JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Strengthening Design of Beigao Interchange Bridge Against Overturning Instability

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Abstract

Engineers frequently design single column pier bridges without a specific pier cap due to limited construction space, economical design and some other factors. For this, a single column pier, single support bridge tends to turn over its supports in the same direction as a moving vehicle when it travels along the lane close to the edge of the deck. This problem is ignored most of the time; in fact, during the investigations of some accidents, the overturning issue was underestimated, but later, in some cases, it was proved that the particular accident was caused by the overturning instability. The bridge, studied in this research is a simply supported box girder bridge. The section consists of three spans with a total length of (24m+30m+20m) 74m, where at the middle, two single column piers with single bearing support have been adopted. The main objective of the research is to analyze the structure to evaluate whether there is any overturning instability present in the bridge. In cases of instability some countermeasures should be taken. Some schemes should be developed to make the bridge safe enough to continue the operation. The selected scheme should be analyzed to visualize the substantial evidence to prove the effectiveness of the developed scheme. For evaluating the actual condition of the bridge, finite element analysis has been done using computer software. The bridge was found to have overturning instability after analyzing the original bridge and calculating the overturning coefficient. Where the overturning coefficient was much less than the standard value. To make the bridge safe, three initial strengthening schemes have been proposed: to enlarge the pier cap; to install steel tie plate and stringers and the last one was to install additional CFST piers. The third one was selected and analyzed in the finite element analysis software, and then according to the analysis report, the overturning coefficient has been calculated, which shows significant increments in the value of the coefficient (84.65% and 39.08% increments in support 4L and 7L, respectively) and the results come closer to the standard value. For more increments, it is suggested to increase the distance between additional piers. However, according to the analysis and evaluation of the bridge before and after applying the strengthening scheme, it can be concluded that the bridge has achieved a significant amount of resistance against overturning instability by applying the scheme, and the amount of resistance can be increased more by taking some countermeasures.

Key words: Overturning instability; Schemes, Single-column pier; CFST pier; Box girder; Overturning coefficient

1. Introduction

1.1 Research Background

In order to connect people, goods, and transportation, bridges are crucial. They are an essential part of the transportation infrastructure, giving automobiles, pedestrians, and even trains a way to pass over rivers, mountains, and other barriers[1].

In addition to their economic benefits, bridges also serve a practical purpose in terms of transportation. Overall, bridges serve a crucial function in linking people and products across different locations and are a vital component of our transportation infrastructure.

However, constructing new bridges including overpasses, viaducts and ramps requires a lot of space. In many cases, there are some already constructed roadways or other bridges exist which make a barrier to construct new bridges or sections and leave a little space to place new piers. So, often engineers choose single column pier for supporting the bridge as single column pier takes less space comparing to the double pier support.

A single point support, transverse double point support, or cover beam with multiple points of support are installed at the end of the single column pier. According to the requirements of nearby auxiliary roads or crossing sections, the single column pier support bridge is constructed either straight or curved. Precast concrete continuous box girders or steel-concrete composite continuous beams, available in 3 to 6 spans and a variety of equal or unequal spans, are used as the primary beam of a single column pier support bridge. To maintain the transverse stability of a single column pier supporting bridge, the pier adopts cover beam at the joint, sets two supports on the cover beam, and the middle pier adopts pier beam consolidation or hinged. The hinged middle pier is typically set into a fixed hinged support, transverse fixed support, or basin type rubber support. Single-pier supported bridge's axis is mostly a spatial curvature[2]. A bridge supported by a single column pier is a spatial structure. Its anti-overturning stability is the primary issue, and its structure, force, and analytical methods are substantially more complicated than those used for double-pier supported bridges. Anti-overturning stability for the single column pier is the main focus for this research.

1.2 Research Topic and Purpose

Bridge Strengthening is huge field in engineering and there are a countless number of research opportunities in this sector. Bridge strengthening is a less popular research topic among the researchers specifically to the young researchers. But due to the growing demand of the bridge maintenance and investigation requirements the importance of strengthening work is getting crucial.

In this research, overturning instability, the most interesting and common factor of bridge failure has been introduced which is often ignored. But there were some alarming accidents occurred due to this problem which then considered as other structural issue but then it was proved that the incidents were happened due to bridge overturning instability. This is enough to understand the actual necessity for doing researches on bridge overturning for preventing further accidents. This research will be focused on strengthening a continuous box girder bridge section of Hainan Ring Expressway against overturning instability.

1.3 Significance of the Topic

It is very challenging to strengthen an existing bridge because there are so many factors to consider. Strengthening projects are complex and dependent on the condition of the structure, where there are few options to choose what to do to deal with the structural issue while considering the available space and existing structural capacity. This is in contrast to designing a new bridge, where all materials can be used according to the current circumstances, such as the ground conditions at the site and the availability of space. Because bridge strengthening projects have so many limitations we are unable to make big modifications in the way we might would like.

Single column piers are common in many overpass bridges and viaducts around the world because they provide numerous advantages to bridges such as simple foundation, simple construction, and effective transparency to the horizon. Due to its simple boundary conditions, bridges with single column piers are more vulnerable to overturning accidents. Vehicles leaving their regular lanes are a common cause of these collisions. In heavy traffic or when carrying greater loads, a bridge's overturning moment resistance can suddenly be unable to counteract the overturning moment brought on by industrial trucks. The boundary conditions of the superstructure fail when bearings separate, which increases the probability of the girder overturning[3].

Bridge overturning is a very common structural phenomenon especially when it is a single column pier bridge and the superstructure is supported on single bearing[4]. It is really one of the most dangerous structural issue which can lead to any fatal accident. To strengthen a bridge against the overturning tendency we must need to develop some appropriate methods.

The bearing capacity of the existing bridges cannot reach the same value needed for carrying the current traffic load due to rapid growth of vehicles, which caused a number of accidents in China. The existing bridges have to be checked carefully and some strengthening schemes should be implemented if necessary to prevent the accidents. But for this clear standards and calculation methods should be maintained. But, there haven't been many researches on bridges' stability against overturning or the specific causes and frequency of such accidents. Both domestically and internationally, methods for determining the stability against overturning are rarely fully specified; in most situations, only basic captions are provided. Even the existing JTG D60-2015 code for curved bridge overturning reduction in China lacks explicit guidelines and methods for doing so, making bridges vulnerable to inadequate overturn resistance during design and overturn incidents during service. Therefore, it is crucial to develop new methods or techniques for fortifying bridges against overturning effects[3].

Investigations into anti-overturning have been conducted on bridges with a single column of support. It is necessary to conduct a specific inspection and calculation assessment on the site of single column supported bridges with safety issues because there are many of them and some of them do pose a risk of overturning. In accordance with the test and check results, a plan for needle treatment of the bridge's current issues is developed, and timely reinforcement treatment is applied to ensure the bridge's safe operation[2].

This topic has the potential to do the relevant research for developing new exceptional and economical way of strengthening.

This topic is important to find out the solution of how to consider the safety and stability factor for anti-overturning design and evaluation of single column pier supported bridge.

This topic will influence the reader to find out how the bridge inspection and evaluation authority finds the magnitude of such diseases and damages during the inspection and how to apply reasonable strengthening solution or methods.

This project includes some strengthening design contains a lot of complex details about the anti-overturning stability of a single column pier supported bridge and the practical application of strengthening treatment for making the bridge stable.

Strengthening projects are required to deal with many types of materials, technologies and construction process which will help to learn about the new developments of the bridge strengthening design technologies in this field and it will motivate the researchers to do researches for finding more advanced solutions.

This research will help the new researchers to know how to consider and avoid the problems found in the detection process and reinforcement treatment in the design process of single column supported bridge.

1.4 General Introduction of the Target Bridge

The Beigao Separation Interchange, which is subjected to strengthen is a part of Hainan Ring Expressway. At the target part of the bridge has two box girder sections. The older section had been constructed in 1994 where the later box girder section had been constructed in 2001. This research is on the newly constructed box girder section of the bridge. The bridge is currently carrying a class -1 highway which has 4 lanes for regular traffic along with two emergency lanes. A small road goes across the bridge under the newly constructed box girder section.

The total length of the bridge is 266 m including 15 spans (16m + 16m + 16m + 16m + 24m + 30m + 20m + 16m + 16m + 16m + 16m + 16m + 16m + 16m + 16m) supported by 16 piers. The elevation of the piers is also different. In this research three spans (24m + 30m + 20m) have been analyzed for checking overturning instability.



Figure 1 The Deck of the Bridge

2. Background Study

2.1 Why Bridge Strengthening is Required

Due to the rapid growth of the demand for transportation, a lot of bridges are being constructed all over the world. These are capable to carry the new demanding amount of traffic load without any hazard. But there are a number of old bridges those have been constructed during past centuries or past decades and many of them still have their lifetime or for some of them we can expand the lifetime by repairing.

Between the 18th and 19th centuries, thousands of bridges, made of a variety of materials, were constructed in the US and Canada. Timber was used to construct a significant number of truss bridges in the US at this time[5]. In addition, the first iron bridge in England was built by Abraham Darby III between 1775 and 1779, which represented a significant advancement in bridge design[6].

And in late 19th century the theory of reinforced concrete had been introduced and in 20th century the concept of reinforced concrete become more advanced. In the mid-19th century, with the development industry sector, vehicles and trains entering into circulation using the current transportation system. As a result, more highways, railroads, and bridges were constructed to meet the rising need for transportation.

In addition, with the help of new inventions and discoveries in science and technology, several methods of construction and types of materials have been introduced to make the construction process easier while keeping it economic and environmental as well. Engineers and contractors from all over the world are working globally to develop more and more advancements in bridge construction technology.

However, the existing structures cannot deal with this rapid growth of demands for carrying more traffic load and not capable for establishing the uninterrupted transportation system although they are somehow useable or can be used after some repairments. so, we need structures with increased capacity.

On the other hand, many of the old bridges are in really bad conditions and most of them are having several structural issues such as deterioration, cracks, Overturning effect due to natural disasters and excessive live load. There are lots of bridge collapse incidents happened in the past centuries and in the past decades as well and it is remained a major issue even now. Maintaining the functioning of the bridges during their intended service life without the risk of failure is one of the issues faced by owners of vast national networks of highway and railroad bridges. However, there are a number of reasons why bridges do fail. A bridge failure is typically the result of a failure somewhere throughout the bridge's lifecycle, from conception to design, construction, and maintenance over the course of its useful life[7]. Bridges are prone to failure and there are many factors which are responsible for the collapse or structural damage of the bridges. The main three types of failures are failures due to natural disasters such as earthquakes, landslides, floods, inefficient design and construction mistakes including using inappropriate materials and finally the man-made failures such as overloading, collision, inefficient inspection and management etc.[8]. The failure also has different types such as critical cracking, overturning, joint failures, deformation or beams, girders or piers and displacement from the original position. In these cases, we must need to build new bridges or strengthen the existing structure to deal with these issues. Considering the environmental damage and cost and efforts while building a new

bridge we should focus on strengthening the existing bridges. If we can increase the load bearing capacity and solve all other problems and make the existing bridge stronger to deal with the new demands, it will be economical and environment friendly and the life span of the bridges will be extended. By strengthening the existing structures engineers can prevent the need for costly and time-consuming replacements of the structures. Overturning collapse has been regarded as one of the most critical failure modes for single column pier bridges in current practices. And this structural failure can be prevented by developing several methods for strengthening the bridge[3], [9].

Bridge strengthening is a growing concern in many parts of the world as transportation infrastructure ages and deteriorates. The importance of maintaining and strengthening bridges has become more apparent in light of catastrophic bridge collapses in recent years, such as the Morandi Bridge collapse in Italy and the FIU bridge collapse in Florida.

Bridge collapses caused by the overturning effect are among the most frequent forms of bridge failures. There lots of cases where overturning effect has been noted while doing inspection of several bridges in United States and Europe, most of them are older bridge.

In response to these events, many governments have increased their investment in bridge safety and strengthening programs. For example, the American Jobs Plan proposed by then President Joe Biden in 2021 includes $115 billion for repairing and rebuilding bridges across the United States. Other countries are also prioritizing bridge strengthening and safety. In Germany, for example, the government of Germany has launched a program to repair and modernize more than 1,100 bridges across the country, with a focus on improving safety and ensuring the lifespan of the infrastructure.

Despite the progress being made, challenges still exist. Funding constraints can limit the scale and scope of bridge strengthening projects, and proper maintenance is crucial to prevent deterioration from recurring. Additionally, climate change poses a growing threat to transportation infrastructure, with more frequent and severe weather events creating additional stress on bridges.

Bridge strengthening has become a crucial issue in China in recent years, as the country's transportation infrastructure continues to age and deteriorate. The Chinese government has invested heavily in bridge safety and strengthening programs in response to the frequent and severe weather events that can cause bridges to fail.

2.2 Recent Researches for Bridge Overturning Monitoring and Strengthening

The lateral overturning stability of single-column pier curved bridges under asymmetric eccentric stress is now being studied by a number of researchers. Using the finite element analysis program ABAQUS, Yu investigated the pier stability of an urban single-column pier viaduct[10]. Wu et al. created simulation models of 23 single-column pier continuous box girder bridges using the Midas/Civil finite element analysis tool and investigated the primary elements influencing the stability of curved girder bridges[11]. Using an expressway separation interchange's continuous beam bridge with a single-column pier as an example, Zhao et al. examined the mechanical causes of transverse instability under overweight and asymmetric eccentric stress[12].

However, challenges remain in achieving the goals of the plan. The scope of the plan is enormous, with more than 1 million bridges in China to maintain. With continued investment and research, China can improve the safety and reliability of its bridges and ensure that they meet the needs of a growing and evolving transportation system.

2.3 Study about the Accidents Due to Overturning of Single Pier Bridges

2.3.1 The Accidents Due to Bridge Overturning Outside China

Although there are a little number of accidents recorded which were caused by bridge overturning outside China, but the accidents caused by improper handling of overturning stability occur from time to time. Europe has seen problems with overturning box girder bridges. High wind loads, poor design considerations, and inadequate maintenance are a few of the elements that contribute to the overturning issue in these structures. Box girders are susceptible to wind-induced stresses because they are tall and thin, especially in areas with severe winds. Furthermore, poor design specifications and inadequate consideration of dynamic impacts can increase the likelihood of overturning. The stability and resilience of box girder bridges in Europe can be improved by performing effective maintenance and routine inspections, which are essential for spotting potential issues and implementing appropriate solutions into taking place.

There was a similar kind of accident happened in Himachal state in India on the 29th of July in 2010, which was actually caused by overturning instability of the bridge. According to the “ZEENEWS” two persons were killed and other two persons were seriously injured due to the collapse of a one-year old over-bridge overpasses Dhami-Basantput-Kingal highway to provide the all-weather connectivity between Rampur and Kinnaur. The bridge was built by Border Roads Organization (BRO). During the incident Four cement-laden trucks were parked on the bridge in that night.

According to “Indian Express” the initial investigation was focused on the design flaw of the bridge. And, initial investigations cast more doubt on the bridge's design than on the materials used in its construction due to the unique way in which the top portion of the bridge turned over from the base structure and slanted to one side, impeding the ability of the bridge to support the weight of the vehicles. The bridge had a load-bearing capability of 70 tonnes and was categorized as "Road Class 7." Although it was estimated that the loads of the trucks parked on the bridge were almost equal, but still the bridge collapsed which was not that natural. So, the government of India issued several programs to investigate the similar type of single column pier curved and straight bridges all over India to prevent further accident like this. Due to a concentration of weight on the outer side of the bridge's curve, the upper platform-road surface area of the bridge has tilted and toppled, but the sub-structure (support structure pillars) is remained undamaged.



Figure 2 The Bridge Accident in India 2010, due to Overturning (Source: (Makhaik Ravinder & Kanwar Amit, 2010: online)

2.3.2 The Accidents Due to Bridge Overturning in China

There are many cases of bridge collapsed due to the overturning instability are recorded in many provinces in China and it is getting very common in China. For example, the Yangmingtang bridge collapsed in Heilongjiang province. There were the similar cases in Wuxi, Guangdong, Shanghai, Hubei and some others areas.

