from aircraft. There is conceivable for this to occur on any part of the structure. The locations of piers must be in such a way that valley are isolated enough such that collision loading from road vehicles will not have to be studied.

- *Wind Load.*

Designing to these or probably to any other standards is unlikely for a bridge of this size. The deck of the bridge relies on aerodynamics to resist the wind loads. Complete wind tunnel testing should be carried out to gain an accepting of the decks response to the applied wind loads. Being located in a valley special attention should be given to funneling effects acting to increase the wind speed and ultimately the wind load. Standard drag coefficients apply to various cross sections, for an octagon (the closest thing to a hexagon) the drag coefficient would may have been used for a primary investigation before using an advanced computer model in conjunction with wind tunnel results. The importance of wind tunnel testing is essential as in terms of aerodynamics it may prove difficult to effectively model the interaction of the whole structure.

- *Temperature Load.*

As with wind loading the standards are unlikely to be of much use as all maps. By assuming the deck of 400 meters in length, about its height is 3.5 meters for the single pier support the temperature effects are very important. The design process should be taken into account for stresses induced with the expansion joints sealed. For the applicable temperature range for the design process taken to be from -35ºC to 45ºC these stresses will be significant and will extensively increase compression in the deck. Another issue arises with the temperature variance between the upper and lower surface of the deck. This will familiarize bending into the deck for which the effect will vary depending on the time of day.

- *Other Load.*

By significant amounts of concrete involved in the design one of the most important loads to be taken i.e. associated with creep of concrete. For the high altitude bridge pier construction of any changes in height, causes uneven across the piers would lead to unfavorable effects as well as theoretically aesthetic problems.

Design Components.

- *Pylons*

  The pylon is the main element that utters the visual form of any cable-stayed bridge, giving an opportunity to convey a distinctive style to the design. The main function of the pylon is to transmit the forces arising from anchoring the stays and these forces will govern the design of the pylon. The pylon should carry these forces by axial compression where as possible, such that any eccentricity of loading is decreased. Thus the effective length of the mast in buckling will not be that of a modest cantilever, twice times the height (2H), but equal to the height (H).

- *Deck*

  The metal deck, which appears very light on which the horizontal floors and the lateral box beams are to be welded. The deck has a counter airfoil shape, providing negative lift in strong wind circumstances, the deck of the cable-stayed bridge is an important part of the structure resisting both bending and an axial force derived from the horizontal component of the stay force. The economic solution for the suspension bridge is a least weight deck section. As such, cable-stayed bridge deck forms have been developed as.

  A steel section incorporating an orthotropic road deck.
  A concrete section.
  A composite steel and concrete section.
  Nevertheless, the strong torsion box can still be beneficial when an extremely eccentric loading is carried, such as where both road and rail are consecutively on the deck and the heavy rail loading has to be located eccentric to the deck section. Such a

deck will improve the circulation of the loads between the two cable planes. The torsion box can also be more easily adapted into a modernized shape, necessary for reducing wind drag and for improving aerodynamic strength in very long spans.

- *Stays or cables*

Cables of bridge is equipped with a mono axial layer laid face to face. Depending on their length, the stays were made of high tensile steel cables, strand has triple protection against corrosion (a coating of petroleum wax, galvanization, and an extruded polyethylene casing). The exterior envelope of the stays is itself coated along its complete length with a double helical weather-strip. The idea is to avoid running water which, in high winds, could cause vibrationin the stays.

- *Stay design*

Many factors must be considered in the design of the stay system including the typical breaking strength and the effective stay modulus. The amount of the breaking strength that can be recognized depends on the relaxation of the stay under stable loads. The permanent strain arising from relaxation increases rapidly when the permanent load in the stay exceeds 50% of the breaking load. The Post-Tensioning Institute (PTI) Recommendations (2001) limit, for normal load combinations, the maximum load in the stay to 45% of the stay breaking load and to 50% for exceptional load combinations.

- *Stay types*

Difficulties rises with the stays of early cable-stay bridges as an effect of deficiencies with the anchorage design, steel material difficulties and deficient corrosion resistance. The development of modern stay systems has largely overcome these problems providing designs that minimize bending of the stay at the anchorage face and combine a double corrosion protection system throughout.

Available stay systems include.

- Locked coil (prefabricated)
- Helical or spiral strand (prefabricated)
- Bar bundles
- Parallel wire strand (PWS)
- New PWS (prefabricated)
- Parallel strand
- Advanced composites.

V. MODERN CONCEPT.

Since the bridge is to be constructed at a higher altitude, wind pressure will be more, in order to utilize that wind energy, we have introduced the wind fans to generate electricity.

Wind turbine.

Efficiency.

Not all the energy of blowing wind can be used, but some small wind turbines are designed to work at low wind speeds. The maximum theoretical power output of a wind machine is thus 0.59 times the kinetic energy of the air passing through the effective disk area of the machine. If the effective area of the disk is a, and the wind velocity V, the maximum theoretical power output P is.

