INTRODUCTION OF CABLE STRUCTURES AND THEIR REAL-LIFE EXAMPLES WITH SKETCHES

Syed Nasir Abbas*[1], Zain Imran, M. Ahsan khizar, Khuwailid Muneeb, Hassan Raza
[1]Departmenof Engineering Technology, College of Engineering and Technology, University of Sargodha, Sargodha, Pakistan
* Corresponding Author, E-mail: nasir051@gmail.com

ABSTRACT: *Cable structures are often used as final or partial intermediate structures in the construction stages of bridges like arch bridges or cable-stayed ones. These bridges are built often by cantilevering, i.e.with subsequent cantilever partial structures, which are cable-stayed too; hence, every construction stage is a cable structure to be analyzed. The methodology of structural analysis of these construction stages as well as the modeling of the structure for the determination of initial cable force is fundamental steps for establishing the actual state of stress and deformation. In the paper, a general methodology of analysis for construction sequences of cable-stayed structures is presented, which can be used both for the design of cable-stayed bridges and arch bridges. The proposed methodology is based on the simple analysis of multiple partial elastic schemes, which follow the actual construction sequence. The aim is that of obtaining a convenient final geometry through the control of deformations from the first stage to the last one, coincident with the service life configuration. Geometry and internal forces are contemporarily checked, as well as cable forces are determined without the need for too many stressing adjustments. Results of analyses, performed for different case studies, are reported, summarized, and commented, in order to show the reliability and the wide range of applicability of the proposed methodology of analysis.*

Keywords: Cable-stayed structures, construction sequence, forward analysis, partial elastic scheme.

I. INTRODUCTION

In cable-supported structures, the cable is the fundamental element. It can be used in the final layout like in cable-stayed bridges or in partial intermediate schemes of construction stages like in arch bridges. The construction methodology most used for these bridges is the cantilever one, i.e. the sequence of cantilever segments, which are cable-stayed from towers until the final scheme is achieved. In arch bridges the cable-stayed cantilever is present only during construction, when the arch segments are assembled, in order to avoid centering and till the arch key is closed; after that, the provisional cables, already used for supporting the arch elements, are dismantled (fig. 1a). This technique was used for the first time in the construction of the St. Louis steel arch bridge over the Mississippi River, designed by J. Eads and completed in 1874. Later, in 1952, it was extended to the construction of concrete arches for the bridges of the Caracas-**La Guaira** motorway in Venezuela, to which E. Freyssinet contributed. Only in particular cases, arch bridges can be built by using stays as permanent structural elements (bowstring bridges). In cable-stayed bridges instead, cables remain always as definitive elements and they have the role of elastic supports of the deck, in service life too. Cable-stayed bridges are frequently built by cantilevering that consists of a sequence of partial cable structures

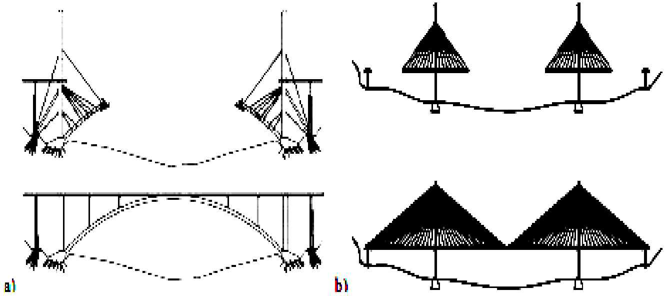

Figure 1 Cantilever construction of cable structures

Cantilever construction is characterized by a sequence in which geometric configuration, restraints, and consequently stress and strain patterns vary many times till the final arrangement is achieved; this method is used today both for concrete and steel structures. For arch bridges, this method implies a different behavior of arch segments between construction stages and the final structure: in intermediate phases, the structure is mainly subjected to bending moments, as a curved beam on elastic supports, whereas after key closure, the arch gains its mainly axial behavior. This implies that, even if the arch shape was designed as the anti-funicular curve of permanent dead loads, bending moments appear in cantilever stages, and residual values remain in the arch after key closure and stay removal. These values of the bending moment will be added to those caused by deck construction, superimposed dead loads, and moving loads.

