CRITICAL ANALYSIS OF THE LUPU BRIDGE IN SHANGHAI

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Abstract: This article provides a critical analysis of The Lupu Bridge in Shanghai. The bridge is currently the world's longest spanning steel arch bridge with a span of 550m. The analysis of this report includes sections on aesthetics, loading, structural analysis and construction. The Lupu Bridge is a steel through-tied box-girder arch bridge and it is also the only steel arch bridge in the world to be completely welded.

Keywords: Lupu Bridge, Steel, Arch Bridge, Longest Span, Welding.

Figure 1: View of bridge deck and arches at night. Ref. [1]

1 Introduction

The Lupu Bridge is located in Shanghai, China. It is currently the seventh crossing to be constructed over the Huangpu River in the city. The bridge is located in the south of the city with the aim to ease congestion in the quickly developing areas around the southern side of the river and the city centre and also to help with the increasing traffic expected at the 2010 world Expo. The venue for this is set to be surrounding the river at the location of the bridge, so it will not only be a vital part of the infrastructure for this event, it will also act as a showpiece for Chinese engineering.

The bridge was officially opened in June 2003 at a total cost of $302 Million US. On completion the Lupu Bridge was the largest spanning arch bridge in the world with a main span of 550m overtaking the New River Gorge Bridge in the United States by 32m. This record is set to be broken in 2008 by the under construction Chaotianmen Bridge in China by only 2m. The total length of the bridge is 3,900m including the approach bridges on either side of the river.

The bridge was originally heavily criticised as it was seen as wasteful by many people in respect to the type of bridge that was actually needed for the project. Many feel that it is just a show piece for the city and the price tag reflected that status. Other designs were proposed that would have been more economical but were rejected in favour of the tied arch design.

The Lupu Bridge is a steel box section through-tied arch bridge. The central span of the deck is suspended from two sets of 28 double cables attached to the two inclined arches.

The ground conditions on either side of the bridge are not suitable for the large thrusts that would be caused by a normal arch bridge and this is what lead to the decision of using a through tied arch which will be discussed further later in this paper.

Below are two elevations of the bridge, the side profile and a view looking longitudinally along the deck. Beneath these drawings is a plan view of the bridge. (Fig. 2)

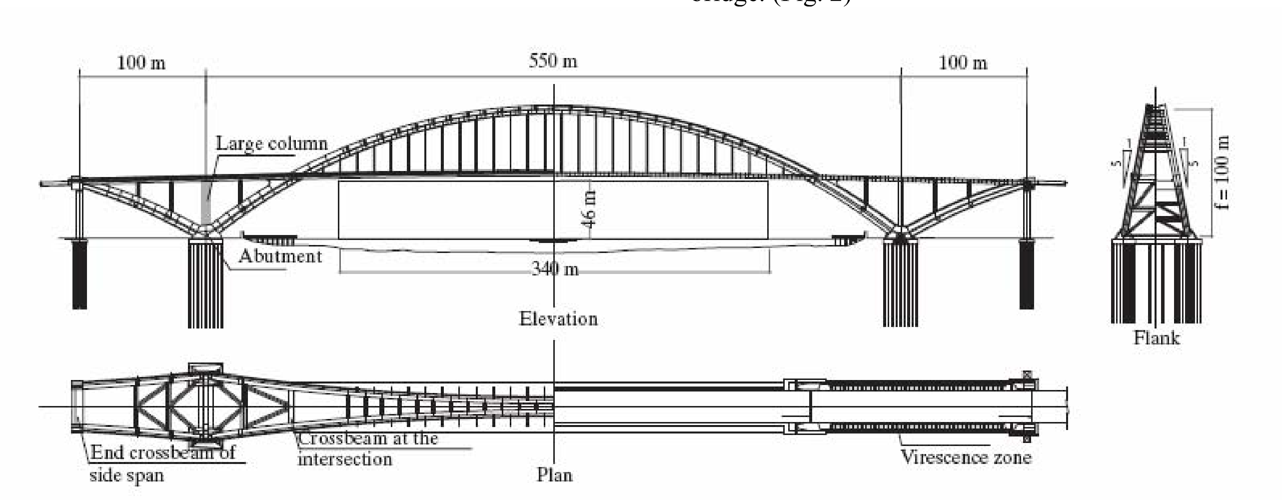

Figure 2: Plan and two elevations. Ref. [2]

2 Aesthetics

When considering the aesthetic qualities of a bridge, Fritz Leonhardt's criteria for assessing the bridges attributes is commonly used as a guideline. He details ten rules that a bridge should adhere to if it is to be considered beautiful. The analysis of the aesthetics of the Lupu Bridge is to be carried out with these ten rules in mind.