The Chunhui bridge overpass in Shangyu, Zhejiang, China, collapsed on Monday, February 21, 2011. Three persons were hurt after four trucks crashed into the highway. After nearly six years of use, this bridge collapsed[14].

In 2018, a bridge collapse in southern China's Guangdong province killed several people, highlighting the need to prioritize bridge strengthening efforts. In response, the Chinese government launched the "Three-Year Action Plan for Bridge Maintenance and Reconstruction" in 2019, with the goal of improving the safety and resilience of Chinese bridges.

The plan involves upgrading and strengthening bridges across the country, with a focus on major bridges and those that are critical to transportation infrastructure. The government has allocated significant funds towards the effort, with more than 50 billion yuan ($7.7 billion) set aside for bridge strengthening projects in the initial phase of the plan.

To achieve the goals of the plan, the government is using a variety of approaches, including inspection and maintenance, repair and replacement, and structural strengthening. Research and development are also playing a critical role in bridge strengthening efforts in China.

In recent years a lot of single column pier, single supported bridges have been turned over their supports and some capsized. And the accidents happened both during construction and during the operation. Some of the related incidents are given below:

2.3.2.1 Shenzhen Binhai Avenue Nanyou Interchange

Shenzhen Binhai Avenue Nanyou interchange and there are other two bridges Qiaocheng west road interchange and Qiaocheng east interchange were constructed in 1999. These three bridges are all three-span single column pier supported continuous bridge. The top main beam of the Nanyou Interchange ramp bridge saw a maximum deflection of 1.53% during the loading test, sinking 60 cm

outside, 63 cm within, and 45 cm outside the beam. The load tests of the other two Bridges also experienced the same issue at the same time [15].

2.3.2.2 Shenzhen Huaqiang Overpass

The continuous curved concrete box girder bridge at the third ramp of the Shenzhen Huaqiang Overpass abruptly shifted outward and tipped over on the 3rd of June, 2000, disrupting traffic on Sungang Road's eastbound left turn onto Huafu Road. The A-ramp bridge had a total length of 415.94 meters and 4 links. It was a one-way ramp. There were 6 spans in the third link of the main link. R=255 m for the curvature's radius while having a span combination of 22.813m+35m+55m+39.938m+55m+32m with a total length of 239.75m. The diameter for the middle pier is 1.6 m which is a single column pier and the diameter for the interconnecting pier is 1.3 which is double column pier[15].

2.3.2.3 A ramp of Jinjin Expressway

On the 15th of July, 2009, A ramp of the mutual interchange of Gangtang Highway which is located on the east side of Tianjin Tanggu Toll Station on the Jinjin, collapsed, causing 5 trucks to plunge under the bridge and killing 6 persons and injuring 7 others. The Jinjin Expressway's Gangtang Interchange's A ramp has a bridge collapse section that is 109 meters long, 8.5 meters wide, 7.5 meters wide, and has a main beam height of 1.3 meters[16].

2.3.2.4 Nanshan Overpass Viaduct

The viaduct at Nanshan Interchange, Donggang Road, Qinhuangdao, slanted on the 28th of September, 2010, as a result of inspection. Overloaded vehicles, some of which are arranged along the outer side of the viaduct curve. The bridge deck is 10.1 meters wide, has a single-column pier in the middle, and a fixed pot support at the center. The total length of the bridge is 130 meters. The Port Authority attempted to stabilize the raised bridge with two steel ingots after raising the bridge deck at the center isolation belt by around 30 cm. However, in its final stages, it also failed.

The automobiles were swiftly and orderly removed from the scene of the accident after it rolled over till the 28th of September. At 3:30 in the afternoon, all of the therapy was over. The bridge roll is gradually reduced as a result of the vehicles' gradual detour. The side-dipping condition improved after the first car crossed the bridge, and fortification measures were then implemented[16].

2.3.2.5 Dong-Ramp Bridge in Kaifeng

On the 8th of April, 2012, three trucks totaling 150 tons parked in the emergency parking lane of the Dong-ramp Bridge in Kaifeng, causing the beam body to be unilaterally torsioned and displaced. As a result, the Huolian Expressway's Kaifeng portion was damaged and closed off for 18 hours[2].

2.3.2.6 G Ramp of Shengtang Interchange

An overturning accident occurred on the 9th of December, 2014, as concrete was being poured for the outer guardrail on the second-span box girder of the G ramp at Shengtang Interchange in the first bid section of the east section of the Chongqing Yiheng Line. At the bridge's curve, a concrete tanker

stopped. The upper structure tipped over, forcing the beam to turn over and collapse to the overpass on the next floor, and the formwork on the exterior progressively warped and fractured[15].

2.3.2.7 Ramp Bridge at Chengnan Exit of Guangdong-Jiangxi Expressway

On the 19th of June, 2015, the ramp bridge at Chengnan exit of Guangdong-Jiangxi expressway suddenly collapsed resulting 1 death and 4 injuries. The collapsed section of the bridge was a continuous beam bridge section with two basic supports and three spans at either end, a total of three span combinations of 25 meters (3x25) makes up the 75-meter-long section of the bridge that has collapsed. At the outermost ends, single piers are used, while the center is supported by double piers. The height of the related 4 piers were different with the exact heights of 5.5, 6.5, 7.5, and 8.5 meters respectively. 76.41 tons, 111.46 tons, 102.87 tons, and 108.89 tons, were the weights of the four huge and heavy-duty trucks respectively those were approaching on the ramp bridge. But all on a sudden, as a result of the bridge's two single column pier supports' overturning instability, they overturned underneath the span[2].

2.3.2.8 Jingshan Railway Bridge

The Jingshan railway bridge has two-way six lane roadways on a superstructure which is a continuous prestressed box girder section. On the 11th of July, 2011, an alarming accident occurred in due to the overturning instability of the entire continuous box girder section of the bridge while five heavy-duty trucks were being driven in the opposite direction across the Jingshan railway bridge on the Ninth street in the East and West Tianjin development zone.

2.3.2.9 Harbin Third Ring Qunli Viaduct

The Harbin ring Qunli viaduct which had 121.96 meters of total length of the main beam. The bridge can be classified as the continuous beam bridge where the beam was a composite steel concrete beam. On the 24th of August, 2012, 4 heavy-duty trucks were on the up ramp of the bridge to drive to the right while carrying 18.625 tons, 153.29 tons, 163.59 tons and 149.68 tons weights respectively. A deadly accident happened due to the overturning instability of the main beam and the beam collapsed resulting the collapsed of the viaduct by turning over its supports. The accident was fatal and not less than three people died while more than five have been injured[17].

2.3.2.10 Chunhui Overpass

On the 21st of February, 2011, a traffic collapse accident happened on the up-ramp of the Chunhui overpass 7K+966 Nanchun Line in Shangyu City, Zhejiang Province, heading in the direction of Shaoxing, Ningbo, and Taizhou. There was 120 meters (6 x 20 meters) in total length of the bridge. The centre abutment uses a single column support, while the abutments at both ends use double column piers. The height of the piers were 2.8 meters, 3.5 meters, 4.2 meters, 4.9 meters, 5.6 meters, 6.3 meters and 7 meters respectively. Three persons suffered minor injuries as a result of the four trucks that popped up on the ramp at the site with vehicle loadings of 28.52 tons (on the inside), 124.44 tons, 125.6 tons, and 110.73 tons[17].

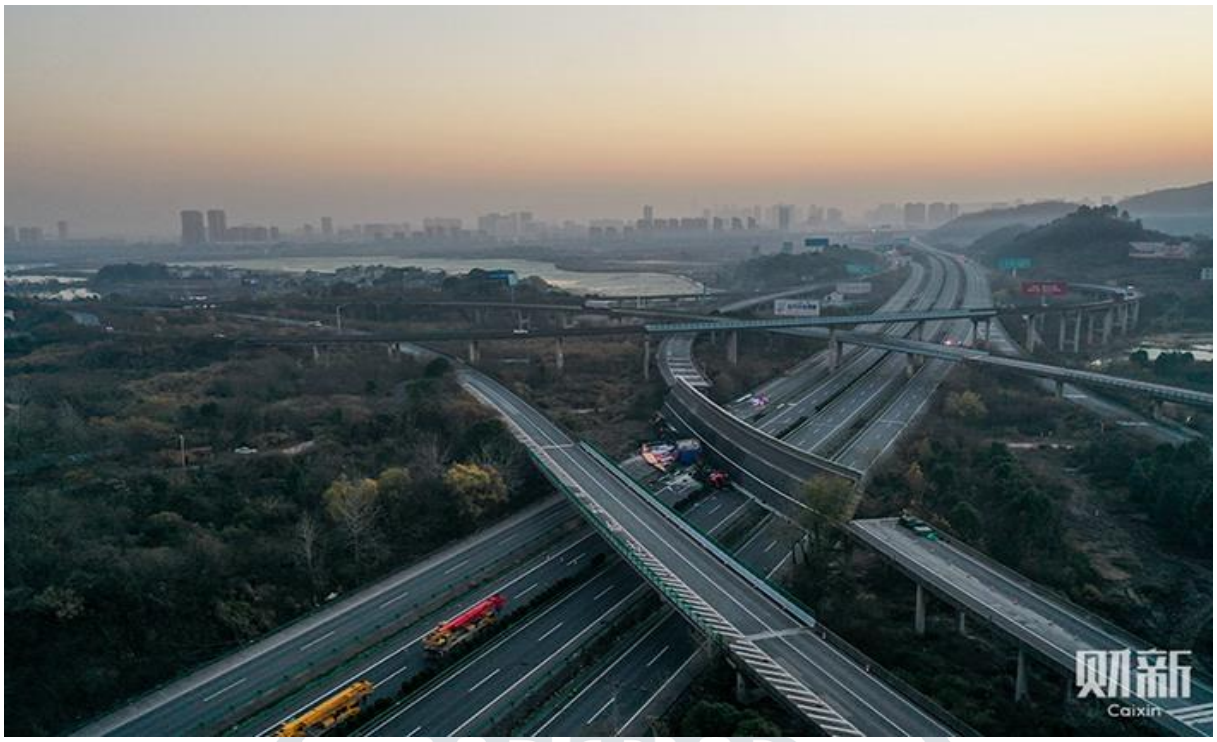


Figure 3 Bridge Collapsed in Hubei due to Overturning (Source:[18])



Figure 4 Yangmingtang Bridge Collapsed in Harbin in 2012 due to Overturning (Source: [19])



Figure 5 Wuxi Bridge Collapsed due to Overturning in Jiangsu (Source: [20])

2.4 Anti-Overturning Calculation of Single Column Pier Bridge

Research on bridge overturning conditions was conducted in 1984 by W. STREIT and R. MANG, who also invented the anti-overturning safety factor[21]. They noted that the anti-overturning safety factor of a bridge is 2.5.

$$\gamma_k = \frac{M_K}{M_{vorh}} \geq 2.5$$

In the formula:

γ_k = Stability Factor

M_k = The stabilizing moment of the stabilizing force on the overturning fulcrum

M_{vorh} = The Overturning Moment of the Overturning Force on the Overturning Fulcrum

A deterioration of the component's strength or bearing capacity is what causes the overturning instability of the single column pier at the middle, according to the research carried out by Li Panzhi et al. of the Beijing Municipal Engineering Design Institute[22], [23]. When the side support is empty and the corner angle of the middle pier support exceeds the limit, the middle pier hinged single-column support beam bridge overturns. When the end support's stability coefficient falls short of specifications, the load under the bridge's second critical overturning state is determined by examining the stability of the safety factor.

$$k = \frac{S_q}{S_p} \begin{cases} \geq 1.5\ (Take\ the\ Pier\ Support\ as\ the\ Control) \\ \geq 2.5\ (The\ Angle\ by\ the\ Middle\ Pier\ Support\ is\ 0.03\ rad) \end{cases}$$

In the Formula:

K: Safety factor of overturning stability under checking load

S_q: Overturning vehicle loads for the most unfavorable load case

S_p: Maximum Vehicle Load in Overturning Critical State

According to Yuan Dai Zheng et al. the basic principle for calculating the lateral overturning stability coefficient is as follows:

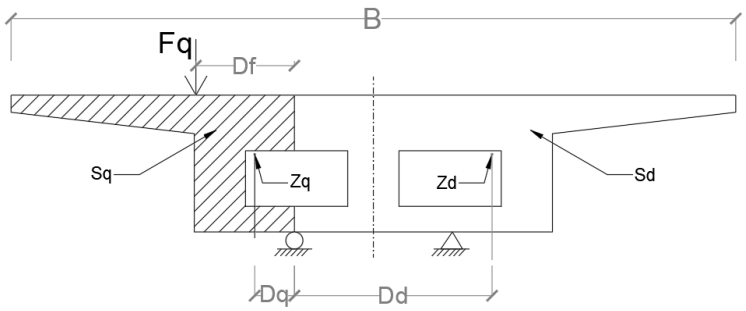


Figure 6 Schematic Diagram for calculating Overturning Coefficient

The overturning fulcrum serves as the boundary between Sq and Sd, the two sections of the bridge's mid-span. The dead weight of the beam body, the second phase dead load of the bridge deck, and the load on the lane are all supported by the Sq section, which also provides overturning force. The dead weight of the beam body and

the second phase dead load of the bridge deck are both supported by the Sd component, which also offers stability force[24].

In the figure:

Fq = The lane load is uniformly distributed load plus a concentrated force, and the most unfavorable arrangement is adopted according to the code

Df = Moment arm of overturning force Fq

Zd = Center of mass of anti-overturning lateral section

Zq = Center of mass of overturned side section

Take the moment of overturning fulcrum:

$$K = \frac{\sum M_d}{\sum Mq} = \frac{G_d \times D_d + E_d \times \frac{B+D}{4} + L_d \times (\frac{B+D}{2} - 0.25)}{G_q \times D_q + E_q \times \frac{B-D}{4} + L_q \times \left(\frac{B-D}{2} - 0.25\right) + F_q \times D_f} \geq 1.3$$

Figure 7 Equation for calculating Lateral Overturning Coefficient

In the equation:

Gq = The self-weight of the Sq section

Eq = Self-weight of Bridge Deck Pavement of Sq section

Lq = Sq section side railing weight

Dq = Gq moment arm

(B-D)/4 = Eq's moment arm

(B-D)/2-0.25 = Lq's moment arm

Gd = Self-weight of Sd partial section

Ed = Self-weight of Bridge Deck Pavement of Sd section

Ld = Sd section side railing weight

Dd = Gd's moment arm

(B+D)/4 = Ed's moment arm

(B+D)/2-0.25 = Ld's moment arm

2.5 Relevant Provisions of Bridge Codes in Different Countries

2.5.1 The Relevant Provision of the British Standard:

The anti-overturning stability of the structure and its components shall be taken into consideration in the failure limit state, according to Section 4.6 of the British "Steel and Concrete Bridges and Combined Bridges" (BS5400) 1978-82[25].

American Code for Design of Highway Bridges AASHTO 2007

The American AASHTO bridge specification states that the vertical force of the multi-directional movable bearing should be greater than 20% of its bearing capacity in order to prevent the bearing from overturning in any bridge limit state[26].

Code for Design of Highway Bridges in Canada (CAN /CSA-S 6-00)

According to clause 8.5.4.3, the structure as a whole and each of its individual parts must be symmetrically resistant to sliding, overturning, lifting, and buckling, and the effects of eccentric loads must be taken into consideration[27].

Japan Road and Bridge Association "Road and Bridge Instructions"

According to Japan's criteria for bridges, the effect coefficient of the live load should be 2 when computing the reaction force on the support[2].