Two requirements have to be fulfilled in the arch bridge: to achieve the exact geometry of the arch at the end of cantilever construction and to minimize the value of residual bending moments in the completed arch. These targets can be obtained by performing a convenient stay stressing sequence and by finding the correct value of initial cable forces, stage by stage. For cable-stayed bridges, the cantilever construction, unlike arch bridges, is characterized by a sequence of structures statically similar to the final one. The principal difference between the partial structures during construction and the final one is that a cantilever segment is attached to the last stay at each construction phase, modifying the geometry and load condition of every stage. This cantilever segment, both in prestressed concrete girders and in steel cross-sections, may imply a stress state heavier than that occurring in service life. In the design of these bridges, the assessment of initial cable forces and the procedure of stay stress adjustments during erection is very important, but constitutes a hard task to achieve, in order to respect the requested geometric profiles of deck and towers at the end of construction. It is not simple to state a convenient methodology of initial stay force determination for the following reasons: at the end of erection, the girder longitudinal profile must satisfy aesthetic and functional requirements, possibly presenting a convenient pre-camber; the towers must keep the vertical profile, in order to avoid second-order effects and to satisfy architectural demands and even though geometrical requirements are satisfied in the so-called dead load configuration, after erection end, the system of stresses has to be checked to avoid high-stress levels in the deck and tower members.

II. OBJECTIVES

The main objective of this research is to study the basics of cable structures and also study their types and uses in real life. The detailed objectives are as under

- Study the basic types of Cable Structures and modern examples of these structures.
- Detailed Explanation of Cable-stayed bridges and suspension bridges.
- Find out the Difference between Cable-stayed bridges and suspension bridges
- Study the Advantages and Disadvantages of Cable-stayed structures
- Study Advantages and Disadvantages of Suspension Bridges
- Study The load Bearing Mechanism of Suspension Bridges

III. LITERATURE REVIEW

IV. SUSPENSION TYPE CABLE STRUCTURES

A **suspension bridge** is a type of bridge in which the deck (the load-bearing portion) is hung below suspension cables on vertical suspenders. The first modern examples of this type of bridge were built in the early 1800s.[1][2] Simple suspension bridges, which lack vertical suspenders, have a long history in many mountainous parts of the world

This type of bridge has cables suspended between towers, with vertical suspender cables that transfer the live and dead loads of the deck below, upon which traffic crosses. This arrangement allows the deck to be level or to arc upward for additional clearance. Like other suspension bridge types, this type often is constructed without falsework.

The suspension cables must be **anchored** at each end of the bridge since any load applied to the bridge is transformed into tension in these main cables. The main cables continue beyond the pillars to deck-level supports, and further continue to connections with anchors in the ground. The roadway is supported by vertical suspender cables or rods, called hangers. In some circumstances, the towers may sit on a bluff or canyon edge where the road may proceed directly to the main span, otherwise, the bridge will usually have two smaller spans, running between either pair of pillars and the highway, which may be supported by suspender cables or their own trusswork. In the latter case, there will be a very little arc in the outboard main cables.

The earliest suspension bridges were ropes slung across a chasm, with a deck possibly at the same level or hung below the ropes such that the rope had a catenary shape.

Precursor The Tibetan Siddha and bridge-builder ThangtongGyalpo originated the use of iron chains in his version of simple suspension bridges. In 1433, Gyalpo built eight bridges in eastern Bhutan. The last surviving chain-linked bridge of Gyalpo's was the ThangtongGyalpo Bridge in Duksumen route to TrashiYangtse, which was finally washed away in 2004.[3] Gyalpo's iron chain bridges did not include a suspended deck bridge, which is the standard on all modern suspension bridges today. Instead, both the railing and the walking layer of Gyalpo's bridges used wires. The stress points that carried the screed were reinforced by the iron chains. Before the use of iron chains, it is thought that Gyalpo used ropes from twisted willows or yak skins.[4] He may have also used tightly bound cloth.