2.1 Functionality

The functionality of a bridge should reflect its apparent ability to successfully achieve the purpose it was built for. In this case the large sweeping arches supporting the wide 6 lane deck impart a feeling of stability whilst maintaining a sense of elegance in the design. This is shown in Fig. 3 below.

Figure 3: Arches protruding out of the deck. Ref. [3]

2.2 Proportions

There should be a balance between the sizes and shapes within the bridge structure. In the main span of the Lupu Bridge this is achieved through the relative sizes of the large section arches and the relatively thin deck section.

The spacing between the cables of the mid span also seem to be in proportion with the spacing of the column supports at the side spans taking into account the relative increase in size from the cables to the columns.

2.3 Order

The structure should be well ordered in that it has a coherence and fluency about the lines and shapes within it. The Lupu Bridge, being an almost entirely welded structure, has mostly smooth clean lines especially those of the arches.

The line of the deck through the intersection of the arches keeps a fluid line through the centre of the bridge bringing the centre span together with the approach bridges on either side enhancing the continuity of the structure.

Equal spacing of the main cables enhances the well ordered nature of the bridge and this is mirrored in the supporting columns of the approach bridges although, due to the large number of columns, at oblique angles it can look confused and overcrowded.

2.4 Refinements

The main arches of the bridge are inclined at a 5˚ angle towards the centre and the box-section size also decreases as you approach the top of each arch. These give an aesthetically pleasing look to the bridge and a sense of increased stability with the wide span at the footings compared to the arch spacing at the apex.

2.5 Integration into the Environment

Surrounded by industrialism and development, the Lupu Bridge fits effortlessly into its environment. The approach bridges slowly rise up out of the city to carry the road over the river in a continuation of all the colours, textures and materials used either side within the city buildings. This can be seen in Fig. 4 below.

Figure 4: Integration into environment. Ref. [4]

2.6 Texture

The bridge is mainly constructed of welded steel which gives the arches a smooth surface texture, accentuating the curvature. This smooth, clean appearance is replicated in the other structural members.

2.7 Character

Figure 5: Night photo. Ref. [5]

At night the bridge comes alive with an impressive and eye catching lighting arrangement.

Driving over the bridge, the ribs are lit way above the deck like a suspended runway drawing you onto and along the roadway, this can be seen in Fig. 1 at the front of the report.

Combinations of subtle lighting arrangements illuminate the bridge into a graceful sweeping bow over the river. Fig.6. Some of the more powerful lighting effects make the bridge visible from miles around, accentuating it's 'show piece' purpose and attitude.

During daylight hours the bridge is strong yet graceful, fulfilling its design without being over the top.

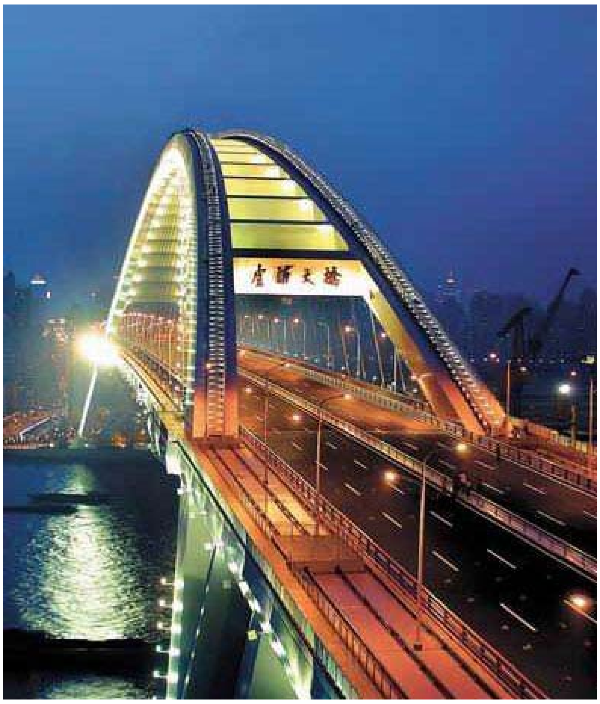

Figure 6: Lighting effects on the bridge. Ref. [6]

2.8 Colour

The approach bridges blend into the cityscape being grey in colour. This is continued through the bridge deck and side span supports enhancing the continuous line across the river.