$P = [0.59\ (½)\ \rho v^3 A]$

Where, ρ is air density
v is velocity
A is area of contact

Types.

Wind turbines can rotate about either a horizontal or a vertical axis, the former being both older and more common. They can also include blades (transparent or not) or be bladeless.

Materials and durability.

Currently serving wind turbine blades are mainly made of composite materials. These blades are usually made of a polyester resin, a vinyl resin, and epoxy thermosetting matrix resin and E-glass fibers, S- glass fibers and carbon fiber reinforced materials. Construction may use manual layup techniques or composite resin injection molding. As the price of glass fibers is only about one tenth the price of carbon fiber, glass fiber is still dominant. One of the predominant ways wind turbines have gain performance is by increasing rotor diameters, and thus blade length. Longer blades place more demands on the strength and stiffness of the materials. Stiffness is especially important to avoid having blades flex to the degree that they hit the tower of the wind turbine. Carbon fiber is between 4 and 6 times stiffer than glass fiber, so carbon fiber is becoming more common in wind turbine blades.

Design and construction.

Wind turbines are designed to exploit the wind energy that exists at a location. Aerodynamic modeling is used to determine the optimum tower height, control systems, number of blades and blade shape.

Wind turbines convert wind energy to electricity for distribution. Conventional horizontal axis turbines can be divided into three components:

- The rotor component, which is approximately 20% of the wind turbine cost, includes the blades for converting wind energy to low speed rotational energy.
- The generator component, which is approximately 34% of the wind turbine cost, includes the electrical generator, the control electronics, and most likely a gearbox (e.g. planetary gearbox), adjustable-speed drive or continuously variable transmission component for converting the low speed incoming rotation to high speed rotation suitable for generating electricity.
- The structural support component, which is approximately 15% of the wind turbine cost, includes the tower and rotor yaw mechanism.

Among all renewable energy systems wind turbines have the highest effective intensity of power-harvesting surface because turbine blades not only harvest wind power, but also concentrate is used to determine the optimum tower height, control systems, number of blades and blade shape.

VI. PURPOSE OF THE PROJECT REVIEW.

- To give a professional advice on the preliminary analysis.
- To propose new solutions.
- To set up a working method for project development.
- To give their view on the viaduct implementation with regard to the natural landscape.
- To reward the different designing teams.

VII. CONCLUSION.

Cable-stayed bridges are widely constructed all over the world. This type of bridge is very competitive economical for medium and long span. In comparison with other types of bridge, cable-stayed bridges are particularly pleasing to the visual senses. Moreover, this type of bridge fills the gap of efficient span range between conventional girder bridges and the very long span bridges. In this study, higher altitude up to 300 meters or more can be seen therefore, this study would give some knowledge of analysis and design for cable-stayed bridge with aerodynamic shape of tower and how to design it by architecturally & aerodynamic shapes. According to analysis results due to own weight, displacements and rotations are symmetric.

ACKNOWLEDGMENT

The study is the achievement of invaluable help from teachers and many other persons.The authors would like to special thanks to supervisor, Prof. Naveen.U.Gunagi, Assistant Professor of Civil Engineering Department, for their invaluable guidance, generous consideration and knowledge. The authors would like to express deep gratitude to Dr. Suresh.D.Mane, &, Prof. Vaibhav.R.Shirodkar, Head of Civil EngineeringDepartment, Girijabai Sail Institute of Technology, Majali, Karwar, for their invaluable supports and managements.

REFERENCES

[1]Liuchuang Weia, Heming Chenga, Jianyun Lia,"Modal Analysis of a Cable-stayed Bridge" 1877-7058 © 2011 Published by Elsevier Ltd. Selection and/or peer-review under responsibility of Kunming University of Science and Technology.

[2] G. MORGENTHAL, Y. YAMASAKI, "Aerodynamic Behaviour of Very Long Cable-Stayed Bridges during Construction" 1877–7058 © 2011 Published by Elsevier Ltd.

[3] S. Ponnuswamy, "Bridge Engineering" Tata McGraw-Hill Publishing Company Limited, 7 West Patel Nagar, New Delhi 110 008, 2nd ed., 2009 pp 66-70.

[4] Jagadish T.R. & Jayaram M.A, "Design of Bridge Structure" Prentice Hall of India, New Delhi.

[5] Khanna, S.K., & Justo, C.E.G., "Highway Engineering" NEM Chand & Bros. Roorkee.

[6] Holger Svensson, "Cable-Stayed Bridges: 40 years of Experience Worldwide. 3rdEd, 2012.

[7] Cristian, Bak, "Aerodynamic Design of Wind Turbine Blades & Materials" National Laboratory for Sustainable Energy, Technical University of Denmark, Woodhead Publishing Limited, 2010.