Chain bridges[l]The first iron chain suspension bridge in the Western world was the Jacob's Creek Bridge (1801) in Westmoreland County, Pennsylvania, designed by inventor James Finley.[5] Finley's bridge was the first to incorporate all of the necessary components of a modern suspension bridge, including a suspended deck that hung by trusses. Finley patented his design in 1808 and published it in the Philadelphia journal, The Port Folio, in 1810.[6]

Early British chain bridges included the Dryburgh Abbey Bridge (1817) and 137 m Union Bridge (1820), with spans rapidly increasing to 176 m with the Menai Bridge (1826), "the first important modern suspension bridge".[7] The first chain bridge on the German-speaking territories was the Chain Bridge in Nuremberg. The Clifton Suspension Bridge (designed in 1831, completed in 1864 with a 214 m central span) is one of the longest of the parabolic arc chain type. The current Marlow suspension bridge was designed by William Tierney Clark and was built between 1829 and 1832, replacing a wooden bridge further downstream which collapsed in 1828. It is the only suspension bridge across the non-tidal Thames. The Széchenyi Chain Bridge, (designed in 1840, opened in 1849), spanning the River Danube in Budapest, was also designed by William Clark and it is a larger-scale version of Marlow Bridge [8].

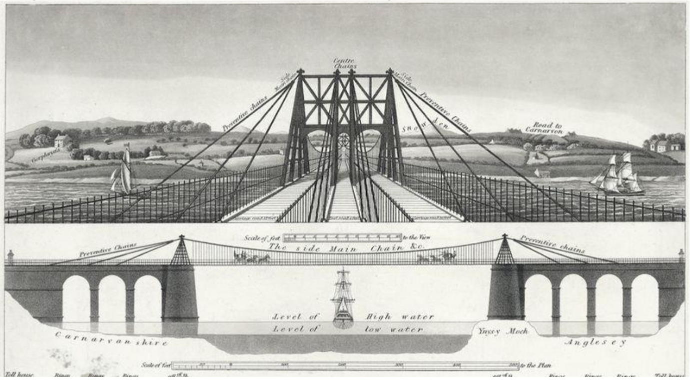

Figure 2 An Early Plan of Chain Bridge over the Menai Strait

An interesting variation is **Thornewill** and **Warham's** Ferry Bridge in Burton-on-Trent, Staffordshire (1889), where the chains are not attached to abutments as is usual, but instead are attached to the main girders, which are thus in compression. Here, the chains are made from flat wrought iron plates, eight inches (203 mm) wide by an inch and a half (38 mm) thick, riveted together [9].

Wire-cable. The first wire-cable suspension bridge was the Spider Bridge at Falls of Schuylkill (1816), a modest and temporary footbridge built following the collapse of James

Finley's nearby Chain Bridge at Falls of Schuylkill (1808). The footbridge's span was 124 m, although its deck was only 0.45 m wide.

The development of wire-cable suspension bridges dates to the temporary simple suspension bridge at Annonay built by Marc Seguin and his brothers in 1822. It spanned only 18 m.[10] The first permanent wire cable suspension bridge was Guillaume Henri Dufour's Saint Antoine Bridge in Geneva of 1823, with two 40 m spans [10]. The first with cables assembled in mid-air in the modern method was Joseph Chaley's Grand Pont Suspendu in Fribourg, in 1834.

In the United States, the first major wire-cable suspension bridge was the Wire Bridge at Fairmount in Philadelphia, Pennsylvania. Designed by Charles Ellet Jr. and completed in 1842, it had a span of 109 m. Ellet's Niagara Falls suspension bridge (1847–48) was abandoned before completion. It was used as scaffolding for John A. Roebling's double-decker railroad and carriage bridge (1855).