The arches are painted white which makes them stand out against the grey colours of the city and blues of the sky and river.

The writing on the first horizontal brace above the deck is painted in red which enables it to stand out and be easily seen and read.

The cables are coloured such that they blend into the background and from a distance effectively become invisible, giving the illusion that the deck is floating above the water.

2.9 Complexity

Too much complexity can make a bridge look confusing and untidy. This might be true of the approach bridges as there are a large number of columns supporting the deck but over the centre spans the structural system is more subtle.

It is not immediately apparent how the central and side spans of the bridge work together to support the superstructure and in this make it interesting without looking too complex on first inspection.

2.10 Nature

Drawing inspiration from natural forms creates some stunning shapes and effects, but I don't think that the Lupu Bridge has done this specifically. Its form is more mechanical in the sense of the bowing action of the arches and industrial in the sense of the materials used.

2.11 Aesthetics Summary

The function and structure of the Lupu Bridge are portrayed in an obvious and simple way with subtle refinements and complexities to add to the bridge's aesthetic appeal. Under Leonhardt's rules, the Lupu Bridge has many of the attributes that could make it beautiful. Bridge aesthetics are however a matter of personal opinion and what may be beautiful to one person may not necessarily be so to another.

3 Construction

The construction of the Lupu Bridge has five major phases. These will be talked about separately in the following sections. The project contractor was the Shanghai Construction (Group) General Co and the bridge was designed by the Shanghai Municipal Engineering Design Institute, China.

3.1 Foundations

The ground conditions either side of the Huangpu River are not suitable for the large thrusts produced by an arch bridge, especially one as large as the Lupu Bridge. Although the arch is tied, reducing the forces transferred to the foundations, the total vertical force is still very large. Also due to the arch being tied, parts of the foundations need to be able to resist uplift as shown in Fig. 7 below. Shanghai has generally soft soil but being next to the river the soil on site is particularly soft. For this reason, piled foundations are the most suitable option.

The foundations consist of 118, 900mm diameter steel tubes, each pile being about 65m in length. The larger surface area of the piles and long length implies that they could be friction rather than bearing piles. This is assuming that the soil consists of clay nearer the

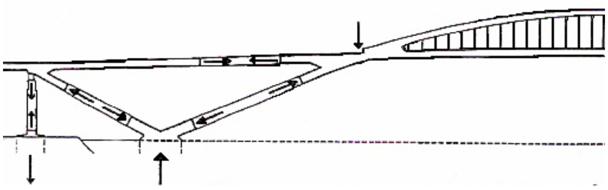

Figure 7: Force diagram of half of the system. Ref. [7]

surface moving into stiffer clay then sand lower down.

The pier cap of the main span foundation is 3.5m thick and crossbeams are used to connect the caps at about 51m centres. The connection between the two pier caps will help to somewhat relieve the stresses in the soil in the horizontal direction and reduce the amount of deflection incurred.

The foundations have also been strengthened by the use of 7oomm diameter soil-cement stirring piles to resist the horizontal force and limit the displacement due to this force. Each of these stirring piles is connected to each other to improve the integrity of the system.

The large number of foundations and addition of stirring piles is partly due to the working loads of the bridge and also due to the loads imparted on the foundations during construction. During construction large temporary towers are built above each abutment. These will impart very large vertical forces into the foundations and will probably be the largest vertical force they will feel.

Due to the horizontal force imparted by the inclined arches the abutment and foundations must also be strengthened in the horizontal direction. The abutment would have to have a high level of prestress in the concrete section and there would also be piles coming from the abutment at an inclination similar to that of the arches.

3.2 Approach Bridges

Figure 8: Approach bridge. Ref. [8]

The focus of this paper is on the 550m central span, but the majority of the length of the Lupu Bridge is in the approach bridges either side of the main arch, a section of which is shown above in Fig. 8. The longer of the two approach bridges is on the south side of the river. This part of the bridge was built in seemingly irregular sections, this was probably to cause minimum disruption to the surrounding city during construction and so that segments needing special equipment could be done in a continuous block of time.

