A

Seminar report

On

Suspension Bridge

Submitted in partial fulfillment of the requirement
for the award of degree
Of Civil

SUBMITTED TO: **SUBMITTED BY:**

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Preface

I have made this report file on the topic **Suspension Bridge;** I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to …………..who assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

Suspension Bridge

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Abstract: ***Bridge is a structure built to span across a valley, road, body of water, or other physical resistance, for the purpose of providing passage over an obstacle. Bridges are those marvel in civil engineering tool kit which help in connecting the places located on other side of bank. Varieties of bridges have evolved from history. Of them one is suspension bridge. It is constructed to span across water body or valley. Nowadays these are the pioneers in bridge technology. Of all the bridge types in use today, the suspension bridge allows for the longest span ranging from 2,000 to 7,000 feet. Also they have quite attractive view which has added to the gloom of suspension bridges.***

INTRODUCTION

There are six main types of bridges:-

1. Arch Bridge
2. Beam Bridge
3. Cable-stayed Bridge
4. Cantilever Bridge
5. Truss Bridge
6. Suspension Bridge

Suspension bridge is most commonly built to span across water body. It is built by suspending the roadway from cables attached to a master cable which runs above the length of the bridge. In addition to being strong and lightweight, suspension bridges are also beautiful. The design of a suspension bridge is simple and straightforward, and takes advantage of several techniques to distribute the weight of the bridge safely and evenly

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The main forces in a suspension bridge are tension in the main cables and compression in the pillars. Since almost all the force on the pillars is vertically downwards and they are also stabilized by the main cables, they can be made quite slender.

In a suspended deck bridge, cables suspended via towers hold up the road deck. The weight is transferred by the cables to the towers, which in turn transfer the weight to the ground.

Most of the weight or load of the bridge is transferred by the cables to the anchorage systems. These are imbedded in either solid rock or huge concrete blocks. Inside the anchorages, the cables are spread over a large area to evenly distribute the load and to prevent the cables from breaking free.

Famous golden gate bridge in San francisco

History: The basic design of a suspension bridge has been in use for centuries. Thousands of years ago, people crossed waterways by swinging hand over hand on suspended cables. Later, these rope cables were replaced by iron which carried more load. Major bridges were still built using a truss design until 1808, when an American inventor named James Finley filed a patent on an early version of a suspension bridge. Finley's design involved stretching two strong chains over the top of several towers and anchoring them on either side of the bridge. He hung lesser chains from the two master chains and used them to suspend a rigid deck, and the modern incarnation of the suspension bridge was born. In 1830, French engineers realized that strongly woven cables were safer than chains, and began to use them in the construction of suspension bridges. Today all use this cabled design, but the basic form of the suspension bridge has remained the same, and engineers continue to push the limits of the spans that suspension bridges can cross.

The construction of bridge seems to be simple, but engineer's quest for longer span suspension bridge makes the construction a challenge. The details are as follows….

RAW MATERIALS:

Many of the components of a suspension bridge are made of steel. Steel is also used for the saddles, or open channels, on which the cables rest atop a suspension bridge's towers. When steel is drawn (stretched) into wires, its strength increases; consequently, a relatively flexible bundle of steel wires is stronger than a solid steel bar of the same diameter. This is the reason steel cable is used to support suspension bridges. The towers of most suspension bridges are made of steel, although a few have been built of RCC.

Design:

Each suspension bridge must be designed individually to take into account many factors. A thorough survey of topography must be carried out and all the factors affecting bridge must be considered. For example, the geology of the site which provides an information about the foundation for the towers and cable types.


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Also the seismic activities in the region must be taken care of, so as to make the bridge not susceptible to earthquakes. The depth and nature of the water being bridged (e.g., fresh or saltwater, and strength of currents) may affect both the physical design and the choice of materials like protective coatings for the steel. In waters which are frequently used by ships the height of the bride also must be taken into account. In very long bridges, it may be necessary to take the earth's curvature into account when designing the towers. The timing of start of work must also be taken to see that the weather conditions don't hamper the critical work when in progress.