The Otto Beit Bridge (1938–39) was the first modern suspension bridge outside the United States built with parallel wire cables.

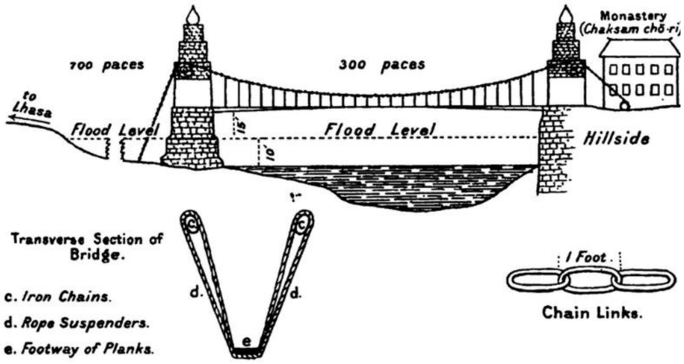

Figure 3 Iron Suspension Bridge

V. STRUCTURE

Bridge main components. Two towers/pillars, two suspension cables, four suspension cable anchors, multiple suspender cables, the bridge deck.

Structural analysis. The main cables of a suspension bridge will form a catenary; the cables will instead form a parabola if they are assumed to have zero weight. One can see the shape from the constant increase of the gradient of the cable with linear (deck) distance, this increase in gradient at each connection with the deck providing a net upward support force. Combined with the relatively simple constraints placed upon the actual deck, that makes the suspension bridge much simpler to design and analyze than a cable-stayed bridge in which the deck is in compression.

VI. VARIATIONS

Under spanned. In an under-spanned suspension bridge, the main cables hang entirely below the bridge deck but are still anchored into the ground in a similar way to the conventional type. Very few bridges of this nature have been built, as the deck is inherently less stable than when suspended below the cables. Examples include the Pont des Bergues of 1834 designed by Guillaume Henri Dufour; James Smith's Micklewood Bridge;[11] and a proposal by Robert Stevenson for a bridge over the River Almond near Edinburgh.[11].

Roebling's Delaware Aqueduct (begun 1847) consists of three sections supported by cables. The timber structure essentially hides the cables; and from a quick view, it is not immediately apparent that it is even a suspension bridge.

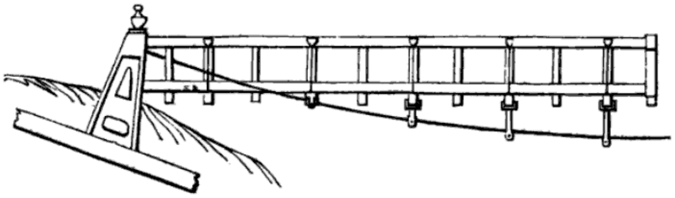

Figure 4 Micklewood Bridge

Suspension cable types. The main suspension cables in older bridges were often made from a chain or linked bars, but modern bridge cables are made from multiple strands of wire. This not only adds strength but improves reliability (often called redundancy in engineering terms) because the failure of a few flawed strands in the hundreds used pose very little threat of failure, whereas a single bad link or eyebar can cause the failure of an entire bridge. (The failure of a single eyebar was found to be the cause of the collapse of the Silver Bridge over the Ohio River.) Another reason is that as spans increased, engineers were unable to lift larger chains into position, whereas wire strand cables can be formulated one by one in mid-air from a temporary walkway

Suspender cable terminations. Poured sockets are used to make a high-strength, permanent cable termination. They are created by inserting the suspender wire rope (at the bridge deck supports) into the narrow end of a conical cavity which is oriented in line with the intended direction of strain. The individual wires are splayed out inside the cone or 'capel', and the cone is then filled with molten lead-antimony-tin (Pb80Sb15Sn5) solder 12].