The deck is most likely made of steel as a continuation of the deck of the main span and also the columns that support it. More is said about this in the section on seismic behaviour.

The box girders of the deck would have been pre-fabricated off site and then craned into position on top of the pre-erected columns. Each section is 13.5m in length as are the central span deck segments. This makes them an acceptable size for transportation to site through the busy city.

Construction of the approach spans was simultaneous with that of the arch reducing the time frame of the work which was less than 3 years.

3.3 Side Spans

The side spans of the Lupu Bridge were constructed using a falsework system as at this point there is still ground to work from. The deck would have been built right up to the crossbeam at the connection of the main span arch to provide extra stability during construction of the arches.

The falsework supporting the side span arch most likely remained in place throughout the construction of the main span to help improve the stability and also to spread the load at the base lowering the bearing pressure on the foundations.

Completion of the side spans could not happen until the arch ribs were completed and the temporary towers deconstructed as these towers were supported on the same abutments.

3.4 Arch Ribs

Figure 9: Cable-Stayed Cantilever Construction. Ref. [2]

The arches were constructed using a cable-stayed cantilever method shown above in Fig. 9. Each section of the arch was stayed back to the temporary towers at either side of the arch after being welded to the previous section. This significantly reduces the bending stresses in the arch during construction and instead puts the constructed arch section into compression as it would be upon completion. The cables from the temporary towers to the ground are connected at the location of the foundations that will be resisting uplift on completion of the bridge. Using the same foundations reduces the cost as extra supports were not needed during construction.

The sections are comprised of a 13.5m length of each arch connected by a horizontal wind brace box section. This is seen below in Fig. 10.

A mobile carriage was used to lift the arch and brace sections up from the river off the barges they were shipped to site on. A computer controlled system was probably used to synchronise the strand jacks during deck lifting. The lifting process is shown in Fig. 10 below.

Figure 10: Lifting the arch sections into position Ref. [6]

The carriage then holds the section in place whilst it is welded to the section previous to it. This secure system is favoured as it reduces differential movement between the existing and new segments allowing smoother application of the welding process.

On site welding, although not ideal, was the option chosen for the construction of the bridge. This could possibly have been avoided by pre-welding larger sections of the arch off site. This may have increased the quality of the weld and would have been a less dangerous method of construction. As the sections are transported up the river there would have been no problem with transporting larger pieces to site although it would significantly increase the weight of the segments facilitating the necessity for more expensive lifting and transportation equipment.

Welding as opposed to bolted connections gives a smooth, uninterrupted surface to the arches increasing its aesthetic appeal. In recent years Chinese welding knowledge and technologies has expanded and the growing confidence led to the Lupu arch being exclusively welded. Fig. 11 shows the welding of the arch.

Figure 11: Welding of the steel arch. Ref [9]

More than 600 tonnes of J507Ni welding bars were used, provided by the Shanghai Welding Equipment Company (SWEC). The weld material used has a super low hydrogen content. This type of weld has been used in other bridges along the river including the Nanpu, Yuangpu, Xupu and Fengpu bridges. In order to guarantee the engineering quality of the Lupu, SWEC made improvements to the original composition of the product, increasing its strength and improving the quality control. The welding bars are comparable to other such quality products produced elsewhere in the world but it was more economical to source materials from China than to import them from other countries.

The rib section size is not uniform. At the apex of the arch the depth of the section is smaller than at the springing points. This increase in depth allows the line of action of some load paths to stay within the arch section, reducing the bending moment induced in the arch itself.

3.5 Deck girders

For the mid span girders, a conventional suspension bridge construction method was used. After the arch had been completed the horizontal cables were put in place tying the two ends of the arch together. This can be seen in Fig. 12 below.

After that the bridge was ready to receive the box girders of the deck. These were again brought up the river on barges to site in 13.5m sections.

The girders were installed from the centre of the arch outwards. This is to ensure that the sag in the horizontal cables is uniform and no distortion of the deck occurred. Another reason is that the load being put on the arch can be carried in compression where as if spans were introduced at other points, large bending moments would be induced in the arch.

Figure 12: Horizontal cable installation. Ref [9]

At the crossbeams at either side of the main span the deck is supported on sliding bearings to allow for expansion due to temperature effects. Also at this location is a damping caging device in the longitudinal direction which reduces the effects on the bridge during an earthquake.