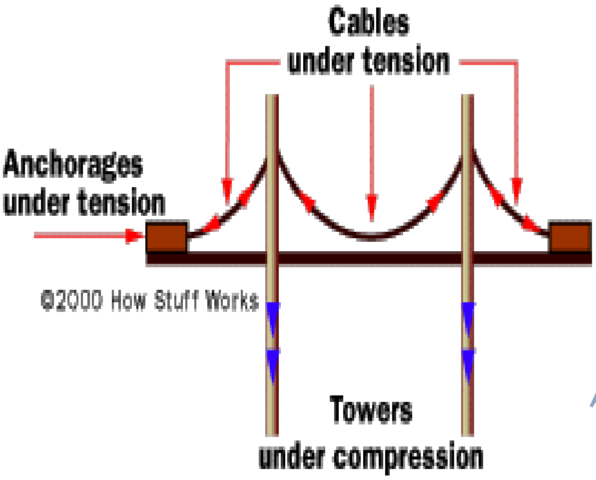
The Manufacturing Process:

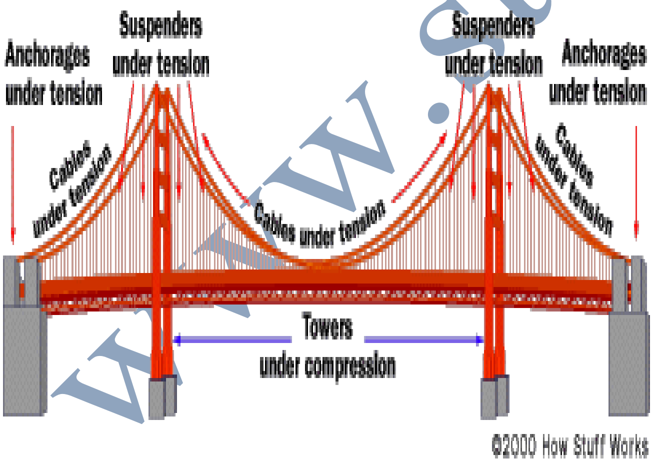
Construction of a suspension bridge involves sequential construction of the towers that will stand in water. It begins with caissons (a steel and concrete cylinder that acts as a circular dam) that are lowered to the ground beneath the water, emptied of water, and filled with concrete in preparation for the actual towers. Some of the major components of bridge are;

1: The towers and cable anchorages

2: The support cable

3. The deck





1:-Tower construction

(a) Thetowers.

Tower foundations are prepared by digging down into earth to a sufficiently firm rock formation**.** Some bridges are designed so that their towers are built on dry land, which makes construction easier. If a tower will stand in water, its construction begins with lowering a caisson (a steel and concrete cylinder that acts as a circular damn) to the ground beneath the water, *caissons* are sunk and any soft bottom is excavated for a foundation. Water is removed from the caisson's interior which allows workers to excavate a foundation without actually working in water. If the bedrock is too deep to be exposed by excavation or the sinking of a caisson, pilings are driven to the bedrock or into overlying hard soil to distribute the weight over less resistant soil may be constructed, first preparing the surface with a bed of compacted gravel. The piers are then extended above water level, where they're capped with pedestal bases for the towers. When the excavation is complete, a concrete tower foundation is formed and poured .When the towers are founded on dry land, deep foundation excavation or pilings are used.Fromthefoundation, towers of single or multiple columns are erected using high-strength reinforced concrete, stonework, or steel. Concrete is used most frequently in modern suspension bridge construction due to the high cost of steel.