The formula for calculating the negative reaction Ru of the support:

$$Ru = 2R_{L+1} + R_D$$

$$Ru = R_D + R_W$$

Figure 8 The equation for calculating Negative Reaction of the Support

In the equation:

Rd = Reaction for Dead Load

$\mathbf{R_{L+1}}$ = Maximum support reaction force produced by Live Load

Rw = Support reaction force caused by wind load

2.5.2 The Relevant Provisions of Highway Bridge Specification in China:

There are currently no particular regulations in China that address how to calculate a bridge's anti-overturning stability, and the guidelines for safety allowance and evaluation criteria are also missing. Currently, the General Code for the Design of Highway Bridges and Drains is JTG D60-2015.

The stripping of the bridge support is prohibited in Article 3.6.8 and Article 9.7.4 of "Reinforced Concrete and Prestressed Concrete Bridge Culvert Design Code" (JTG D62-2004)[28].

The following regulations are found in Article 4.1.9 of the discussion draft of the Code for Design of Highway Reinforced Concrete and Precast Concrete Bridges and Culverts (JT G D62-2012)[29]:

Medium- and small-span girders Bridges with integrated sections need to perform a superstructure anti-overturning checking calculation. The superstructure's stability coefficient against overturning must adhere to the following standards:

$$\gamma_{qf} = \frac{S_{bk}}{S_{sk}} \begin{cases} \geq 2.5\ (When\ Applying\ Lane\ Load) \\ \geq 1.3\ (When\ Applying\ Vehicle\ Load) \end{cases}$$

In the equation:

γ_{qf} = Stability coefficient against Overturning

S_{bk} = Standard effect of vehicle load (including impact) that overturns the superstructure

S_{sk} = Standard combination of action effects that stabilize the superstructure

The stability coefficient of transverse overturning should not be less than 1.3 under the action of the most adverse combination of predicted loads, according to 5.2.1 of the current Code for Design of Railway Bridges (T B10002-2017). A reinforced concrete cantilever beam bridge span structure's longitudinal overturning stability coefficient shouldn't be less than 1.3 under a vertical load that corresponds to a stress that is greater than 30% of the permitted value. According to Specification 5.2.1, Since it is usually accepted that the support is a rigid body, the following mathematical formula is used to determine the stability and overturning moment: The calculating formula is as follows for the lateral edge of the support and the hinge center of the support:

$$K = \frac{\sum Md}{\sum Mq} \geq 1.3$$

In the equation:

K = Overturning Stability Coefficient

M_d = Resistance Moment

M_q = Overturning Moment

3. Methodology

3.1 Understanding the Structural Characteristics and Behavior of the Target Bridge

Strengthening a bridge is really difficult due to the complicated sections and construction process as there are lots of constraints for developing the appropriate way which should have clear and possible constructability as well as the ability to strengthen the bridge and ability to mitigate the critical problem. In this case the bridge was a single column pier bridge and is in critical situation of the bridge deck girder to turn over the bearing supports. This is a special problem regarding to bridge instability and most of the time the engineers and contractors underestimate this phenomenon and ignore the required checkups during investigation. As a result, the accidents occurred and the number of accidents due to overturning instability is growing day by day.

Incorrectly calculated anti-overturning factors, curved bridges with insufficient curve radius, and bridges with inappropriate bearing settings are the three bridge types that are most prone to overturn. In this case as this is single column single support bridge, the bridge is prone to overturning and has the same structural behavior of the other single pier bridges.

3.2 Finding and Evaluating of Actual Problem

To understand the actual problem the actual condition of the bridge while loading is required to be imagined first. For that, several loading patterns have been designed according to the Chinese standard of minimum space between two vehicles, between two wheels as well as between vehicles and the barriers. Then the critical loading condition has been selected.

Table 1 The Minimum Distance between Vehicles According to the Chinese Standard

Distance Between	Two Wheels	Two Vehicles	The Vehicles and The Barriers
Distance in cm	**180**	**130**	**≥50**

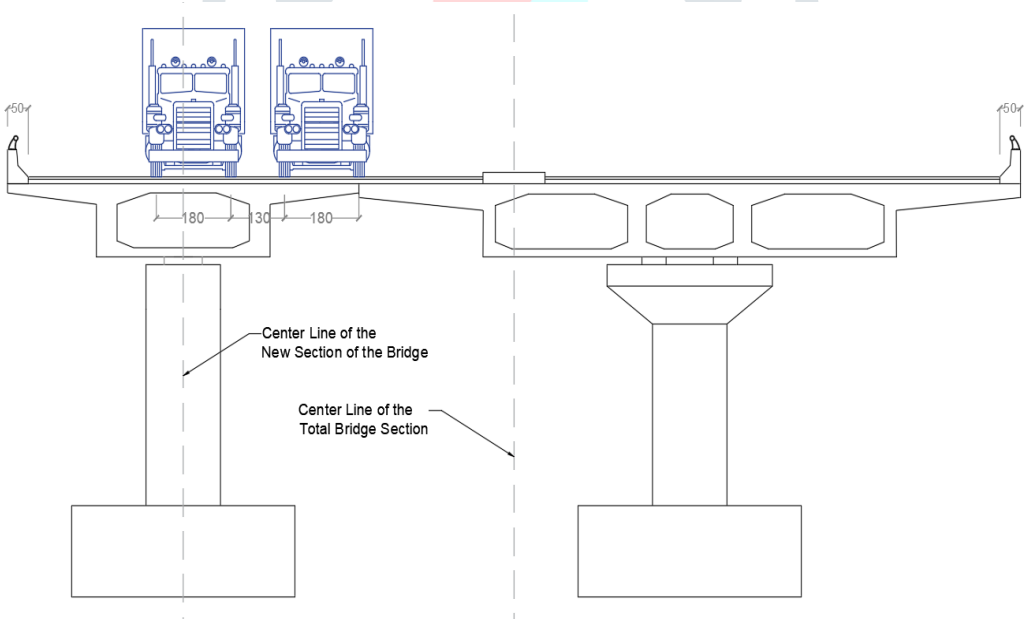


Figure 9 Placement of Vehicles on the defined lanes for Maximum Live Load Effect

Two lanes at the right side have been defined on which two heavy trucks have been placed. The distance between two lanes is 3.1 m. In this condition the bridge will be subjected to maximum effect under live load This effect can be caused the overturning of the bridge deck. All the analysis and calculation have been conducted according to this condition of live load placement on the defined lanes.

3.3 Developed some Appropriate Schemes to Strengthen the Bridge

During the initial period several possible schemes of strengthening the target bridge against overturning instability have been proposed for initial review. After considering all the factors which are vital for strengthening the bridge three possible practical solutions or schemes have been selected for further investigation. Drafting of detailing and other relevant drawings have been made to understand the structural behavior of the bridge after strengthening and find the effectiveness of the schemes.

Finally, among all the three schemes one has been selected considering the simple construction method, weight of the component, transportability and cost effectiveness. And the selected scheme has been subjected to structural analysis and all the calculations have been done using the final scheme only.

3.4 Sections and Elevation Drawing

All the section drawings and other relevant drawings have been made using AutoCAD which is a 2D drafting and annotation software.

First, all the sections of the existing bridge have been drawn and then according to the actual section drawing the potential fortifying or strengthening schemes applied on them in separate drawings.

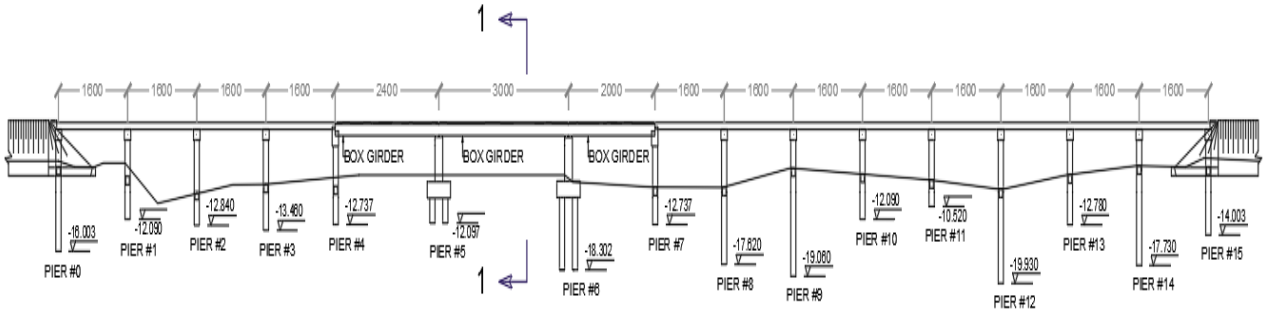


Figure 10 The Elevation of the Total Length of the Bridge

The elevation of the whole bridge has been drawn in accordance with the original drawing and designing data. In this drawing the exact locations of the piers and the depth of the piles have been visualized.

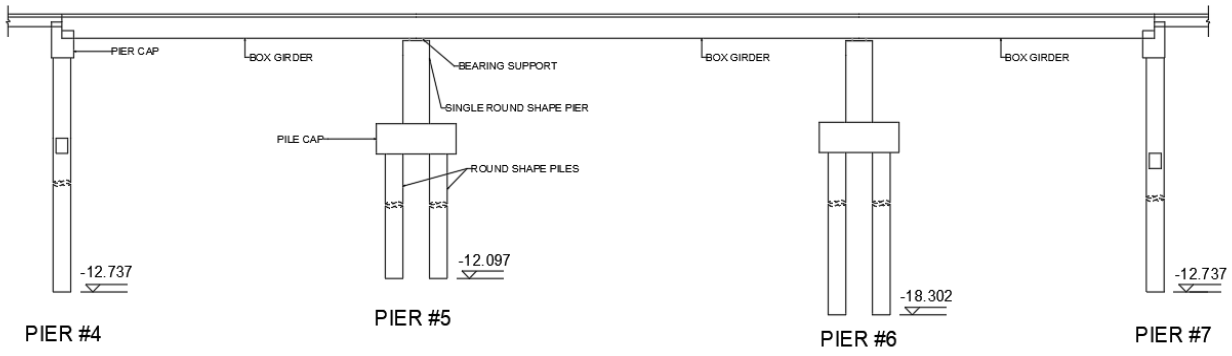


Figure 11 The Box Girder Section which is Subjected to Strengthen Against Overturning

The newly built box girder section with a total span length of 74 m (24m + 30m + 20m) is subjected to turn over its support due to overturning instability. The section has 4 piers which are pier #4, pier #5, pier #6 and

pier #7 and the no. 5 and 6 both piers have single support for holding the box girders. All together there are 6 supports: support 4R and 4L are on the top of the pier 4; support 5 and 6 are on the top of the pier 5 and 6 respectively; support 7R and 7L are on the top of the pier 7.

The deck pavement of the bridge placed on the box girders. There are three different sections have been used for the box girders.

