



A short passage about cable stayed bridges (History types cable arrangement installation)

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Abstract

The aim of this study is identify cable bridges and have a short review about the history and attempts after world war II, 1960 is the magnificent times to innovate and progress in designing, calculations and analyses of bride elements. 6 structural systems are identified. Flexible and strong steel cables are being used for bridges. It is the best choice for long spans. Tower, span, cables are the main elements of cable styed bridges. Cables are twisted from narrow strings. Shape and appearance of the bridges are identified. Cable arrangements such as fun, harp, semi harp are the most important that are shown here. Types of towers are such as single, double, portal and a shape mostly use in cable bridges.

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Keywords : Bridge stayed cables , tower, span , cantilever , suspension bridges;

1. Introduction

Bridges can be classified according to various types such as structural systems, spans lengths, materials, procedure of building and usage.

Structural Systems bridges:

- 1- Girder bridges ,Beam bridges
- 2- Truss bridges
- 3- Arch bridges
- 4- Truss cantilever bridges

- 5- Cables bridges
- 6- Frame shape bridges

After World War II, there were many bridges which had not destroyed totally, only the upper parts have been damaged but the foundations were still stable, in the other hand lack of steel materials in the market forced governments to repair and use these fundamental structures.

Related to these projects, many magnificent progressive technics have been innovated in bridge building technology. One of the most important

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progresses of this era was using pre tensioning models in structural bridge building.

1960 decay 'was the magnificent years of using cantilever shape in pre tensioning structural bridge building .these technic was used to build single span bridges .many years later the same procedure used in pre tensioning concrete span bridge structures, in these bridges types straight vertical cables were used for holding and connect the deck to towers instead of hanger parabolic cables [1].

2. Cable stayed bridges specifications

- Very flexible and strong steel cables have been used in this model; because of lighter structures and long spans which can be covered it is very economic.
- Even a few cables are strong enough to support the bridge 'but the flexibility of cables can be mention as a weakness against the wind so it is very important to have exact studies for long spans to guarantee satisfaction stability against the wind.
- Light weight of the structure is a bad property in stormy conditions and a good one related to seismic waves.
- Unbalanced and sinking of foundations during the life cycle of the structure or in an earthquake evidence can damage the cable bridges badly' so exact and accurate design and calculations are required for foundations.
- Modern shape and simplicity appearance of cable stayed bridges are fascinating factors for them.
- Specified cables properties and structure have caused to have complicated condition for designing [1].

3. Cable types for cable bridges

These cables are made of soft steel' high resistance steel (high carbon steel)' anti rust steel' polymer and aramid fibers'

Many narrow strings have twisted and form the structure of heavy duty cables' in the other hand steel cables are made of spiral circular bar strings twisted

by using polymer or strong locked cables for holding main cable strings by each other and finally produce the steel cables (spiral strings are usually coated by a shield).



Fig. 1. Spiral strings coated by a shield

Spiral strings have weaker reaction than the locked strings coil.

Elasticity module of spiral cable strings is equal to $E=150$

They have various dimensions between 3-90 mm special strings in pushing behavior have loaded in structure tension meanwhile pulling aside' in this way by pre tensioning in cable and load rotation decreases the upper and lower final tension' the amount is nearly 45% .

The Yang Module of locked coil strings is equal to $E=160$

The diameters of strings are from 10 to 160 mm.

Special specifications of various materials are shown in bellow table.[2]

Table 1
Special specifications of various materials

Strain at 50% of UTS	UTS (MPa)	E (GPa)	
0.24%	400-800	210	Solid steel bar
1%	1550-1770	170	Steel strand
1.5%	1550-1770	112	Wire rope
6%	910	7.5	Polyester fibre
2.5%	2800	112	Aramid fibre

4. Cable stayed bridges classifications

There is no specified classification about cable stayed bridges.

Generally they can be modified by factors such as numbers of spans, towers, cables and the type of supporting beams, thus there are different models depending on towers models, numbers and cables arrangement & numbers.

There are models which cables of one of the tower joint to the span and the other side in a foundation or counter balanced.

4.1. Cables bridges according to cables arrangement are classified as below: [3]

- Parallel cables joints
- Semi-harp cables joints
- Fan cables joints

4.2. Cables bridges according to tower types are classified as below:

- Single tower
- Double towers
- Portal towers
- A shape towers



Fig. 2. Cable stayed bridge A shape tower

5. Structural systems of Cable stayed bridges

For building cable stayed bridges there are two structural systems:

- Bridges with parabolic cables
- Bridges with straight cables

Parabolic bridges are used for wide distance spans it contains two tall towers which is placed at each side of span.