(b)Cable anchorages (Anchorage construction)

Anchorages are the structures to which the ends of the bridge's cables are secured. They are massive concrete blocks securely attached to strong rock formations. Anchorages are constructed, usually in tandem with the towers, to resist the tension of the cables and form as the main anchor system for the entire structure. These are usually anchored in good quality rock, but may consist of massive reinforced concrete deadweights within an excavation. During construction of the anchorages, strong eye bars (steel bars with a circular hole at one end) are embedded in the concrete. Mounted in front of the anchorage is a spray saddle, which will support the cable at the point where its individual wire bundles fan out—each wire bundle will be secured to one of the anchorage's eye bars. Some of the anchorages are even made air tight so that they don't come in contact with air, which often results in rust. When the towers and anchorages have been completed, a pilot line must be strung along the cable's eventual path, from one anchorage across the towers to the other anchorage.

Large devices called *saddles*, which will carry the main suspension cables, are positioned atop the towers. Typically of cast steel, they can also be manufactured using riveted forms, and are equipped with rollers to allow the main cables to shift under construction and normal loads.

Anchorage of akashikaikyo bridge.

One of the prime points while constructing anchorage would be to see that it is strong enough bears the load of entire cables. Sufficient space must be provided inside anchorage so as to carry the maintenance work.

*II:-**THE SUPPORT CABLE***

The main suspension cable in older bridges was often made from chain or linked bars, but modern bridge cables are made from multiple strands of wire. This contributes greater redundancy; a few flawed strands in the hundreds used pose very little threat, whereas a single bad link or eye bar can cause failure of the entire bridge.
Another reason is that as spans increased, engineers were unable to lift larger chains into position, whereas wire strand cables can be largely prepared in mid-air from a temporary walkway.
The cables are made of thousands of individual steel wires bound tightly together. Steel, which is very strong under tension, is an ideal material for cables; a single steel wire, only 0.1 inch thick, can support over half a ton without breaking.

When the towers and anchorages have been completed, a pilot line must be strung along the cable's eventual path, from one anchorage across the towers to the other anchorage. Various methods can been used to position the pilot line. A helicopter might be used. Or the line might be taken across the expanse by boat and then lifted into position. When the pilot line is in place, the temporary suspended walkways, called *catwalks*, are erected using a set of guide wires hoisted into place via winches positioned atop the towers. A catwalk is constructed for the bridge's entire length, about 3 ft (1 m) below the pilot line, so workers can attend to the cable formation. These catwalks follow the curve set by bridge designers for the main cables, which are accordingly to the shape of bridge. Typical catwalks are usually between eight and ten feet wide, and are constructed using wire grate and wood slats.

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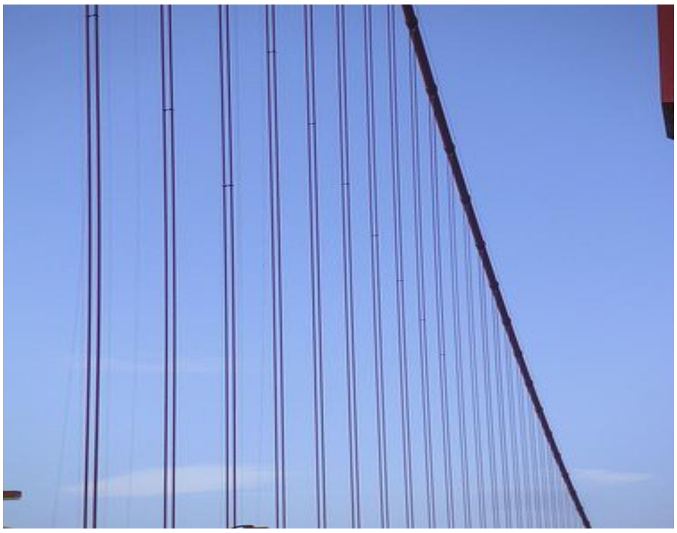
Cat walks