After the deck had been fully constructed and the approach bridges completed the temporary works could be removed and the road surface laid. After this the remaining railings, safety barriers and lighting were installed.

4 Materials

The main material used in this project is steel. The arches, deck, bracing, columns and pile foundations are all steel sections. This is the only material that is capable of spanning such a large distance in a single span. It also has the best properties for withstanding seismic activity out of the major bridge building materials as it is ductile.

Concrete is used at the abutments as this is the most effective way of creating an anchorage.

Extensive welding was carried out on the bridge especially on the arches. Both the steel and welding bars come from Chinese companies as they are locally available and technologies in welding are quickly evolving.

The deck is mainly steel but has a 75mm layer of tar to create the black road surface to provide a better driving surface.

5 Loading

There are a number of different loads that can be acting upon the bridge at any one time. These will each be addressed separately below. It is assumed that the Chinese bridge codes were used in the design of this bridge but not having access to these, the equivalent British Standards will be used throughout this paper.

5.1 Dead Load

The dead load is obtained from the weight of the permanent parts of the bridge structure itself. This includes the steel deck, arches, wind bracing, columns and bracing under the deck.

The dead load is calculated by obtaining the mass of the section of bridge being considered and multiplying it by the appropriate design factors. Steel has a unit weight of 7850 kg/m^3 and the safety factors used are γ_{fl} = 1.05 and γ_{f3} = 1.1. All safety factors are taken from BS5400-2:2006.

Being constructed of steel box sections the Lupu Bridge would have a relatively low self weight compared to other arch bridges made of concrete or stone for example. Due to it's large size though there is a substantial amount of steel contained within the structure making the dead load of the bridge a significant factor in design.

5.2 Imposed Dead Load

The imposed dead load comes from the road surface itself and other removable objects such as hand rails and lamp posts along the roadway. The road surface of the Lupu Bridge is made of a 75mm thick layer of tar, there are hand rails along either side of the bridge, safety railings on either side of the road surface and one along the central reservation and lamp posts positioned between every other set of cables on both sides of the bridge. The safety factors for imposed dead load are different according to the type of material being considered. The factors for the road surface are as follows, γ_{fl} = 1.75 and γ_{f3} = 1.1. The unit weight of tar is 2400 kg/m^3.

5.3 HA and HB Live Loading

The loading produced from traffic flowing across the bridge including a uniform load, an abnormal load and a Knife Edge Load (KEL) are considered. HA loading refers to a uniform traffic loading and an additional KEL, HB loading refers to an abnormally large load passing across the bridge.

From BS5400-2:2006, section 3.2.9.3.1, the number of notional lanes across the carriageway is 7 as the width of available road surface is 24.5m across the deck. This gives a notional lane width of 3.5m. From Table 13 of BS5400-2:2006 the uniformly distributed HA loading for a deck of length 450m is 19.5kN/m. To gain a load intensity from this nominal uniform load the HA loading is divided by the number of notional lanes. This gives a load intensity of 8kN/m^2 after multiplying by appropriate factors.

The KEL is taken as 120kN per notional lane.

HB loading is varied according to the effect we want it to have on the system we are analysing. For full HB loading the factored loading for the front two axels is 1287kN as is the back two axels. This can either be spread over two notional lanes or just one. There must be a 25m gap in front of and behind the abnormal load.

5.4 Pedestrian Loading

The loading from pedestrians can be used in two ways depending on the calculation that the load is being used for. Either two strips of loading along the passenger walk ways of 4kN/m should be used. Or a uniformly distributed load of 1.4kN/m^2 over the whole deck surface. This loading has come from BS5400-2:2006 Section 6.5.1.1 as the calculation shows below where HAUDL is the HA uniformly distributed load and L is the length of the deck section in equation (1).

$$= \frac{5 \times HAUDL \times 10}{L + 270} \tag{1}$$

$$= \frac{5 \times 19.5 \times 10}{450 + 270}$$

$$= 1.35 kN / m$$

5.5 Seismic Load and behaviour

The seismic loading used in design was for an intensity 7 earthquake.

Steel is a ductile material and therefore a good choice for a bridge situated in a seismic area as large deformations would occur giving warning before any possible collapse.