Two heavy duty twisted cable strings are passed from the upper part of each tower and stiffened to big anchor bolts that are embedded in reinforced concrete foundations placed in each side of bridges.

Bridge deck is hanged to the cable via some vertical cables that directly bear the load of the deck.

Thus, in bridges with straight cable load of span is bearing by various cables that is installed on different elevation points of each tower.

By evaluating the systems of installed cable bridge, we can get that all the time the design of these systems is completely linear and 2-dimensional which can bear the forces in two dimensions, as a result these structures are weak in controlling the dynamic forces such as wind and seismic waves [1].

6. Suspension bridges with parabolic cables

Load and weight are held by thick cables, the detail parts are as such parabolic cables, straight cables, span and towers which act like bridge platforms.



Fig. 3. Suspension bridges with parabolic cables

The most important models are as

- Cable tightened and joint to span
- Cable tightened to a place in foundation

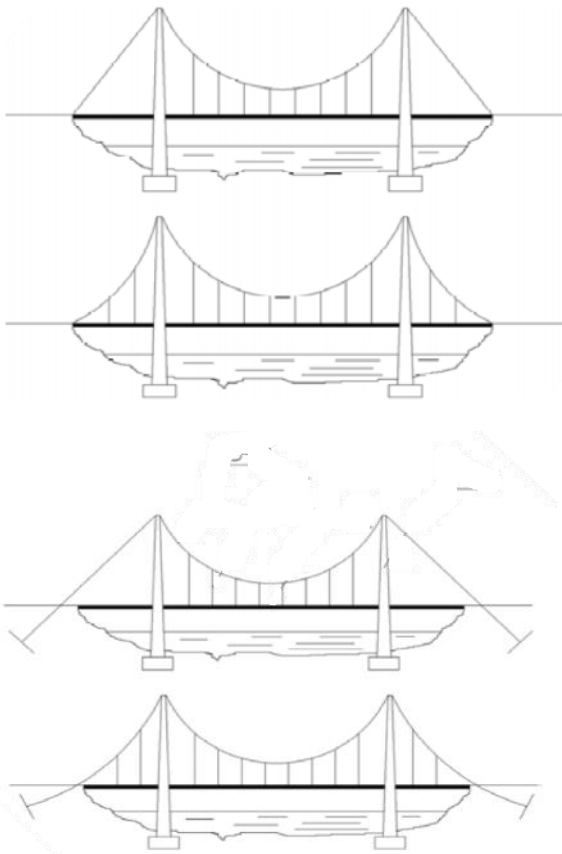


Fig. 4. Cable tightened and joint to span Cable tightened to a place in foundation

6.1. Mechanism

Suspension bridges are made of a girder' one or more towers which are placed in the middle of the span.

The girder usually is a truss or an arc shape supporting beam.

Plain girder beams are not designed for short distance.

There are blocks with anchor in each side of the bridge for holding two ends of main cables.

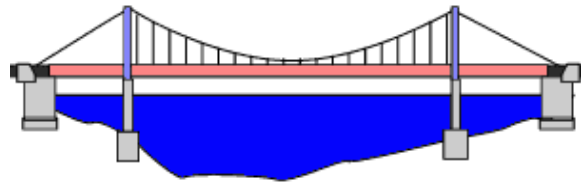


Fig. 5. Blocks with anchor in each side of the bridge

Main cables are traced from one restrained side to the saddle of the tower and be continued to the other side of tower and tightened there.

The cables on the saddle are freely slide over and carry the load in vibration conditions and transfer the load to towers.

Hanging shorter cables (Known as hanging cables) are jointed to the main cables for holding deck and girder as a suspension parts.

Balanced big heavy balls are not used in some cases.

The main cables ends are stiffened directly to the girder for balancing the middle span leaning on the weights of span ends and finally the main cables are tightened.

Bridge weights and live loads via hanging cables are hold and supporting mostly by towers.