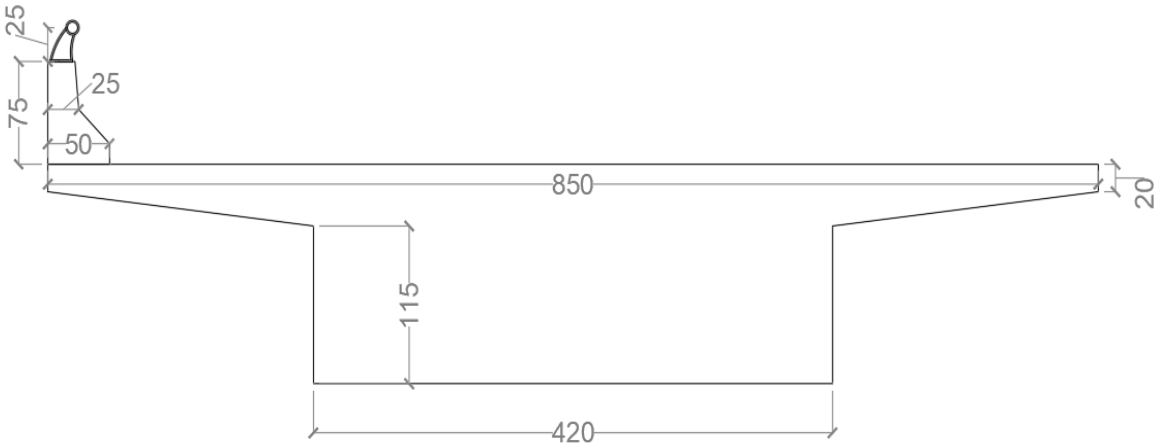


Figure 12 Box Girder Section 1-1

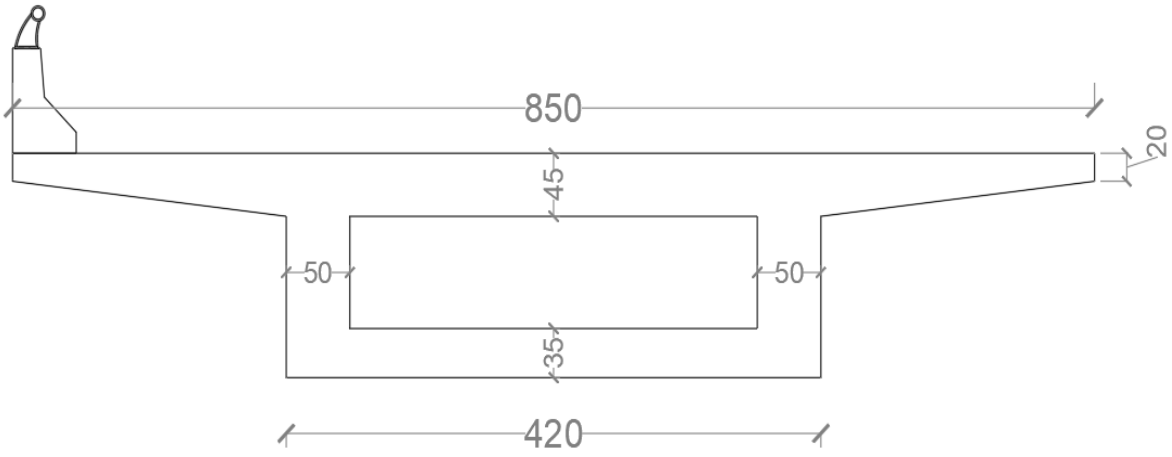


Figure 13 Box Girder Section 2-2

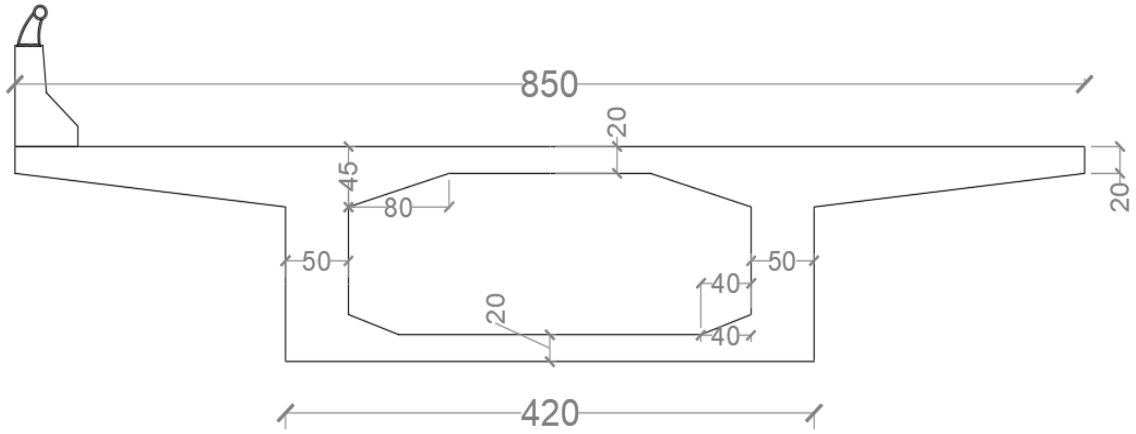


Figure 14 Box Girder Section 3-3

3.5 Calculation Method

3.5.1 Calculation Method for Live Load Impact Factor

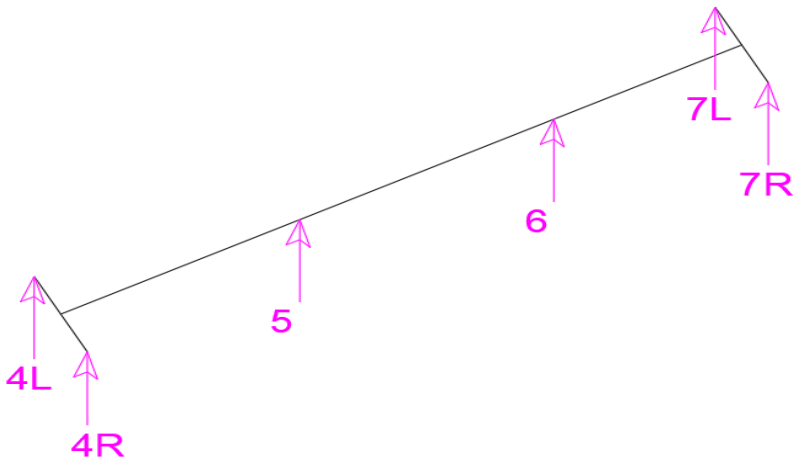


Figure 15 The Position and Name of the Bearings Before Strengthening

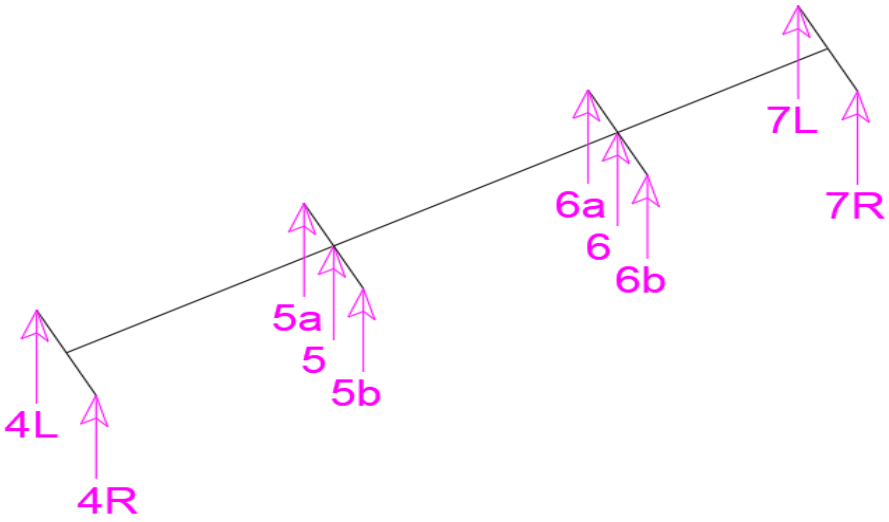


Figure 16 The Positions and Name of the Bearings After Strengthening

According to the Chinese standard code JTG D-60, 2015, the live load has been considered as lane load. While qk has been considered as the uniformly divided lane load and the pk has been considered as the concentrated load. The value of the qk is 10.5 KN/m according to the code. And the standard value of pk can be calculated according to the below table:

Table 2 For Calculating pk

计算跨径 L_0（m）	$L_0 \leqslant 5$	$5 < L_0 < 50$	$L_0 \geqslant 50$
P_k（kN）	270	$2\ (L_0 + 130)$	360

First the support bearing 4L has been considered and according to the maximum influence the position of pk and qk has been determined. Then according to this pk and qk the impact of the load on the other supports at the same time has been calculated.

当 $1.5\text{Hz} \leqslant f \leqslant 14\text{Hz}$ 时，$\mu = 0.1767\ln f - 0.0157$

Figure 17 Equation for Calculating Impact Factor

In the picture:

f = Frequency

μ = Impact Factor

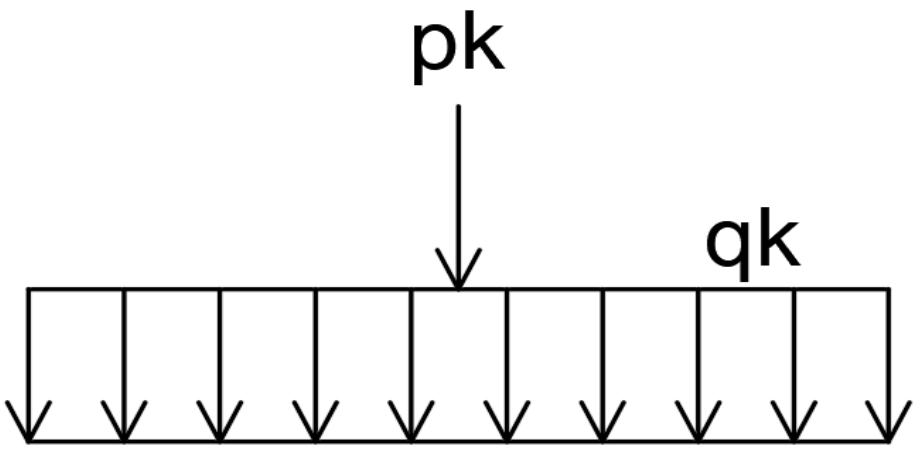


Figure 18 The Loading Method for pk and qk

Pk = The Concentrated Load

qk = The Uniformly Distributed Load

This pk and qk have been placed on the influence lines of the critical supports and its impact on the other supports have been calculated simultaneously.

3.5.2 Calculation Method for Overturning Coefficient

The calculation has been done according to the Chinese code JTG 3362 – 2018 for finding the overturning coefficient.

Table 3 Live load Impact

项目			支座编号							
			1-1	1-2	2	3-1	3-2	4	5-1	5-2
l_i m			4	0	0	4	0	0	4	0
支座竖向力 kN	R_{Gki}（永久作用标准值效应）		657	699	3886	1608	1611	3886	657	699
	失效支座对应最不利汽车荷载的标准值效应	$R_{Qki,11}$	-335	456	1030	-245	508	260	-57	273
		$R_{Qki,31}$	-229	515	1068	-494	618	462	-119	314
		$R_{Qki,51}$	-58	274	266	-247	503	1031	-335	456
特征状态1验算	1.0 R_{Gki}+1.4 $R_{Qki,11}$		188	1337	5328	1265	2322	4250	577	1081
	1.0 R_{Gki}+1.4 $R_{Qki,31}$		336	1420	5381	917	2476	4533	490	1138
	1.0 R_{Gki}+1.4 $R_{Qki,51}$		576	1082	4259	1262	2315	5330	188	1337
	验算结论		满足要求							
特征状态2验算	稳定效应$\sum R_{Gki}l_i$ kN·m		2628	0	0	6433	0	0	2628	0
	失稳效应 kN·m	$\sum R_{Qki,11}l_i$	1340	0	0	980	0	0	228	0
		$\sum R_{Qki,31}l_i$	916	0	0	1976	0	0	476	0
		$\sum R_{Qki,51}l_i$	232	0	0	988	0	0	1340	0
	稳定性系数		$\sum R_{Gki}l_i / \sum R_{Qki,11}l_i$	4.59	$\sum R_{Gki}l_i / \sum R_{Qki,31}l_i$	3.47	$\sum R_{Gki}l_i / \sum R_{Qki,51}l_i$	4.57		
	验算结论		满足要求							

注：支座竖向力以向下为正，向上为负。

R_{Gki} = Under Dead Load

R_{Qki} = Under Live Load

The main condition of checking:

If, the coefficient is ≥ 2.5; No overturning

If, the Coefficient is ≤ 2.5; Overturning Instability

3.6 Evaluated the Outcomes and Results from the Analysis Software

After doing the analysis of the original bridge and extracted all the data and calculated the overturning coefficient to find out the actual condition of the bridge. Then the selected strengthening scheme has been applied to the analysis software “Midas Civil”. And the same analysis process has been followed as previous and after the analysis all the data including the influence lines and reaction forces have been extracted from the software. After extracting the data, the impact of the live load and finally, the overturning coefficient of the bridge have been calculated using same calculation process and method as previous.

3.7 Designed the Construction Organization Design and Overall Plan of Construction

Construction organization design refers to constructing the overall plan of the construction including the construction process, construction techniques, the schedules of working, estimation of construction materials, estimation of the man power and equipment and the method project management in order to keep tracking the progress of the construction and get a good grip of overall process to mitigate the possible risks or taking some initial measures to solve some unforeseeable issues. In this paper only, the construction plan has been considered. The process of the construction has been given as a Chart. The amount of materials required is also calculated using the sections drawing of the selected scheme for strengthening the bridge.

4. Schemes for Strengthening the Bridge

The anti-overturning design method is currently being developed, and the evaluation criteria for bridge overturning are still up for debate. A comprehensive investigation of anti-overturning design, covering anti-overturning factor, curved bridge geometry, bearing placement, etc[29].

When designing a bridge, the designer should take all relevant aspects impacting the bridge's anti-overturning into account. The figure below illustrates how resilience design criteria and structural anti-overturning criteria correspond[29].

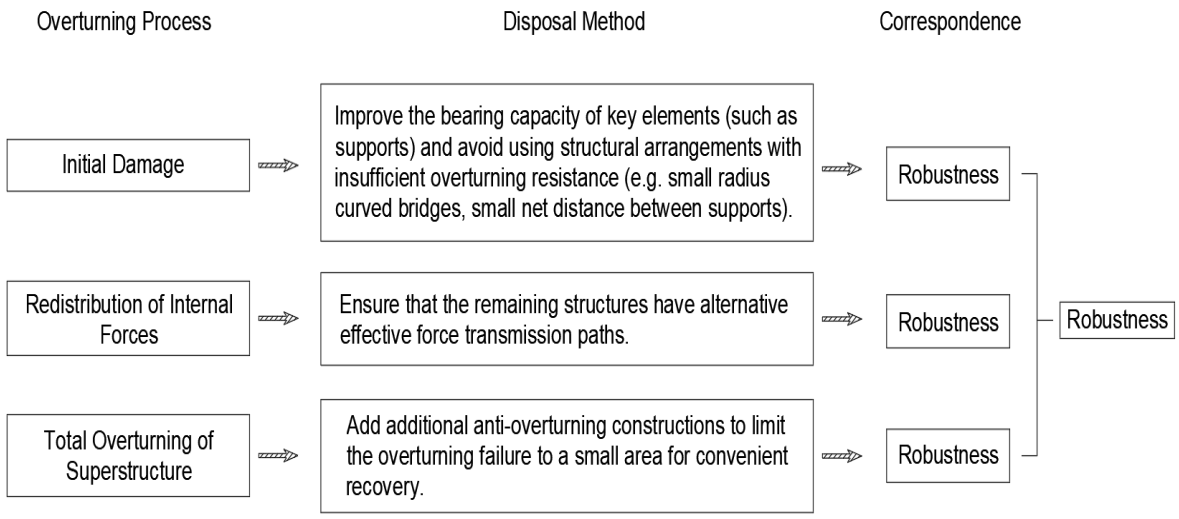


Figure 19 Correspondence between structural anti-overturning and resilience design criteria

For strengthening the bridge which have overturning instability some measures should be considered. There are several methods one can develop to reduce overturning possibility of a bridge but if the method requires any construction method such as removing the box girders or acquiring much more land which is almost not possible or very difficult to do or any construction technology which is not that economical then the method would not be considered for strengthening the bridge. So, during the method or scheme developing and designing period several factors have to be considered such as constructability, cost, effectiveness, installation or casting process, aesthetics and so on.

4.1 Enlarging the Single Column Piers of the Bridge

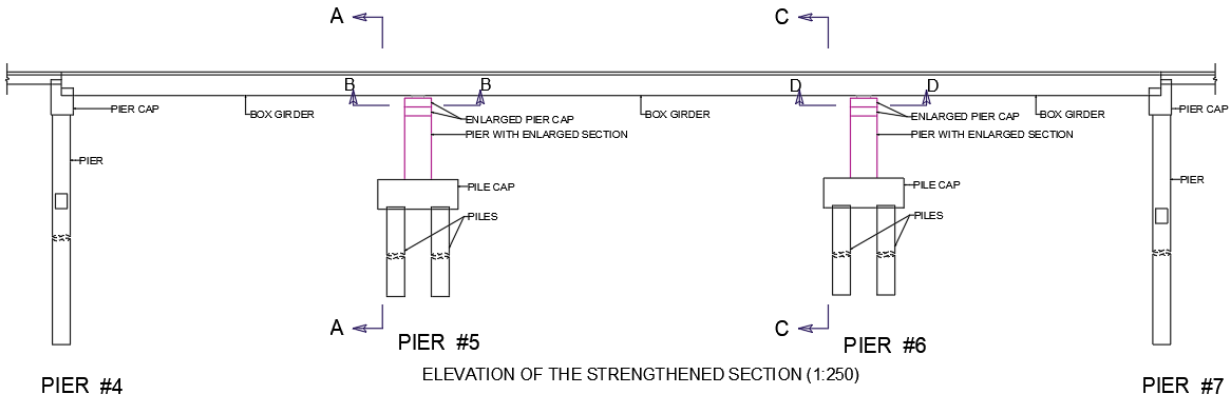
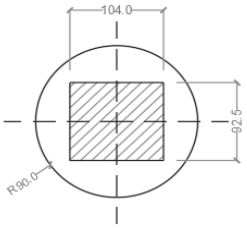


Figure 20 Elevation After Enlarged the Piers

To strengthen the bridge one of the most effective way could be enlarging the pier which will provide the space for enlarging the pier cap. The enlarged pier will be effective to set additional bearing supports which will be connected with the box girder. The concrete C50 could be used for the enlargement. And as to the bearings, ISO certified JTPOT-001 (HS-4016950090) One-way Movable support and ISO certified JTHDR-001 (HS-4016999090) Fixed support can be used on each pier.