The central span of the bridge is tied and has no relative horizontal force components acting on the rest of the structure. Bearings are located at these connections to allow the independent movement of the central span in relation to the side spans. Accompanied by damping devices at the same location, these bearings will help to localise the oscillations of the bridge during an earthquake and through the dampers, dissipate the vibrations. This isolation of the central span will help to limit the damage to this section

5.6 Wind Load

The city experiences a few typhoon spells a year which brings not only torrential rain but also strong, powerful winds and sometimes tornadoes.

The bridge has been designed to withstand a force 12 typhoon. One of the elements which have been incorporated into the design to protect the bridge from these effects are the large wind brace sections joining the two arches together. These large box sections enable the two arches to act together so that when there is a wind loading on one side of the bridge, the opposite side feels an increase in the compression force acting on it as it resists the windward sides' deflection.

The deck of the bridge does not have any parapets, which gives it a shorter section size and therefore a smaller area on which the wind can act.

All railings, safety barriers and lamp posts on the bridge are of circular section which also helps to reduce the wind loading as they reduce the surface area and are a more aerodynamic shape, helping the air to flow around them.

5.7 Temperature

The geographical coordinates of the bridge are 31˚13'N, 121˚28'E. The climate is subtropical, monsoon influenced and humid. Shanghai in particular has a climate where the summer is much wetter than the winter and is also very humid due to unstable tropical air masses.

Shanghai experiences periods of freezing temperatures during the winter and in the hotter months of July and August a 32˚C average high. Temperature extremes of -10˚ and +41˚ have been recorded.

During the spring months from March to June, the city experiences large diurnal variations which are the time when the bridge is most at risk from temperature effects. This is because parts of the bridge will remain cooled whilst those exposed to the sun will warm up and expand causing differential movements and forces within the structure that put additional strain on the materials.

The thermal expansion coefficient of steel is $12x10^{-6}/˚C$.

The approach bridges are not a major concern in regards to temperature effects as they are curved in plan, therefore any increase in size will just result in a greater curve deflection and a small increase in bending moment of the steel columns.

The main arch span is of more concern. The bearing joints at either side of the span will allow for an increase in size. Also, because the arch is tied any temperature effects causing the steel to want to expand will be restrained by the horizontal cable ties. Therefore an increased capacity in the cables will prevent the stresses affecting the rest of the structure as they will be self contained.

6 Calculations

To analyse this structure a number of assumptions need to be made as little information is available about the dimensions or design loadings on the bridge.

6.1 Suspender Cable Radius

Calculations of the dead load on the bridge for the central span to estimate the diameter of the deck hangers are summarised below. Estimates of the section sizes are taken from Fig. 13 below.

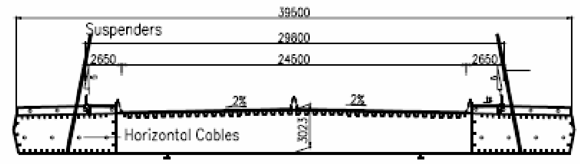

Figure 13: Section of main span girder
Ref. [2]

Total area of steel in deck = $1115200mm^2$
∴ Volume = $501.8m^3$
∴ Dead load = 40,000kN
∴ Factored dead load = 46,200kN

Table 1: Imposed dead loads

Material	Load (kN)
Road surface (tar)	58,800
Circular section railings	2400
Safety barriers	4800
Lamp posts	3360

The factored imposed dead load consists of the separate loads from different materials shown in Table 1 above.

Therefore the total factored imposed dead load is 76,000kN acting on the central span of the bridge.

The loading from vehicles across the bridge is given above in the section on HA and HB loading.

The pedestrian loading is also given above in the section on pedestrian loading.

Summing these loads gives the design loading for condition 1 in BS5400-2:2006 and results in a uniformly distributed load of 335kN/m. To calculate the diameter of the vertical hangars the assumptions that all of the cables take the same load, that the deck is pinned at either end and the deck side supports also carry the same vertical loading are made.

There are 28 pairs of hangers along the 450m length of deck between the supports spaced at 13.5m intervals.

This gives a vertical reaction at each support of 5016kN.