VII. FORCES

Three kinds of forces operate on any bridge: the dead load, the live load, and the dynamic load. Dead load refers to the weight of the bridge itself. Like any other structure, a bridge has a tendency to collapse simply because of the gravitational forces acting on the materials of which the bridge is made. Live load refers to traffic that moves across the bridge as well as normal environmental factors such as changes in temperature, precipitation, and winds. Dynamic load refers to environmental factors that go beyond normal weather conditions, factors such as sudden gusts of wind and earthquakes. All three factors must be taken into consideration when building a bridge.

The principles of suspension used on a large scale also appear in contexts less dramatic than road or rail bridges. Light cable suspension may prove less expensive and seem more elegant for a cycle or footbridge than strong girder supports. An example of this is the Nescio Bridge in the Netherlands, and the Roebling designed 1904 Riegelsville suspension pedestrian bridge across the Delaware River in Pennsylvania.[13] The longest pedestrian suspension bridge, which spans the River Paiva, Arouca Geopark, Portugal, opened in April 2021. The 516 meters bridge hangs 175 meters above the river.[14].

Where such a bridge spans a gap between two buildings, there is no need to construct special towers, as the buildings can anchor the cables. Cable suspension may also be augmented by the inherent stiffness of a structure that has much in common with a tubular bridge.

VIII. EXAMPLES

Followings are few **real-life** examples of Suspension Bridges

Figure 5Union Bridge(England/Scotland, 1820),

Figure 6Ben Franklin Bridge (USA, 1926)

Figure 7Golden Gate Bridge (USA, 1937)

The longest suspension bridge from 1937 to 1964. It was also the world's tallest bridge from 1937 to 1993 and remains the tallest bridge in the United States.

IX. CABLE-STAYED STRUCTURE

A cable-stayed bridge has one or more towers (or pylons), from which cables support the bridge deck. Distinctive features are the cables or stays, which run directly from the tower to the deck, normally forming a fan-like pattern or a series of parallel lines. This is in contrast to the modern suspension bridge, where the cables supporting the deck are suspended vertically from the main cable, anchored at both ends of the bridge and running between the towers. The cable-stayed bridge is optimal for spans longer than cantilever bridges and shorter than suspension bridges. This is the range within which cantilever bridges would rapidly grow heavier, and suspension bridge cabling would be more costly.

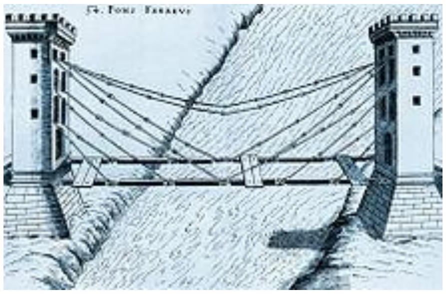

Figure 8 Cable-Stayed Bridge

Cable-stayed bridges were being designed and constructed by the late 16th century, [15], and the form found wide use in the late 19th century. Early examples, including the Brooklyn Bridge, often combined features from both the cable-stayed and suspension designs. Cable-stayed designs fell from favor in the early 20th century as larger gaps were bridged using pure suspension designs, and shorter ones using various systems built of reinforced concrete. It returned to prominence in the later 20th century when the combination of new materials, larger construction machinery, and the need to replace older bridges all lowered the relative price of these designs [16].

The earliest known surviving example of a true cable-stayed bridge in the United States is E.E. Runyon's largely intact steel or iron Bluff Dale Suspension bridge with wooden stringers and decking in Bluff Dale, Texas (1890), or his weeks earlier but ruined Barton Creek Bridge between Huckabay, Texas and Gordon, Texas (1889 or 1890).[17, 18]. In the twentieth century, early examples of cable-stayed bridges included A. Gisclard's unusual Cassagnes bridge (1899), in which the horizontal part of the cable forces is balanced by a separate horizontal tie cable, preventing significant compression in the deck, and G. Leinekugel le Coq's bridge at Lézardrieux in Brittany (1924). Eduardo Torroja designed a cable-stayed aqueduct at Tempul in 1926.[19] Albert Caquot's 1952 concrete-decked cable-stayed bridge over the Donzère-Mondragon canal at Pierrelatte is one of the first of the modern type, but had little influence on later development.[19]. The steel-decked Strömsund Bridge designed by Franz Dischinger (1955) is, therefore, more often cited as the first modern cable-stayed bridge..