Schematic diagram of the layout of the No. 6 pier support of the left bridge



Schematic diagram of the layout of the No. 6 pier (after strengthening) support of the left bridge

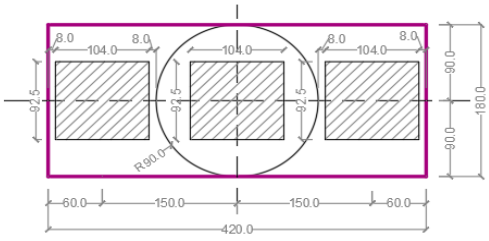
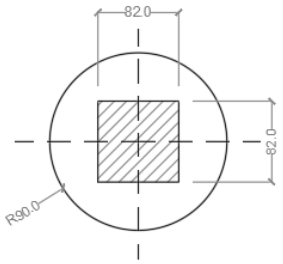


Figure 21 The Positions of Additional Bearings on Pier 6

Schematic diagram of the layout of the No. 5 pier support of the left bridge



Schematic diagram of the layout of the No. 5 pier (after strengthening) support of the left bridge

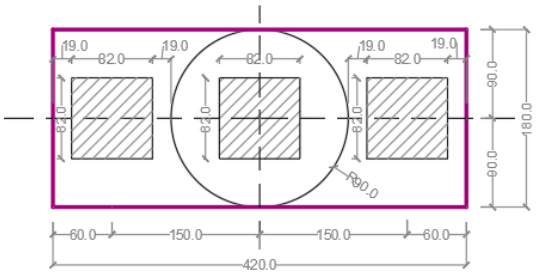


Figure 22 The Positions of the Additional Bearings on Pier 5

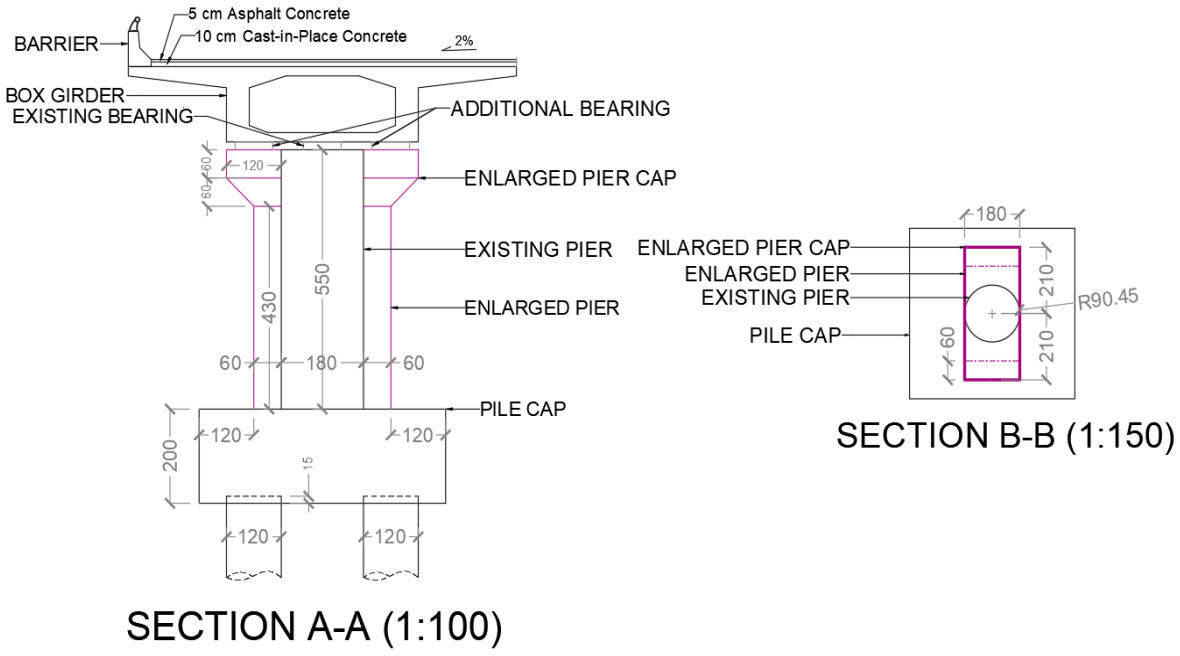


Figure 23 The Sections of the Enlarged Piers of Pier 5

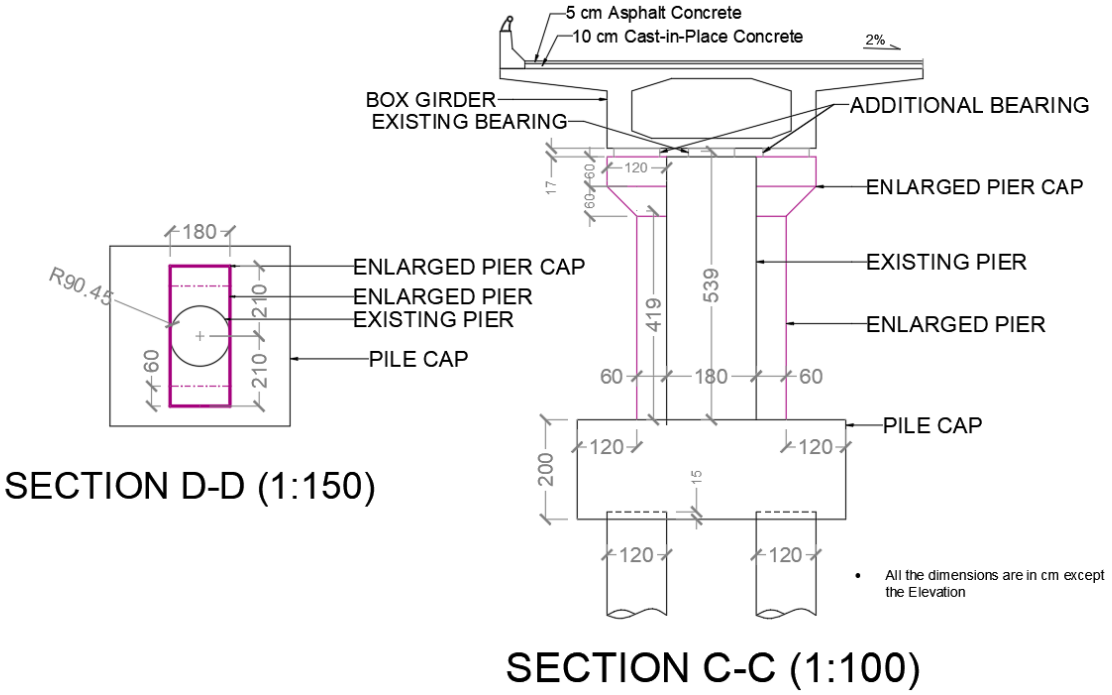


Figure 24 The Section of the Enlarged Pier of Pier 6

Advantages:

- By enlarging the pier cap, the cross-section area of the superstructure and substructure can be increased.
- Two additional supports can be added on the enlarged area which will counter the overturning effect of the bridge.
- It will increase the load bearing capacity of the bridge.
- It can reduce the needs of constructing additional piers.
- It is an effective solution for increasing the bearing capacity of the bridge.

Disadvantages:

- The weight of the concrete of the enlarged portion has to be considered.
- The capacity of the foundation must be improved in order for it to support the additional load as the weight of the pier increases.
- This method will severely damage the original structure because for retrofitting work it is required to drilled the new steel bars into the existing concrete to get better attachment.
- If foundation needs improved it will be costly and require additional construction time.

4.2 Using the Steel Tie Plate Between the Box Girder and Pier

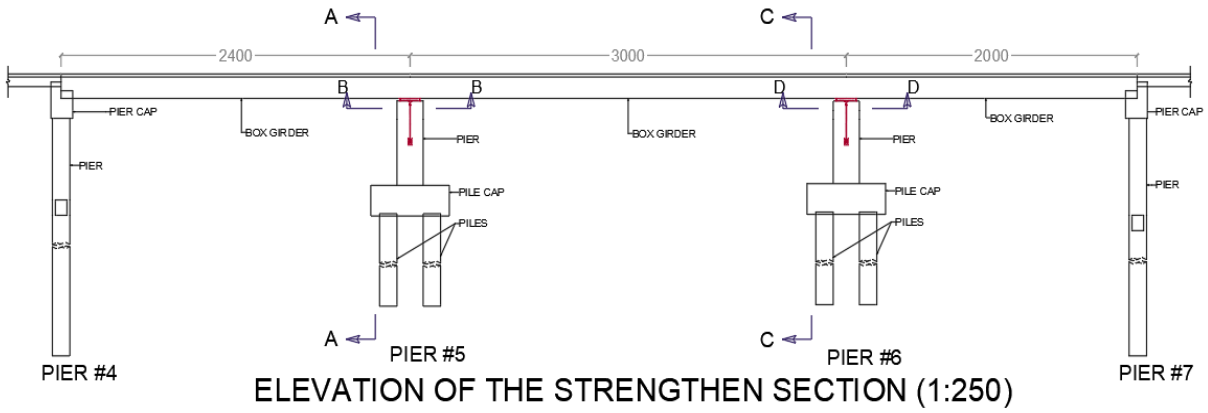


Figure 25 Strengthened Section of the Bridge After Installing Steel Tie Plates

Steel Tie plates are useful to strengthen the bridge against overturning instability and this method has been used in several other cases. Installing steel plates provides the rigid connection between the bridge deck girders and the pier while reducing the overturning tendency of the bridge. By connecting the pier 5 and pier 6 to the edge of the box girders the overturning instability of the bridge can be reduced significantly.