Along the deck span the reaction load at each point is shared between 4 identical cables, 2 on either side of the bridge. Assuming again that each cable takes the same loading, the tension induced is 1245kN. Therefore to find the radius of the cables the following calculations are performed using equations (2) and (3).

$$Strength(\sigma) = \frac{Force(F)}{Area(A)} \qquad (2)$$

$$A = \frac{F}{\sigma}$$
$$= \frac{1245}{470 \times 10^{-3}}$$
$$= 2668mm^2$$

Therefore the radius of the cable can be calculated from the following;

$$Radius = \sqrt{\frac{2668}{\pi}} \qquad (3)$$

$$= 29mm$$

These calculations were performed with the assumption that the strength of the steel cables is 470N/mm^2. This assumption is also used in the following cable calculation.

6.2 Horizontal cable ties

To calculate the dimensions of the horizontal ties, the self weight of the arch first needs to be calculated. This is shown in the calculation below.

$$Volume = 435m^3$$
$$Weight = 7850 \times 435$$
$$= 3415000kg$$
$$Mass = 34000kN$$

The mass of the wind braces also need to be found.

$$Volume = 80m^3$$
$$Weight = 7850 \times 80$$
$$= 625000kg$$
$$Mass = 40300kN$$

Adding these two values together and adjusting by the use of the appropriate load factors gives a design loading of 103kN/m. Adding this design load to the load imparted by the cables on the arch we obtain the uniformly distributed design load for the arch, 259kN/m.

Resolving the arch system assuming that the arch is pinned at the bases, gives the in plane reaction forces as 58275kN. Resolving this force into horizontal and vertical components finds that the horizontal force tying the arch is 53,000kN.

Finding the size of cable needed to take this force is shown in the calculation below using equation (2).

$$A = \frac{F}{\sigma} \qquad (2)$$
$$= \frac{53000}{470 \times 10^{-3}}$$
$$= 112765mm^2$$

This area is shared between 8 cables giving a cable radius of 67mm.

6.3 Abutment forces

By taking into account the vertical forces produced by the tied arch and those from the deck section over the abutment area the forces transmitted to the ground can be found by taking moments around the abutment and the tension tie. Making assumptions about the angles of the arch away from the abutment the tensional force felt at the vertical support is calculated at 31000kN and the compression force felt at the abutment is equivalent to 14,000 tonnes. Although these values are large they aren't as large as expected and this is partly due to the many assumptions made during calculation. There are also many other load cases to be analysed and they would definitely provide higher forces than those gained here. This is true for all the calculations presented in this paper. They are rough estimates based on many assumptions.

6.4 Serviceability

The bridge was load tested not long after completion with 36 trucks of load capacity 30 tons all driving over the bridge at once. The deck sunk at the maximum point 116mm under the 1000 ton load. This is an acceptable deflection for this bridge.

7 Susceptibility to intentional damage

The Lupu Bridge is a showpiece for the city and a major arterial route from the north to the south. In this respect it may be a target for intentional damage as it would cause major disruption to the city.

The clearance underneath the deck over the water is very large as there is a port nearby the bridge and large ships need to be able to pass under it. The abutments are built well into the bank away from the water edge so any intentional damage would be unlikely to occur in these areas.

The place that damage is most likely to occur is under the approach bridges as there is a large number of columns underneath the roadway. A vehicle could drive into this area and potentially remove a column or maybe more.

Due to the bridge being recently designed and constructed, this kind of damage is unlikely to cause collapse because the scenario would have been considered in design and structural checks carried out to make sure that the bridge would be safe.

The bridge was possibly most venerable during construction when the arches were being welded into place, stayed to the temporary towers.

8 Future Changes

The Lupu Bridge has been built to ease congestion in the central shanghai area, as have the bridges built before it. Previously if the capacity across the river needed to be increased a new bridge was built to solve the problem, rather than trying to modify the ones already in existence.

The Lupu Bridge has been built as a show piece for Shanghai and due to this it is unlikely that it will be changed. Increasing the capacity of the bridge is not easily achievable due to its shape and the ground conditions on either side of the river. Large foundations have been built to accommodate the existing loads and any additional work to the bridge would require a significant increase in their capacity.

9 Conclusion

The Lupu Bridge, as well as being a stunning, eye catching and graceful bridge, is also a remarkable feat of engineering. The carefully thought out aesthetics all work together to create what is a seemingly effortless structure across the water. From photographs it is hard to grasp the sheer scale of the elements which go to make up the Lupu Bridge, all of which are necessary to make the large spanning arch possible.

Advances in welding techniques and technologies were created in the process of building this bridge and have done a great deal to promote the Chinese standing in the world of steel arch engineering.

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