To begin spinning the cable, a large spool of wire is positioned at the anchorage. The free end of the wire is looped around a strand shoe (a steel channel anchored to an eye bar). Between the spool and the strand shoe, the wire is looped around a spinning wheel that is mounted on the pilot line. This wheel carries the wire across the bridge's path, and the wire is looped around a strand shoe at the other anchorage; the wheel then returns to the first anchorage, laying another strand in place. The process is repeated until a bundle of the desired number of wire strands is formed (this varies from about 125 strands to more than 400). During the spinning, workers standing on the catwalk make sure the wire unwinds smoothly, freeing any kinks. As spools are exhausted, the end of the wire is spliced to the wire from a new spool, forming a continuous strand. When the bundle is thick enough, tape or wire straps are applied at intervals Once the vertical cables are attached to the main support cable, the deck structure must be built in both directions from the support towers at the correct rate in order to keep the forces on the towers balanced at all times. A moving crane lifts deck sections into place, where workers attach them to previously placed sections and to the vertical cables that hang from the main suspension cables. To keep the wires together. The wire coming off the spool is cut and secured to the anchorage. Then the process begins again for the next bundle.

The number of bundles needed for a complete cable varies; on the Golden Gate Bridge it is 61, and on the Akashi Kaikyo Bridge it is 290. When the proper number have been spun, a special arrangement of radially positioned jacks is used to compress the bundles into a compact cable, and steel wire is wrapped around it. Steel clamps are mounted around the cable at predetermined intervals to serve as anchoring points for the vertical cables that will connect the decking to the support cable.



MASTER CABLE AND SUSPENDED CABLE IN PLACE

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III: - THE DECK

Most suspension bridges have open truss structures to support the roadbed, particularly owing to the unfavorable effects of using plate girders, discovered from the Tacoma Narrows Bridge (1940) bridge collapse. Recent developments in bridge aerodynamics have allowed the re-introduction of plate structures. This type of construction to be used without the danger of vortex shedding and consequent aeroelastic effects, such as those that destroyed the original Tacoma Narrows Bridge

After vertical cables are attached to the main support cable, the deck structure can be started. The structure must be built in both directions from the support towers at the correct rate in order to keep the forces on the towers balanced at all times. The wire used in suspension bridge construction is a galvanized steel wire that has been coated with corrosion inhibitors. After vertical cables are attached to the main support cable, the deck structure can be started. The structure must be built in both directions from the support towers at the correct rate in order to keep the forces on the towers balanced at all times. In one technique, a moving crane that rolls atop the main suspension cable lifts deck sections into place, where workers attach them to previously placed sections and to the vertical cables that hang from the main suspension cables, extending the completed length. Alternatively, the crane may rest directly on the deck and move forward as each section is placed. At specific points along the main cable (each being the exact distance horizontally in relation to the next) devices called "cable bands" are installed to carry steel wire ropes called *Suspender cables*. Each suspender cable is engineered and cut to precise lengths, and are looped over the cable bands. In some bridges, where the towers are close to or on the shore, the suspender cables may be applied only to the central span.

DECK BEING PUT IN PLACE

Special lifting hoists attached to the suspenders or from the main cables are used to lift prefabricated sections of bridge deck to the proper level, provided that the local conditions allow the sections to be carried below the bridge by barge or other means. Otherwise, a traveling cantilever derrick may be used to extend the deck one section at a time starting from the towers and working outward. If the addition of the deck structure extends from the towers the finished portions of the deck will pitch upward rather sharply, as there is no downward force in the center of the span. Upon completion of the deck the added load will pull the main cables into an arc mathematically described as a parabola, while the arc of the deck will be as the designer intended — usually a gentle upward arc for added clearance if over a shipping channel, or flat in other cases such as a span over a canyon. Arched suspension spans also give the structure more rigidity and strength.