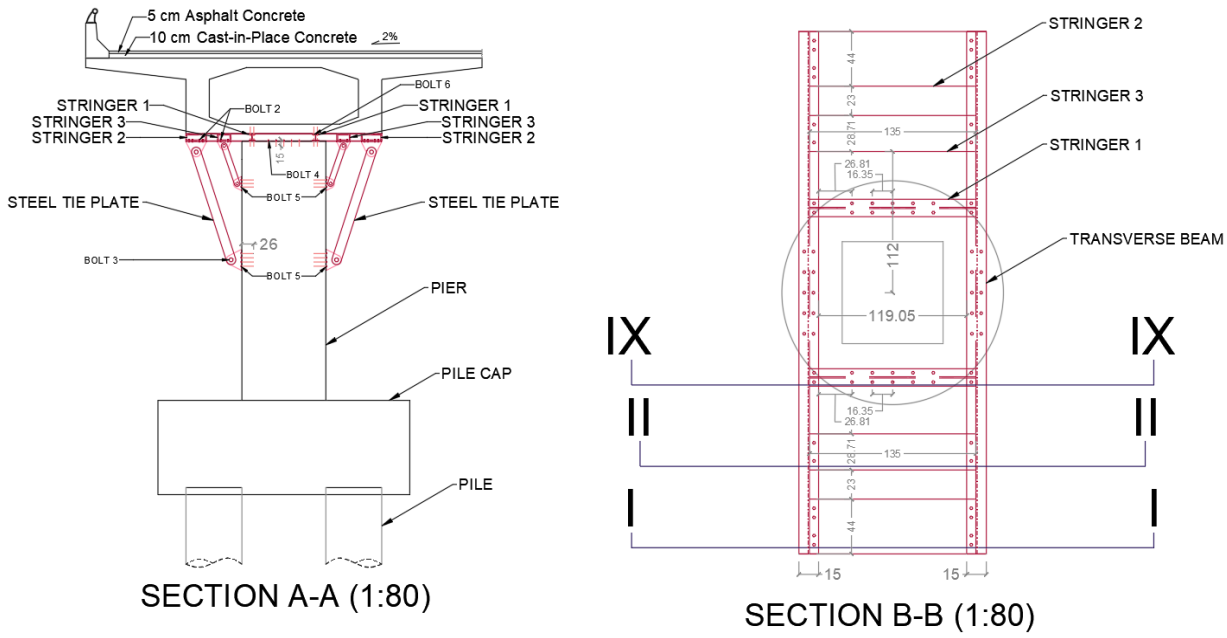


Figure 26 Sections of the Pier 5 and 6 After Installing Steel Connections

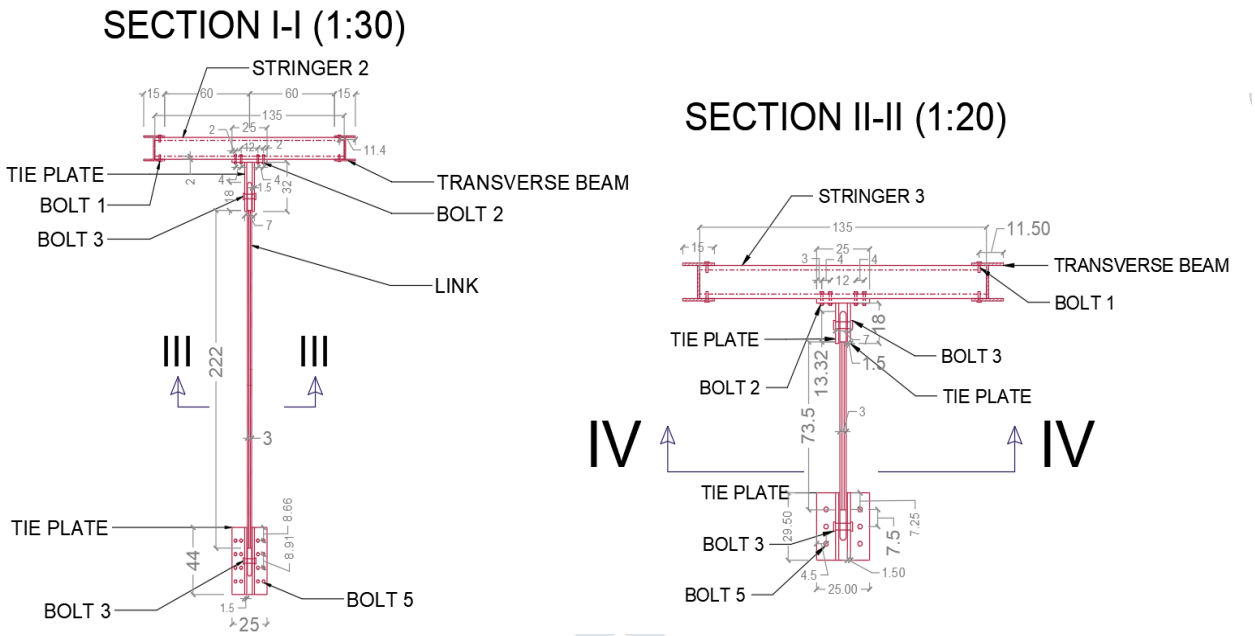


Figure 27 The Sections of the Steel Tie plates

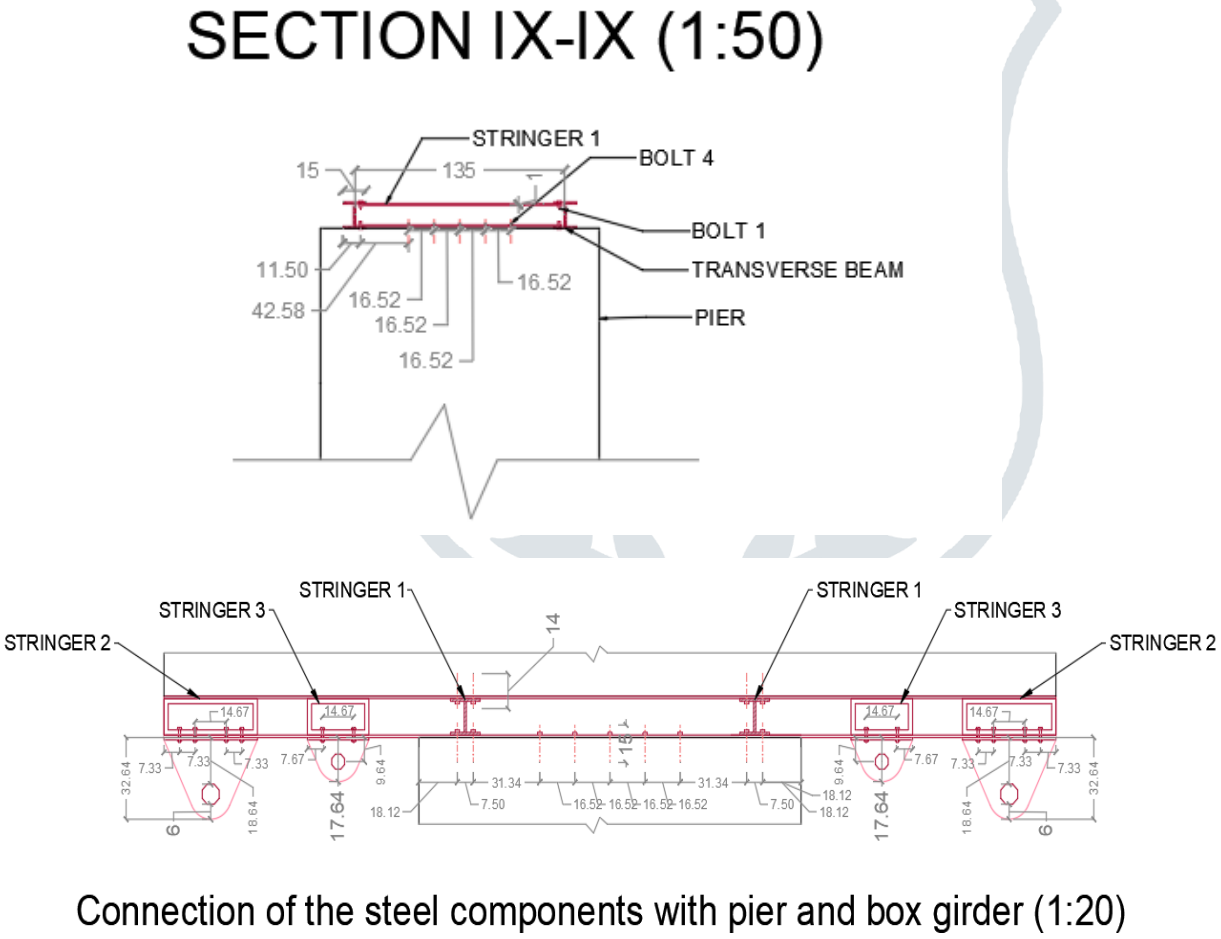


Figure 28 The Connection Between Steel Components and the Concrete

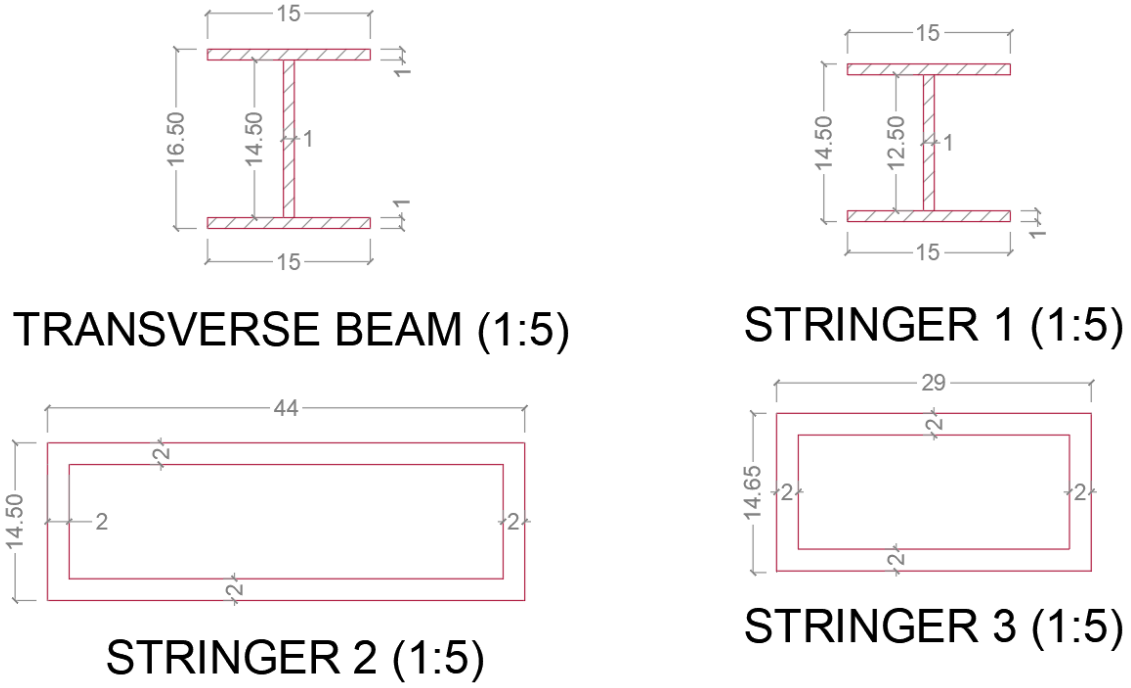


Figure 29 Steel Stringers and Transverse Beams

Advantages:

- Installing the tie plates will be easier than other methods for reducing the overturning instability.
- The tie plates will make rigid connections between the edges of the girders and the pier.
- It will be cost effective.
- The transverse steel beams along with the stringers can make a stronger and stable support system.
- The transverse beams will help the tie plates to reduce overturning by increasing the connecting area between the box girders and pier.

Disadvantages:

- Installing the stringers will be difficult.
- There are PSC cables through the box edges which should be considered while installing the stringers.
- The height of the strengthening porting will be increased.
- Installing Bearings on top of the stingers will be difficult as there is only little space available.
- This method will damage the original structure moderately.

4.3 Using Additional CFST Pier Along with the Existing Pier

Additional piers will directly provide additional supports to the bridge deck girders. But in this case the prime concern is to make the bridge safe against overturning instability so, the additional piers will not transport the dead load to the ground. The CFST piers have been suggested due to reducing the self-weight of the additional piers to make it easy to install and to get all the advantages of CFST technology. The additional piers will have bearing supports on top of them. The bearings will have only one degree of freedom as they will move just downward direction.

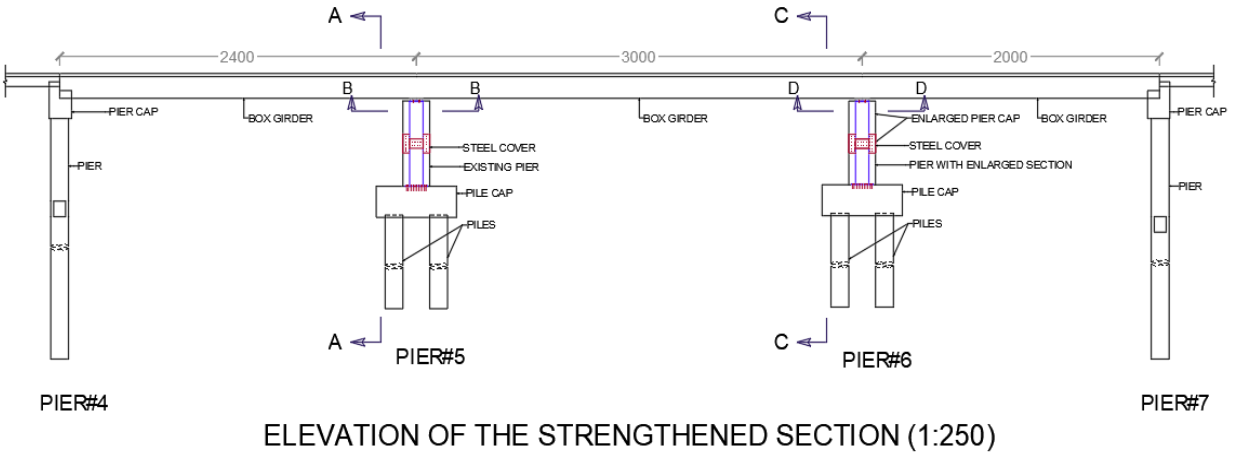


Figure 30 Strengthened Section of the Bridge After Installing the Additional Steel Piers

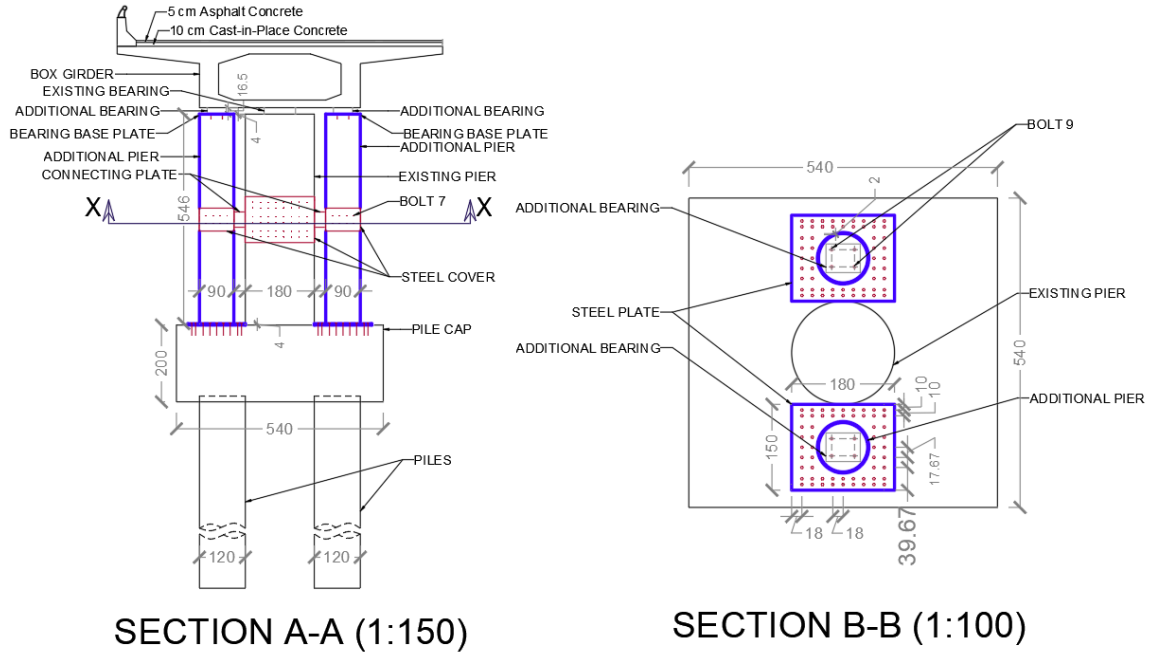


Figure 31 The Section View of Pier 5 with Additional Column

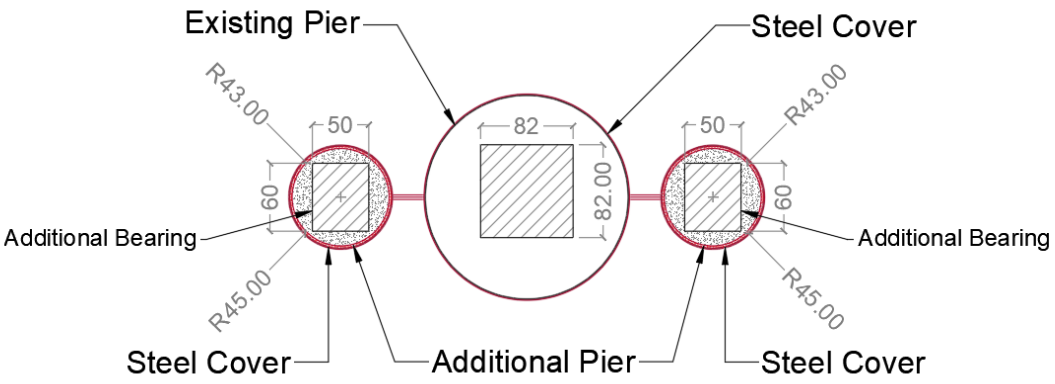


Figure 32 Section of the Piers with the position of Bearings

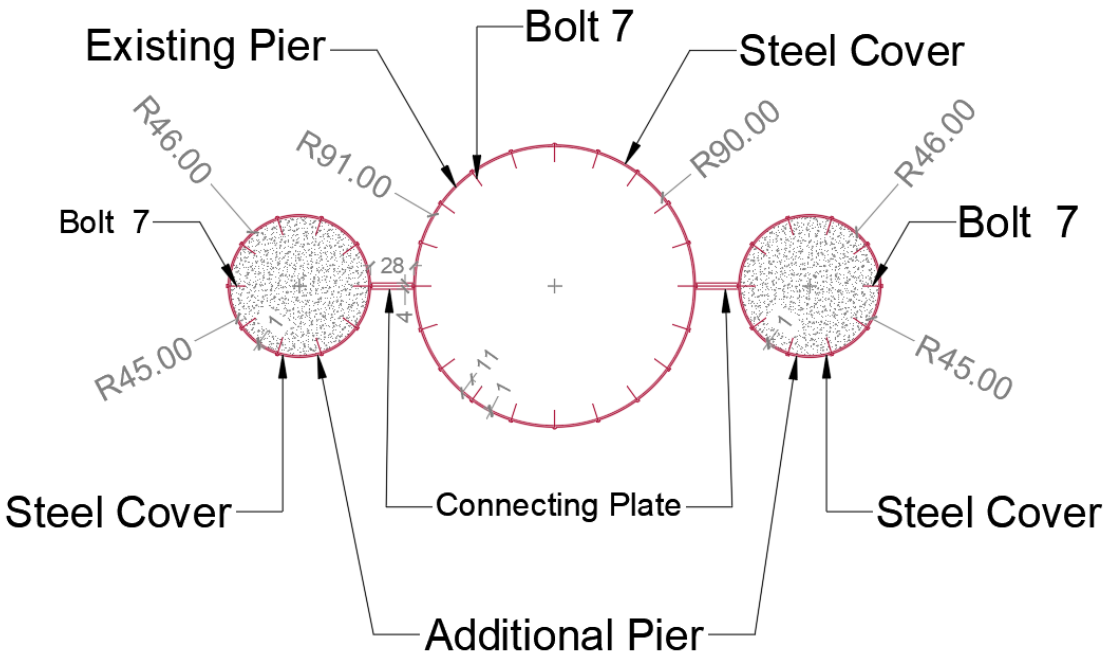


Figure 33 Typical Steel Cover

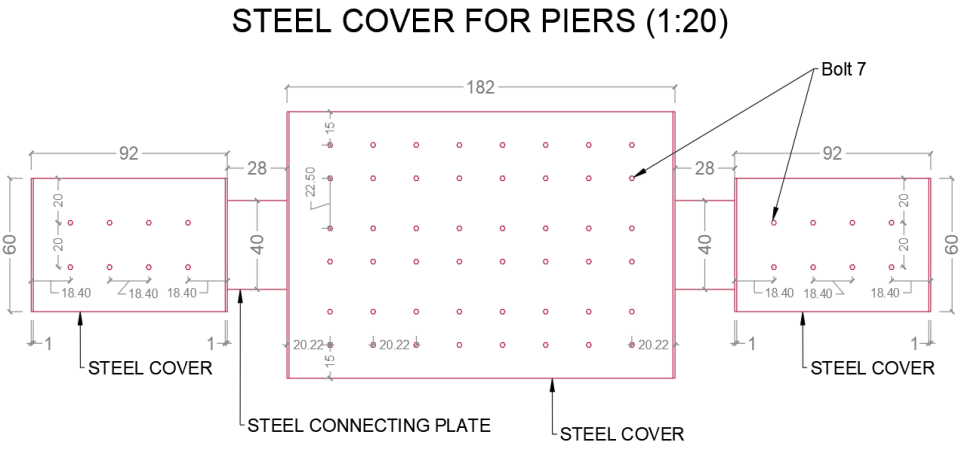


Figure 34 Steel Cover

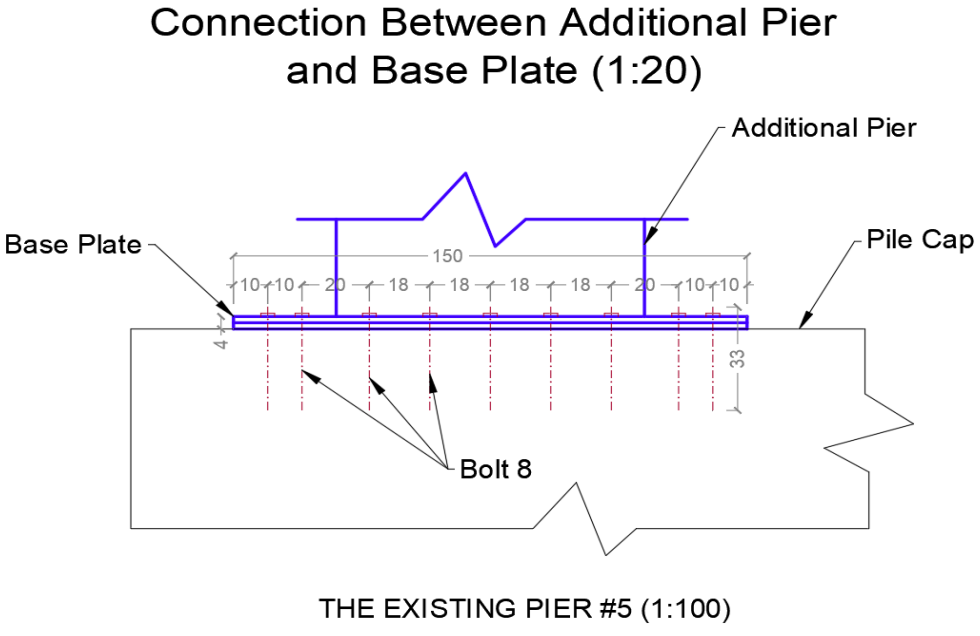


Figure 35 Connection Between Piers with the Pile Cap

Advantages:

- The additional piers will give additional support to the bridge at the both edges of the box section.
- The additional piers will make the bridge safe by reducing the overturning instability.
- The additional piers can be installed on the existing foundation.
- The piers will be lightweight but will be so strong both in compression and tension as steel and concrete composition is used.
- The installation process will be easier than other methods.
- It will be a cost-effective method as CFST columns use more than 10% less steel than traditional reinforced concrete.
- As steel surrounds the concrete, it is well plasticized.
- Less shrinkage and creep of concrete.
- No formwork will be required as the steel tube will play the role of the formwork.
- Pumping method can be implemented to cast the concrete which will reduce the man power and cost.
- The construction process is easier and quicker so it will take less time to install the additional piers.