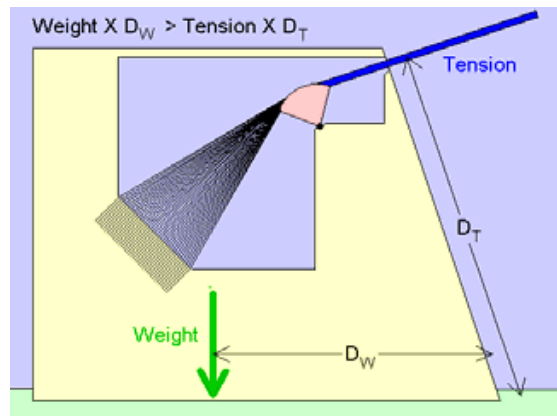


Fig. 6. The cables end joint

Although suspension bridges with high spans are stable and can carry heavy traffic live loads but aerodynamic forces can damage them easily.

So spiral activities are done to increase the stability and resistance of bridges in a way that in critical situation such as stormy weather the swinging movement can be controlled [1].

7. Straight cables suspension bridges

This model with long spans is more common since 1950.

The main basic point of this model is that the deck is jointed to the towers via cables in different points ‘they are suitable for spans from 180 to 480 meters.



Fig. 7. Straight cables suspension bridges

- Portal frame
- Portal frame without upper element (tighten to base)
- Portal frame without upper element
- Triangular
- Diamond shape

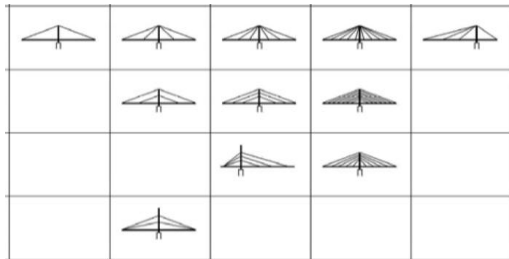


Fig. 8. Straight cables models

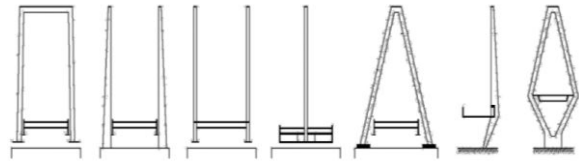


Fig. 9. Straight cables towers

7.1. Mechanism

This model elements are such as a continuous girder one or more towers (which are placed in the middle or to each side of spans).

Diameter shape cables are used to support the girders to towers.

Related to its cables and structure this model has special specifications that complicated calculations are required for.

More complicated calculation must be done for very wide spans which are placed in windy and high temperature places.

It is impossible to occur this calculations and analysis without using a computer program [1].

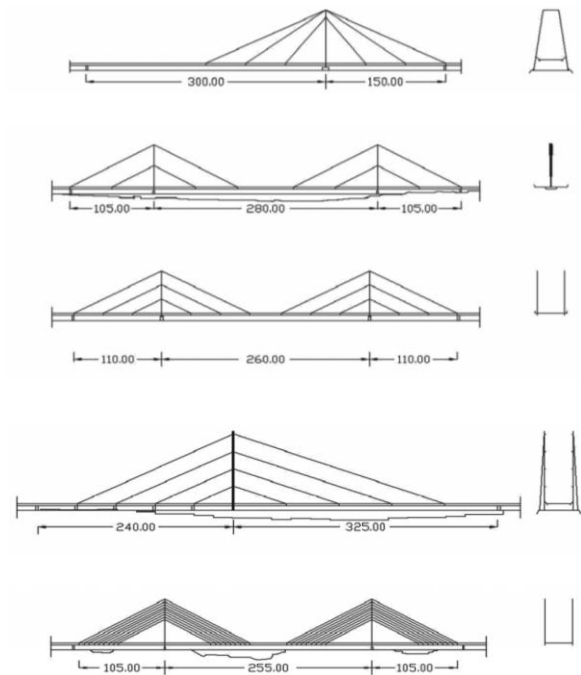


Fig. 10. Straight cables bridges

8. Comparing straight cable bridges with suspending bridges with parabolic cables

For spans between 150 to 850 meters Cable Bridge is the best choice.

Cable bridges are very suitable for gaps between hinged bridges and suspension bridges. In the same situation suspension cable bridge needs more cables but in hinged bridges more materials are used that causes the bridge more and more heavy.

Cable bridges and suspension cable bridges both have deck which is hanged by cables and by the way both of them have towers.

But holding the deck load is different' related to the systems of connecting cables to the towers.

In suspension cable bridges, cables are freely passed via upper points of towers and transferring load to supports is done in every ends.

In cable bridges this can be done only by towers.

In cable bridges less cable are required and can be made by pre construction concrete blocks, in same shape speed of installation are faster [1].

9. Installing instruction and tensioning cables

Bridge is a narrow structure and can be deform by any external forces.