X. DESIGNS

There are four major classes of rigging on cable-stayed bridges: mono, harp, fan, and star.[20].

- The mono design uses a single cable from its towers and is one of the lesser-used examples of the class.
- In the harp or parallel design, the cables are nearly parallel so that the height of their attachment to the tower is proportional to the distance from the tower to their mounting on the deck.
- In the fan design, the cables all connect to or pass over the top of the towers. The fan design is structurally superior with a minimum moment applied to the towers, but, for practical reasons, the modified fan (also called the semi-fan) is preferred, especially where many cables are necessary. In the modified fan arrangement, the cables terminate near the top of the tower but are spaced from each other sufficiently to allow better termination, improved environmental protection, and good access to individual cables for maintenance.,[21].
- In the star design, another relatively rare design, the cables are spaced apart on the tower, like the harp design, but connect to one point or a number of closely spaced points on the deck. [22].

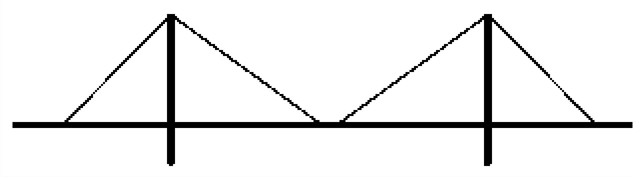

Figure 9Mono Design

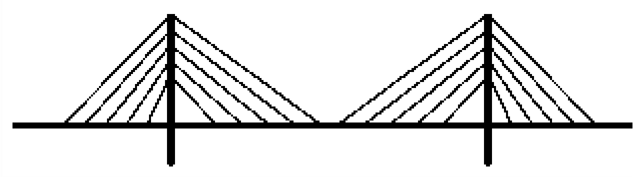

Figure 10Harp Design

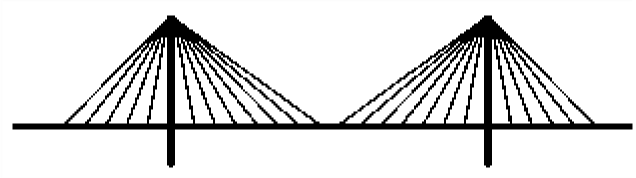

Figure 11Fan Design

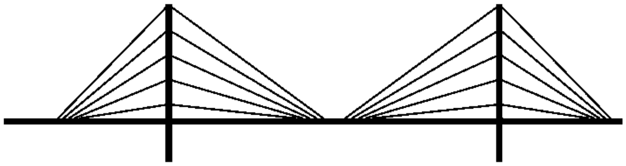

Figure 12Star Design

XI. VARIATIONS

Side-spar cable-stayed bridge. A side-spar cable-stayed bridge uses a central tower supported only on one side. This design allows the construction of a curved bridge

Cantilever spar cable-stayed bridge for more radical in its structure, the Puente del Alamillo (1992) uses a single cantilever spar on one side of the span, with cables on one side only to support the bridge deck. Unlike other cable-stayed types, this bridge exerts a considerable overturning force upon its foundation and the spar must resist the bending caused by the cables, as the cable forces are not balanced by opposing cables. The spar of this particular bridge forms the gnomon of a large garden sundial. Related bridges by the architect Santiago Calatrava include the Puente de la Mujer (2001), Sundial Bridge (2004), Chords Bridge (2008), and Asset de l'Or Bridge (2008).