Disadvantages:

- The piers will only support the bridge against the overturning instability and they will not increase the load bearing capacity of the bridge.
- As there is a limited amount of space, highly precise dimensions of the steel piers and installation area should be provided.
- Special safety measures are required for pouring concrete into the steel piers.
- Under maximum loading the steel used in CFST columns can deviates from the original position more than the concrete.
- The additional steel piers may reduce the aesthetic value of the bridge.

4.4 The Comparison Between the Schemes

Among the three schemes, using additional piers has been selected for further analysis. To explain the rationale behind choosing the final scheme a straight forward comparison has been established between the three proposed schemes.

Table 4 Comparison Between Three Schemes

Schemes / Factors	Enlarging the Pier Cap	Using Steel Tie Plate and Stringers	Using Additional CFST Piers
Materials	Concrete	Steel	Concrete and Steel
Main Construction Content	Enlarging piers and constructing a pier cap.	Installing steel tie plate between piers and stringers which	Installing 2 additional concrete filled steel piers.

		will hold the girders.	
Durability	Medium	Medium	High
Construction Difficulty	Moderate Difficulty	Highly Difficult	Low Difficulty
Damage to Original Structure	Will have Significant Damage	Will Have Moderate Damage	Will Have No/Low Damage
Maintenance	Low	High	Low
Construction Time	Longer	Medium	Very Short
Cost	Expensive	Expensive	Cheapest
Comparison Result	Not Selected	Not Selected	Selected

5. Detailed Method of Modeling and Analysis

The bridge model has been made using the bridge modeling and analysis software "Midas Civil" according to the original bridge design. The model has been analyzed after defining the actual loads including live loads along the predefined lanes. During the modeling of the bridge some modifications have been done. Due to short of time and to simplify the analysis process the pre-stressed cables were not defined. And only one section (section 3=3) has been used in the model. Although some details have been ignored but these may not make any crucial constraints to achieve the main objective of the research. Two models have been made for analyzing the bridge before and after strengthening. So, in this chapter data for 2nd model (After strengthening) has also be given along the data of 1st model (Before strengthening). The methods and steps of modeling of the bridge in "Midas Civil" has been described below.

5.1 Creating Nodes

At first the nodes have been defined according to the original bridge.

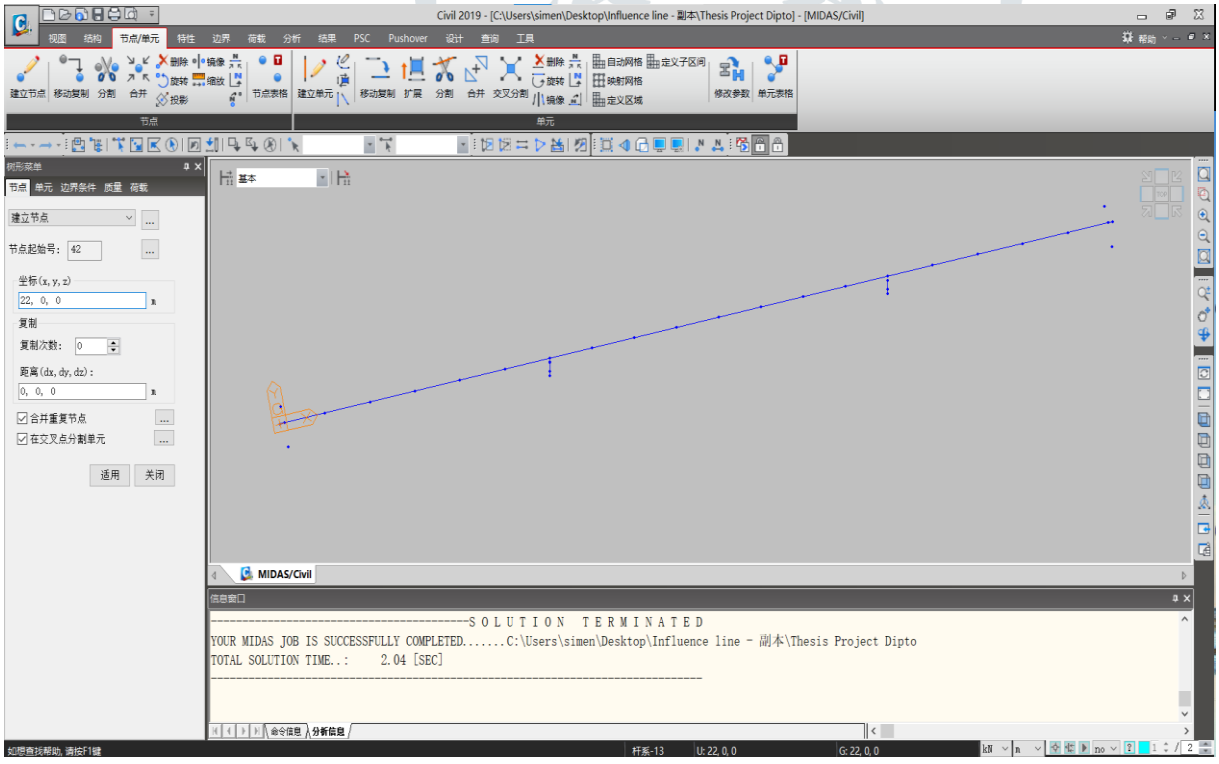


Figure 36 Creating Nodes

Table 5 Table of Nodes Before Strengthening

Nodes	X(m)	Y(m)	Z(m)
1	24.000000	0.000000	-7.265000
2	54.000000	0.000000	-7.160000

3	24.000000	0.000000	-7.100000
4	54.000000	0.000000	-6.990000
5	24.000000	0.000000	-5.500000
6	54.000000	0.000000	-5.390000
7	54.000000	0.000000	-1.770000
8	24.000000	0.000000	-1.765000
9	0.400000	-1.575000	-1.695000
10	73.600000	-1.575000	-1.695000
11	0.400000	1.575000	-1.695000
12	73.600000	1.575000	-1.695000
13	0.400000	-1.575000	-1.600000
14	73.600000	-1.575000	-1.600000
15	24.000000	0.000000	-1.600000
16	54.000000	0.000000	-1.600000
17	0.400000	1.575000	-1.600000
18	73.600000	1.575000	-1.600000
19	0.000000	0.000000	0.000000
20	0.000000	0.000000	0.000000
21	0.400000	0.000000	0.000000
22	4.000000	0.000000	0.000000
23	8.000000	0.000000	0.000000
24	12.000000	0.000000	0.000000
25	16.000000	0.000000	0.000000
26	20.000000	0.000000	0.000000
27	24.000000	0.000000	0.000000
28	27.750000	0.000000	0.000000
29	31.500000	0.000000	0.000000
30	35.250000	0.000000	0.000000
31	39.000000	0.000000	0.000000
32	42.750000	0.000000	0.000000
33	46.500000	0.000000	0.000000
34	50.250000	0.000000	0.000000
35	54.000000	0.000000	0.000000
36	58.000000	0.000000	0.000000
37	62.000000	0.000000	0.000000
38	66.000000	0.000000	0.000000

39	70.000000	0.000000	0.000000
40	73.600000	0.000000	0.000000
41	74.000000	0.000000	0.000000

Table 6 Table of Nodes After Strengthening

节点	X(m)	Y(m)	Z(m)
1	24.000000	0.000000	-7.265000
2	54.000000	0.000000	-7.160000
3	24.000000	0.000000	-7.100000
4	54.000000	0.000000	-6.990000
5	24.000000	0.000000	-5.500000
6	54.000000	0.000000	-5.390000
7	54.000000	0.000000	-1.770000
8	24.000000	0.000000	-1.765000
9	0.400000	-1.575000	-1.695000
10	73.600000	-1.575000	-1.695000
11	0.400000	1.575000	-1.695000
12	73.600000	1.575000	-1.695000
13	0.400000	-1.575000	-1.600000
14	73.600000	-1.575000	-1.600000
15	24.000000	0.000000	-1.600000
16	54.000000	0.000000	-1.600000
17	0.400000	1.575000	-1.600000
18	73.600000	1.575000	-1.600000
19	0.000000	0.000000	0.000000
20	0.000000	0.000000	0.000000
21	0.400000	0.000000	0.000000
22	4.000000	0.000000	0.000000
23	8.000000	0.000000	0.000000
24	12.000000	0.000000	0.000000
25	16.000000	0.000000	0.000000
26	20.000000	0.000000	0.000000
27	24.000000	0.000000	0.000000
28	27.750000	0.000000	0.000000
29	31.500000	0.000000	0.000000
30	35.250000	0.000000	0.000000

31	39.000000	0.000000	0.000000
32	42.750000	0.000000	0.000000
33	46.500000	0.000000	0.000000
34	50.250000	0.000000	0.000000
35	54.000000	0.000000	0.000000
36	58.000000	0.000000	0.000000
37	62.000000	0.000000	0.000000
38	66.000000	0.000000	0.000000
39	70.000000	0.000000	0.000000
40	73.600000	0.000000	0.000000
41	74.000000	0.000000	0.000000
42	24.000000	1.650000	-1.765000
43	24.000000	1.650000	-1.600000
44	24.000000	-1.650000	-1.765000
45	24.000000	-1.650000	-1.600000
46	54.000000	-1.650000	-1.770000
47	54.000000	-1.650000	-1.600000
48	54.000000	1.650000	-1.770000
49	54.000000	1.650000	-1.600000

5.2 Defining the Material properties

The material properties have been defined according to the Chinese standards and the actual material used in the original bridge.

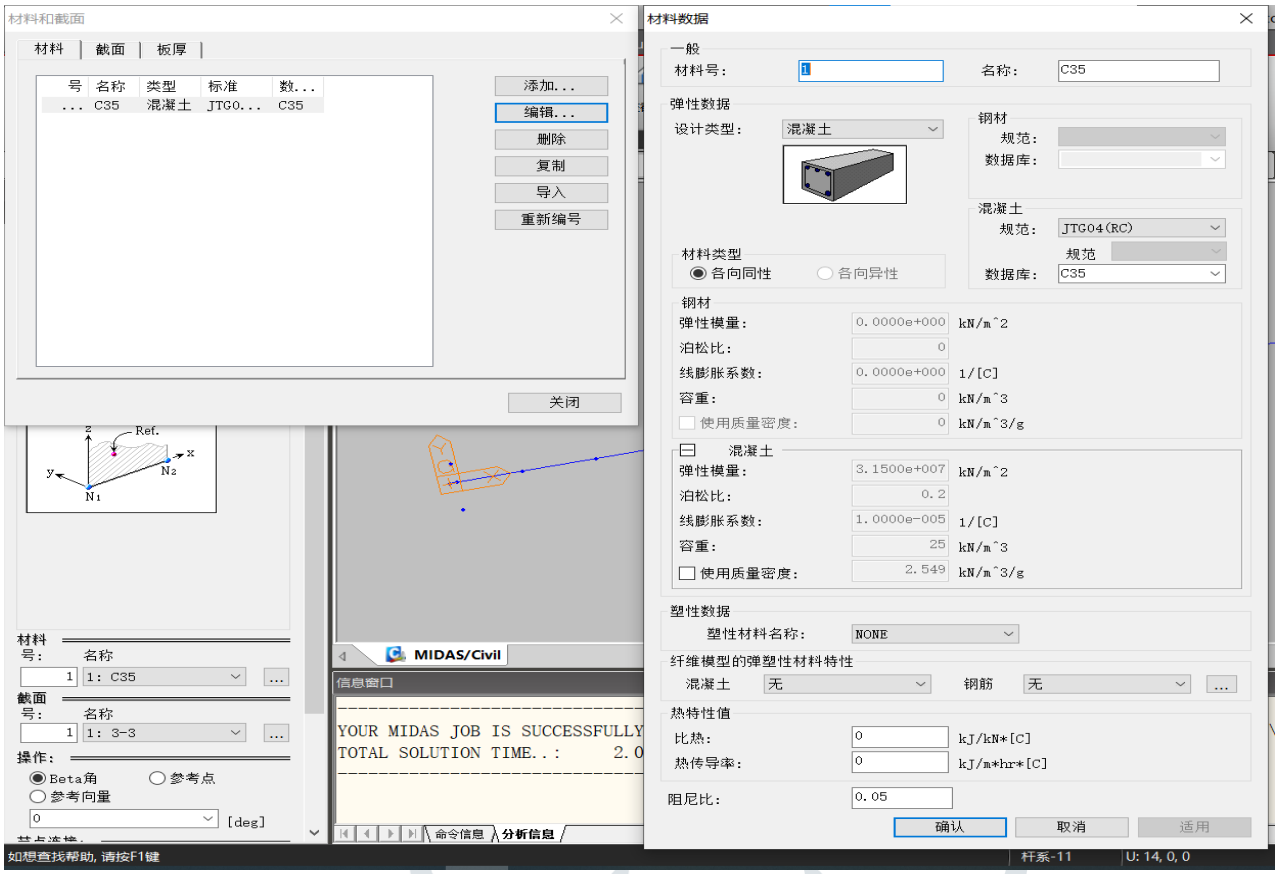


Figure 37 Defining Material properties

Table 7 Table of Material Properties Before Strengthening

Number	Name	Type	Specification	DB	Dencity	Elastic Modulus (kN/m^2)	Poisson's Ratio	Thermal Expansion coefficient (1/[C])	Dencity (kN/m^3)	Mass Dencity (kN/m^3/g)
1	C35	Concrete	JTG04(RC)	C35	X	3.15E+07	0.2	1.00E-05	2.50E+01	2.55E+00

The steel and concrete material listed below is for the additional CFST piers.

Table 8 Table of Material Properties for Strengthening

No.	Name	Type	Specification	DB	Dencity	Elastic Modulus (kN/m^2)	Poisson's Ratio	Thermal Expansion Coefficient (1/[C])	Dencity (kN/m^3)	Mass Dencity (kN/m^3/g)
1	C35	Concrete	JTG04(RC)	C35	X	3.15E+07	0.2	1.00E-05	2.50E+01	2.55E+00
2	Q235	Steel	JTG D64-2015 (S)	Q235	X	2.06E+08	0.31	1.20E-05	7.85E+01	8.00E+00

5.3 Defining Sections

For creating the elements first, the sections are to be defined. For that the sections have been drafted using AutoCAD and then imported to the analysis software. Then the sections have been made defined using the "Section Property Calculator" which will be described in the next chapter.