For calculating the cables stress, information and coordination of stiffened points are required

We suppose that cables are like springs with stiffness equal to K,

Structure of a bridge is supposed to be a model that its stiffness is equal to K_s ,

Physical model is modified without geometrical dimensions.

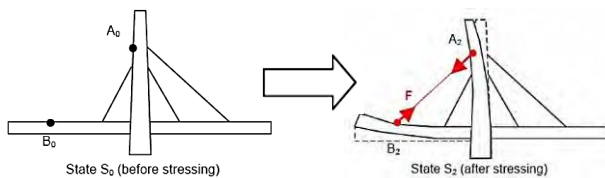


Fig. 11. Pylon deformation after installing the bridge

Cables are formed from several single strings, so when it is pulling with S_i

Strand, the amount of force is decreasing in installed cables.

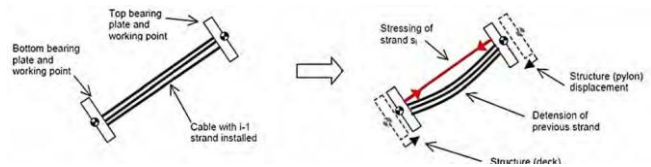


Fig. 12. Decreasing force in installed cables.

In below diagram decreasing the force of each strand is shown after the next strand pulling the cable, the reason is moving and changing in the sit.

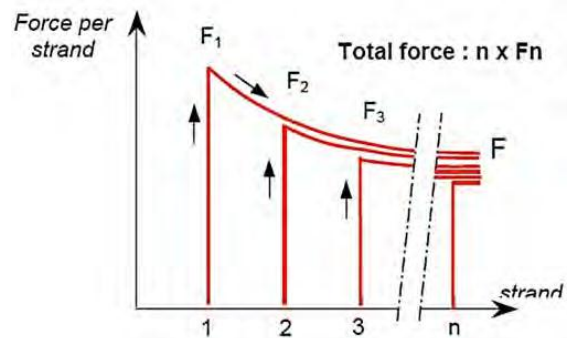


Fig. 13. Decreasing force diagram of each strand

As the structure is flexible ,the amount of tension during pulling process in the strand are not same ,in the other hand the distance of restrained points are differ from each other. The first strand is fixed to one of the restrained points and the other end of the cable is cut and fixed to another strand with bolt and nut. The pulling force is equal to amount which is mentioned in design analyses .and notified the structure deformation which have been calculated [4].

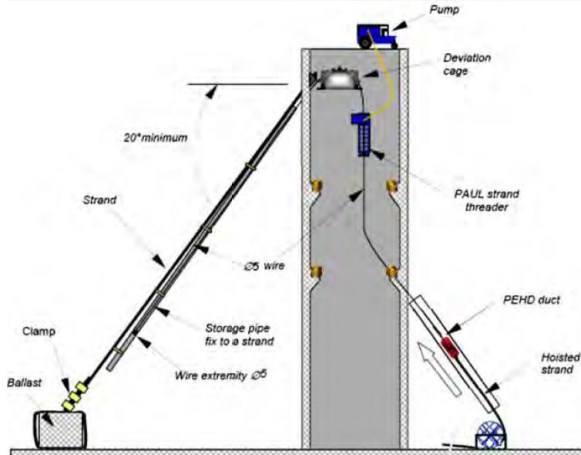


Fig. 14. Installation shape of cables

10. Equipment which are used for installation process

Equipment like rolic, strand, barg, vertical crane are used in this process [5].

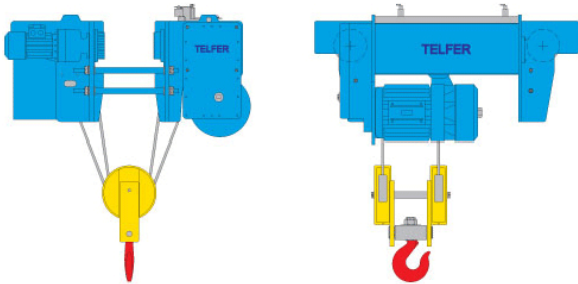


Fig. 15. Rolic, strand, barg, vertical crane

11. Conclusion

It is the best choice for long spans. Tower, span, cables are the main elements of cable stayed bridges. Shape and appearance of the bridges are identified. Cable arrangements such as fan, harp, semi harp are the most important that are shown here. Types of towers are such as single, double, portal and a shape mostly use in cable bridges.

Acknowledgments

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