Multiple-span cable-stayed bridgeable-stayed bridges with more than three spans involve significantly more challenging designs than do 2-span or 3-span structures

XII. CONCLUSION

XIII. Comparison between Cable-stayed Structures and Suspension stayed Structures

Cable-stayed bridges and suspension bridges may appear to be similar but are quite different in principle and in their construction.

I**n suspension bridges**, large main cables (normally two) hang between the towers and are anchored at each end to the ground. The main cables, which are free to move on bearings in the towers, bear the load of the bridge deck. Before the deck is installed, the cables are under tension from their own weight. Along the main cables smaller cables or rods connect to the bridge deck, which is lifted in sections. As this is done, the tension in the cables increases, as it does with the live load of traffic crossing the bridge. The tension on the main cables is transferred to the ground at the anchorages and by downwards compression on the towers**.**

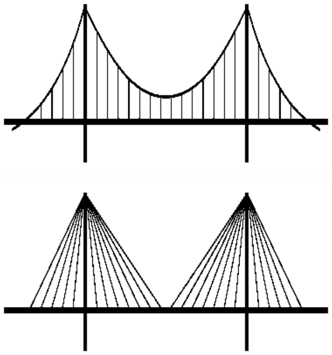

Figure 13 Suspension Bridge & Cable-Stayed Bridge

In cable-stayed bridges, the towers are the primary load-bearing structures that transmit the bridge loads to the ground. A cantilever approach is often used to support the bridge deck near the towers, but lengths further from them are supported by cables running directly to the towers. By design, all static horizontal forces of the cable-stayed bridge are balanced so that the supporting towers do not tend to tilt or slide and so must only resist horizontal forces from the live loads.

Advantages.

- Longer main spans are achievable than with any other type of bridge.

- Less material may be required than other bridge types, even at spans they can achieve, leading to a reduced construction cost.
- Except for installation of the initial temporary cables, little or no access from below is required during construction and so a waterway can remain open while the bridge is built above.
- They may be better able to withstand earthquake movements than heavier and more rigid bridges.
- Bridge decks can have deck sections replaced in order to widen traffic lanes for larger vehicles or add additional width for separated cycling/pedestrian paths

Disadvantages.

- Considerable stiffness or aerodynamic profiling may be required to prevent the bridge deck from vibrating under high winds.
- The relatively low deck stiffness compared to other (non-suspension) types of bridges makes it more difficult to carry heavy rail traffic in which high concentrated live loads occur.
- Some access below may be required during construction to lift the initial cables or to lift deck units. That access can often be avoided in cable-stayed bridge construction.

XIV. EXAMPLES

Following are few **real-life examples** of Cable-Stayed Bridges

Figure 14 Brooklyn Bridge

Figure 15Arthur Ravenel Jr. Bridge

Figure 16Jiaxing-Shaoxing Sea Bridge

The bridge is an eight-lane structure that spans 10,100 meters. It was opened on 23 July 2013 and is currently the longest cable-stayed bridge in the world.

XV. CONCLUSIONS

Advantages.

- Longer main spans are achievable than with any other type of bridge.
- Less material may be required than other bridge types, even at spans, they can achieve, leading to a reduced construction cost.
- Except for installation of the initial temporary cables, little or no access from below is required during construction and so a waterway can remain open while the bridge is built above.
- They may be better able to withstand earthquake movements than heavier and more rigid bridges.
- Bridge decks can have deck sections replaced in order to widen traffic lanes for larger vehicles or add additional width for separated cycling/pedestrian paths

Disadvantages.

- Considerable stiffness or aerodynamic profiling may be required to prevent the bridge deck from vibrating under high winds.
- The relatively low deck stiffness compared to other (non-suspension) types of bridges makes it more difficult to carry heavy rail traffic in which high concentrated live loads occur.
- Some access below may be required during construction to lift the initial cables or to lift deck units. That access can often be avoided in cable-stayed bridge construction.