Design of the deck also plays a major role in defining stability of bridge. As navigation needs to carried even after building the bridge, so the height of deck above the surface of sea must be taken care of, so that it is not too low or too high. If too low then it may hit the ships and if too high then it may not resist even low turbulent air. If decks sway a bit then it may even result in large scale destruction. Thus the decks must be designed such that they are light weight and can carry heavy load. Sufficient passage must be given for air to pass through them, such that it offers minimum resistance. Also space must be provided below the deck so as to carry out the maintenance work. For this purpose box or triangular based deck are most advisable. In case of longer span bridges, the deck must have slight amount of swing so as to resist the turbulent air. One of major issues during design would be to see that the deck is given some limit to bulge, so that it won't collapse when the load imposed on it by the traffic above can be absorbed if it exceeds the safe limit.

Completed deck work

Precautions while constructing suspension bridge:

1. The foundation type and depth must be the major attention that needs to be taken care of, since the entire load of bridge is being transferred into ground by means of towers. The towers must be designed such that it becomes easy for the maintainers to climb the tower for purpose of painting etc. In case of seismic prone regions steel towers are advisable, since they have allowable swing on either side the towers don't collapse during a sustainable earthquake. Also huge pendulums can be fixed within towers which help in maintaining tranquility of the bridge, whenever there is earthquake, by swaying in opposite direction to that of towers by means of hydraulics.

3. It must be accounted that the anchorages are strong enough to with stand the stress and strain imposed on them by the master and suspended cables. Another major issue regarding anchorages would be addressing the impact of weather conditions which often results in rusting of the cables within anchorages. So it is evitable to make the entire anchorage air tight.

4. After hoisting pilot cable utter issue needs to be addressed is the safety of catwalks, which will used by workers to put in place the suspension cables.Using large no of wire strands make the cable strong enough to carry the heavy load deck. Hence the wire strands must be closely spanned so that it can with stand heavy load of deck without crossing the allowable tensile limit. Also it is advisable to paint the support cables to prevent it from rusting.

5. Once the master and suspended cables are in place the deck must be placed in position..The hydraulics which moves the deck should be sufficiently lubricated so that they will not fail in between, as it consumes huge amount of time to repair them. As a precautionary measure the navigation of ships must be stopped when the decks are being placed. Major issue that needs to be addressed during placing of decks would be safety of workers.

6. 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.

Advantages of suspension bridge:-

1. The center span may be made very long in proportion to the amount of materials required, allowing the bridge to economically span a very wide canyon or waterway.

2. It can be built high over water to allow the passage of very tall ships.

3. Neither temporary central supports nor access from beneath is required for construction, allowing it to span a deep rift or busy or turbulent waterway.

4. being relatively flexible it can flex under severe wind and seismic conditions, where a more rigid bridge would have to be made much stronger and so also heavier.

Akashi kaikyo bridge-Japan, world's longest suspension bridgeItsspan extends about 1990mts

Limitations compared to other bridge types:-

1. Considerable stiffness or aerodynamic profiling may be required to prevent the bridge deck vibrating under high winds.

2. The relatively low deck stiffness compared to other types of bridges makes it more difficult to carry heavy rail traffic where high concentrated live loads occur.

3. Under severe wind loading, the towers exert a large torque force in the ground, and thus require very expensive foundation work when building on soft ground.

4. Considerable stiffness or aerodynamic profiling may be required to prevent the bridge deck vibrating under high winds

5.The relatively low deck stiffness compared to other (non-suspension) types of bridges makes it more difficult to carry heavy rail traffic where high concentrated live loads occur

6. Some access below may be required during construction, to lift the initial cables or to lift deck units. This access can often be avoided in cable-stayed bridge construction.

CONCLUSION

These are the pinnacles in modern day's bridge technology.Longer spans of up to

2000 ft-7000 ft is possible. They are ideal for covering busy waterways such as Gulf, Strait, Lake, etc.These bridges are mainly meant for light & heavy roadways rather than railways.The main forces in a suspension bridge are tension in the main cables and compression in the pillars**.**

In future suspension bridges can be the tools which will test the engineer's limits…………….

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