XVI. Recommendation

These are Few Recommendations that can be helpful in civil engineering regarding Cable-Stayed Bridges & Suspension Bridges

- Cable-Stayed Bridges have much greater stiffness since the cables can handle more pressure. They are also much more resistant to environmental changes such as the frequent occurrences of earthquakes. Such types of bridges take less time to construct and are economical too since they require fewer materials and fewer building hours. Cable-Stayed Bridges are preferred over conventional steel suspension mainly because of the reduction in moments in the stiffening girders,

- While the construction of conventional suspension bridges for further inland applications in the US is doubtful, new economical types of bridges employing 'high-strength wires are continually being developed. At least one German engineering firm has established offices in the US to market those new designs. With the continued pressure on highway authorities to build more economical bridges, it is likely that several of those new bridge types will be used. Information contained in the other reports should be useful in understanding the potential maintenance problems presented by those new bridge types and in formulating procedures to cope with those problems.

XVII. REFERENCES

1. ChakzampaThangtongGyalpo Architect, Philosopher, and Iron Chain Bridge Builder
2. Lhasa and Its Mysteries by Lawrence Austine Waddell, 1905, p.313
3. Bhutan. Lonely Planet. 2007. ISBN 978-1-74059-529-
4. ChakzampaThangtongGyalpo" (PDF). Centre for Bhutan Studies. p. 61.
5. Iron Wire of the Wheeling Suspension Bridge". Smithsonian Museum Conservation Institute. Archived from the original on 30 April 2011.
6. Bridges: Three Thousand Years of Defying Nature. MBI Publishing Company. 12 November 2001. ISBN 978-0-7603-1234-6.
7. Menai Bridge - bridge, Wales, United Kingdom". britannica.com.
8. "Marlow Suspension Bridge". Retrieved 11 December 2008. Cove-Smith, Chris (2006). The River Thames Book. Imray Laurie Norie and Wilson. ISBN 0-85288-892-9
9. https://www.ice.org.uk/disciplines-and-resources/ice-library-and-digital-resources/historical-engineering-works/details?hewID=2746#details
10. Transitions in Engineering: Guillaume Henri Dufour and the Early 19th Century Cable Suspension Bridges. Birkhauser. ISBN 3-7643-1929-1
11. T R Barnard (1959). "Winding Ropes and Guide Ropes:" Mechanical Engineering. Coal Mining Series (2nd ed.).
12. "World's longest pedestrian suspension bridge opens in Portugal". the Guardian. 29 April 2021.
13. "DRPA: Delaware River Port Authority". drpa.org.
14. McGloin, Bernard. "Symphonies in Steel: Bay Bridge and the Golden Gate". Virtual Museum of the City of San Francisco. Archived from the original on 25 February 2011.
15. Types of Bridges". History of Bridges.
16. Nordrum, Amy. "Popular Cable-Stay Bridges Rise Across U.S. to Replace Crumbling Spans". Scientific American. Retrieved 30 April 2017.
17. Bluff Dale Suspension Bridge". Historic American Engineering Record. Library of Congress.
18. Barton Creek Bridge". Historic American Engineering Record. Library of Congress.
19. Troyano, Leonardo (2003). Bridge Engineering: A Global Perspective. Thomas Telford. pp. 650–652. ISBN 0-7277-3215-3.
20. "Cable Stayed Bridge". Middle East Economic Engineering Forum.
21. Sarhang Zadeh, Olfat (October 2012). "Comparison Between Three Types of Cable Stayed Bridges Using Structural Optimization" (PDF). Western University Canada.
22. T.K. Bandyopadhyay; Alok Baishya (2000). P. Dayaratnam; G.P. Garg; G.V. Ratnam; R.N. Raghavan (eds.). International Conference on Suspension, Cable Supported, and Cable Stayed Bridges: November 19–21, 1999, Hyderabad. Universities Press (India). pp. 282, 373. ISBN 978-81-7371-271-5.