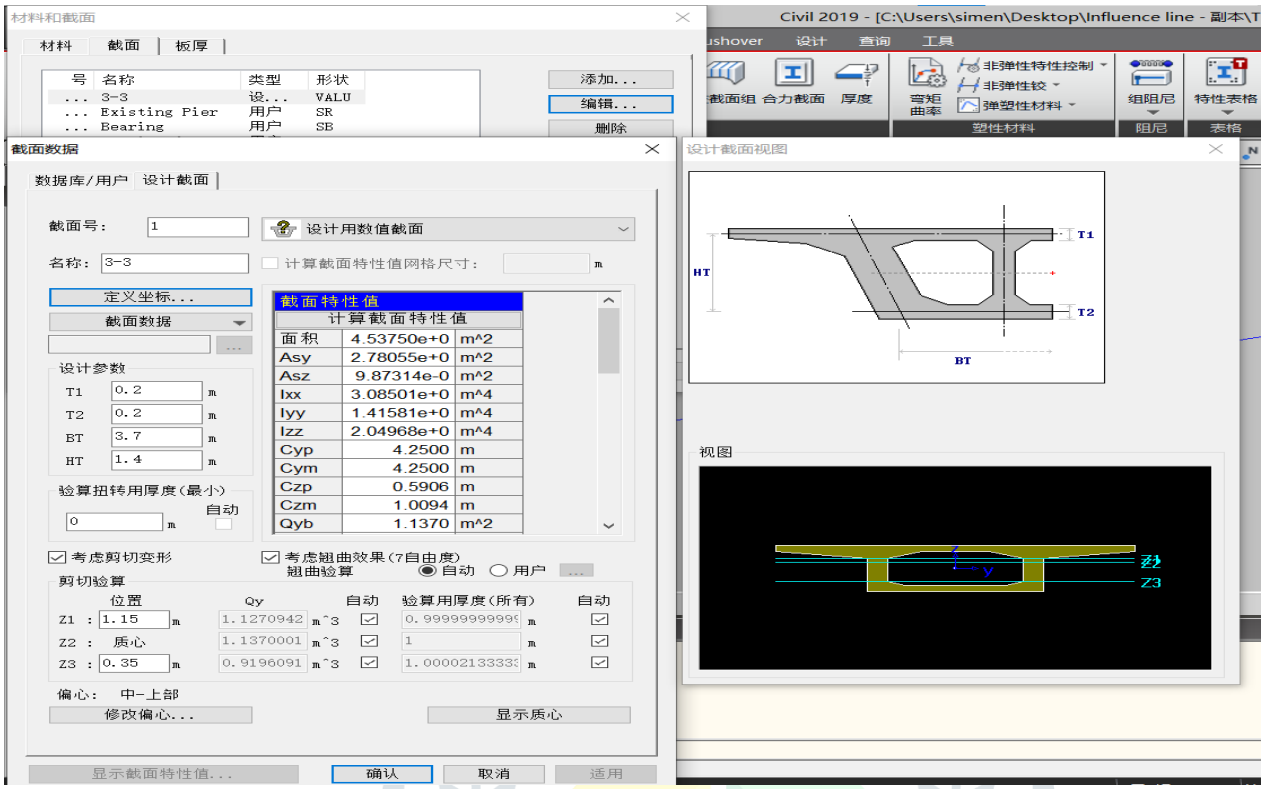
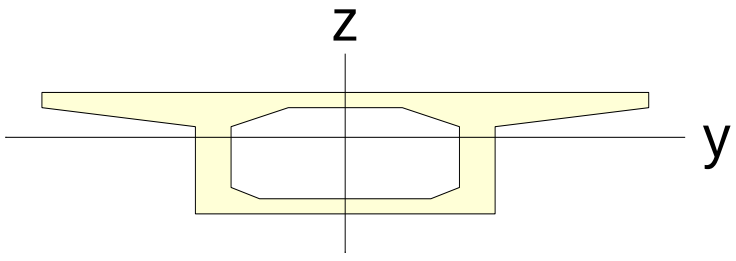


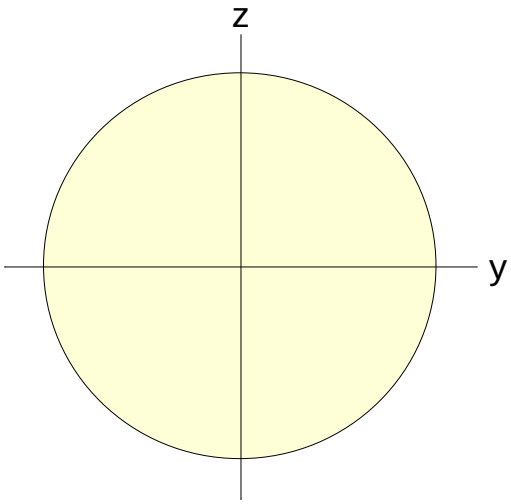
Figure 38 Defining the Sections

Only two sections have been used for modeling the bridge, one section (section 3-3) has been used to model the bridge deck and the section named as "Existing Pier" has been used to model the piers.



A(m²)	Asy(m²)	Asz(m²)	z(+)(m)	z(-)(m)
4.537	2.781	0.987	0.591	1.009

Ixx(m 4)	Iyy(m 4)	Izz(m 4)	y(+)(m)	y(-)(m)
3.085	1.416	20.497	4.250	4.250



A(m 2)	Asy(m 2)	Asz(m 2)	z(+)(m)	z(-)(m)
2.545	2.290	2.290	0.900	0.900
Ixx(m 4)	**Iyy(m 4)**	**Izz(m 4)**	**y(+)(m)**	**y(-)(m)**
1.031	0.515	0.515	0.900	0.900

Figure 39 The box girder section 3-3 and the existing pier section with properties

5.4 Creating Elements

The elements have been created according to the predefined sections. As there are no tapered sections used in this modeling so the only one section (section 3-3) which has been used to define element between two nodes.

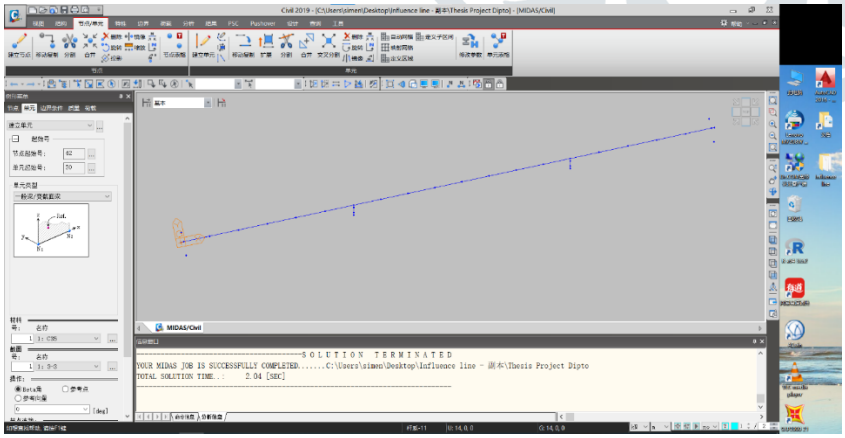


Figure 40 Creating the Elements

Table 9 Table of Elements Before Strengthening

Element	Type	Material	Property	β-Angle ([deg])	Node 1	Node 2	Kind	Hook/Gap (m)	Lu (m)	Tension (kN)	Allow.Comp/Tens (kN)	Use limit	Ultimate Comp/Tens (kN)
1	Beam	1	2	0	3	1	Lu	0	0	0	0	X	0
2	Beam	1	2	0	4	2	Lu	0	0	0	0	X	0
3	Beam	1	2	0	5	3	Lu	0	0	0	0	X	0
4	Beam	1	2	0	6	4	Lu	0	0	0	0	X	0
5	Beam	1	2	0	8	5	Lu	0	0	0	0	X	0
6	Beam	1	2	0	7	6	Lu	0	0	0	0	X	0
7	Beam	1	1	0	20	21	Lu	0	0	0	0	X	0
8	Beam	1	1	0	21	22	Lu	0	0	0	0	X	0
9	Beam	1	1	0	22	23	Lu	0	0	0	0	X	0
10	Beam	1	1	0	23	24	Lu	0	0	0	0	X	0
11	Beam	1	1	0	24	25	Lu	0	0	0	0	X	0
12	Beam	1	1	0	25	26	Lu	0	0	0	0	X	0
13	Beam	1	1	0	26	27	Lu	0	0	0	0	X	0
14	Beam	1	1	0	27	28	Lu	0	0	0	0	X	0
15	Beam	1	1	0	28	29	Lu	0	0	0	0	X	0
16	Beam	1	1	0	29	30	Lu	0	0	0	0	X	0
17	Beam	1	1	0	30	31	Lu	0	0	0	0	X	0
18	Beam	1	1	0	31	32	Lu	0	0	0	0	X	0
19	Beam	1	1	0	32	33	Lu	0	0	0	0	X	0
20	Beam	1	1	0	33	34	Lu	0	0	0	0	X	0
21	Beam	1	1	0	34	35	Lu	0	0	0	0	X	0
22	Beam	1	1	0	35	36	Lu	0	0	0	0	X	0
23	Beam	1	1	0	36	37	Lu	0	0	0	0	X	0
24	Beam	1	1	0	37	38	Lu	0	0	0	0	X	0
25	Beam	1	1	0	38	39	Lu	0	0	0	0	X	0
26	Beam	1	1	0	39	40	Lu	0	0	0	0	X	0
27	Beam	1	1	0	40	41	Lu	0	0	0	0	X	0
28	Beam	1	3	0	8	15	Lu	0	0	0	0	X	0
29	Beam	1	4	0	7	16	Lu	0	0	0	0	X	0

5.5 Defining the Supports

Supports are one of the structural components of a bridge who hold the bridge deck and transfer the load. Supports help the bridge deck for doing little movements which helps the bridge to be stable against the lateral impact of external loads.

Table 10 Table of Supports Before Strengthening

Node	Dx	Dy	Dz	Rx	Ry	Rz	Rw
1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1
9	0	1	1	1	0	1	0
10	1	1	1	1	0	1	1
11	0	1	1	1	0	1	0
12	1	1	1	1	0	1	1

Table 11 Table of Supports for Strengthening

Node	Dx	Dy	Dz	Rx	Ry	Rz	Rw
1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1

9	0	0	1	0	0	0	0
10	0	0	1	1	0	1	0
11	0	0	1	0	0	0	0
12	0	0	1	1	0	1	0
42	0	0	1	0	0	0	0
44	0	0	1	0	0	0	0
46	0	0	1	0	0	0	0
48	0	0	1	0	0	0	0

5.6 Creating the Links

Links are used for making the connection between the box girders and the supports. Two types of links have been used one is rigid and other is elastic link.

Creating Elastic and Rigid Links Before Strengthening

Table 12 Table of Elastic Links Before Strengthening

No.	Node 1	Node 2	Type	B Angle ([deg])	SDx (kN/m)	SDy (kN/m)	SDz (kN/m)	SRx (kN*m/[rad])	SRy (kN*m/[rad])	SRz (kN*m/[rad])	Shear Spring Location	Distance Ratio SDy	Distance Ratio SDz
1	26	15	Rigid	0	0	0	0	0	0	0	X	0.5	0.5
2	15	8	Rigid	0	0	0	0	0	0	0	X	0.5	0.5
3	34	16	Rigid	0	0	0	0	0	0	0	X	0.5	0.5
4	16	7	Rigid	0	0	0	0	0	0	0	X	0.5	0.5
5	13	9	Rigid	0	0	0	0	0	0	0	X	0.5	0.5
6	17	11	Rigid	0	0	0	0	0	0	0	X	0.5	0.5
7	14	10	Rigid	0	0	0	0	0	0	0	X	0.5	0.5
8	18	12	Rigid	0	0	0	0	0	0	0	X	0.5	0.5

Table 13 Table of Rigid Links Before Strengthening

Master Node	Type	Slave Nodes
20	111111	13 17
41	111111	14 18

Creating Elastic and Rigid Links for Strengthening

Table 14 Table of Elastic Links for Strengthening

No.	Node 1	Node 2	Type	β Angle ([deg])	SDx (kN/m)	SDy (kN/m)	SDz (kN/m)	SRx (kN*m/[rad])	SRy (kN*m/[rad])	SRz (kN*m/[rad])	Share spring Location	Distance Ratio SDy	Distance Ratio SDz
1	18	12	Rigid	0	0	0	0	0	0	0	X	0.5	0.5
2	14	10	Rigid	0	0	0	0	0	0	0	X	0.5	0.5
3	35	16	Rigid	0	0	0	0	0	0	0	X	0.5	0.5
4	16	7	Rigid	0	0	0	0	0	0	0	X	0.5	0.5
5	27	15	Rigid	0	0	0	0	0	0	0	X	0.5	0.5
6	15	8	Rigid	0	0	0	0	0	0	0	X	0.5	0.5
7	17	11	Rigid	0	0	0	0	0	0	0	X	0.5	0.5
8	13	9	Rigid	0	0	0	0	0	0	0	X	0.5	0.5
9	43	42	Rigid	0	0	0	0	0	0	0	X	0.5	0.5
10	45	44	Rigid	0	0	0	0	0	0	0	X	0.5	0.5
11	47	46	Rigid	0	0	0	0	0	0	0	X	0.5	0.5
12	49	48	Rigid	0	0	0	0	0	0	0	X	0.5	0.5

5.7 Rigid Links

Table 15 Table of Rigid Links for Strengthening

Master Nodes	Types	Slave Nodes
21	111111	13 17
27	111111	43 45
35	111111	47 49
40	111111	14 18

5.8 Releasing Beam End

The beam end release has been used for releasing end of the pier's elements to eliminate the bending moment in the piers.

Table 16 Table of Beam End Releases

Unit	Type	Flag-i	Fxi	Fyi	Fzi	Mxi	Myi	Mzi	Wi	Flag-j	Fxj	Fyj	Fzj	Mxj	Myj	Mzj	Wj
5	Relative Value	110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Relative Value	110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

5.9 Defining the Lanes

Lanes are provided through the bridge modeler in the context of bridges to show where vehicle loads affect a bridge superstructure. Reference lines, which can be layout lines or frame-object pathways, create lanes.

The lanes are defined due to imposing the live load. The position of the lanes has been determined considering the maximum effect due to the live load. After some basic calculation two lanes have been fixed with exact location. The distance between the middle section of the box girder and the “Lane-1” is 3.35 m and the to the “Lane-2” the distance is 0.25 m. The minimum distance between the vehicles according to Chinese standard has been given in the table-1.

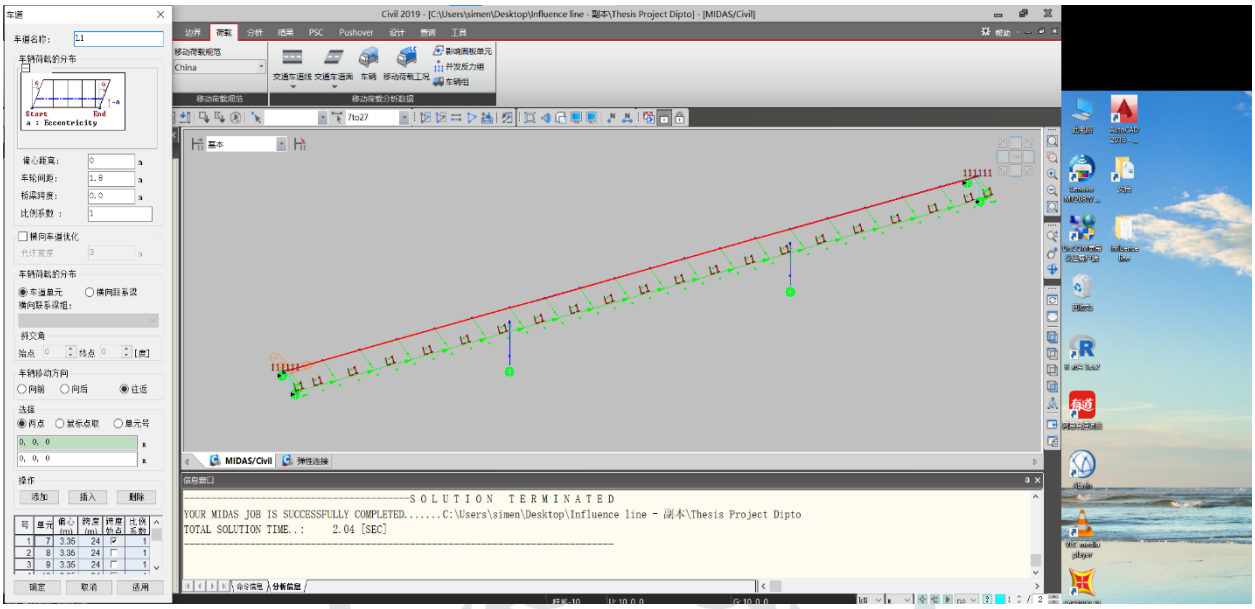


Figure 41 Defining Lane-1

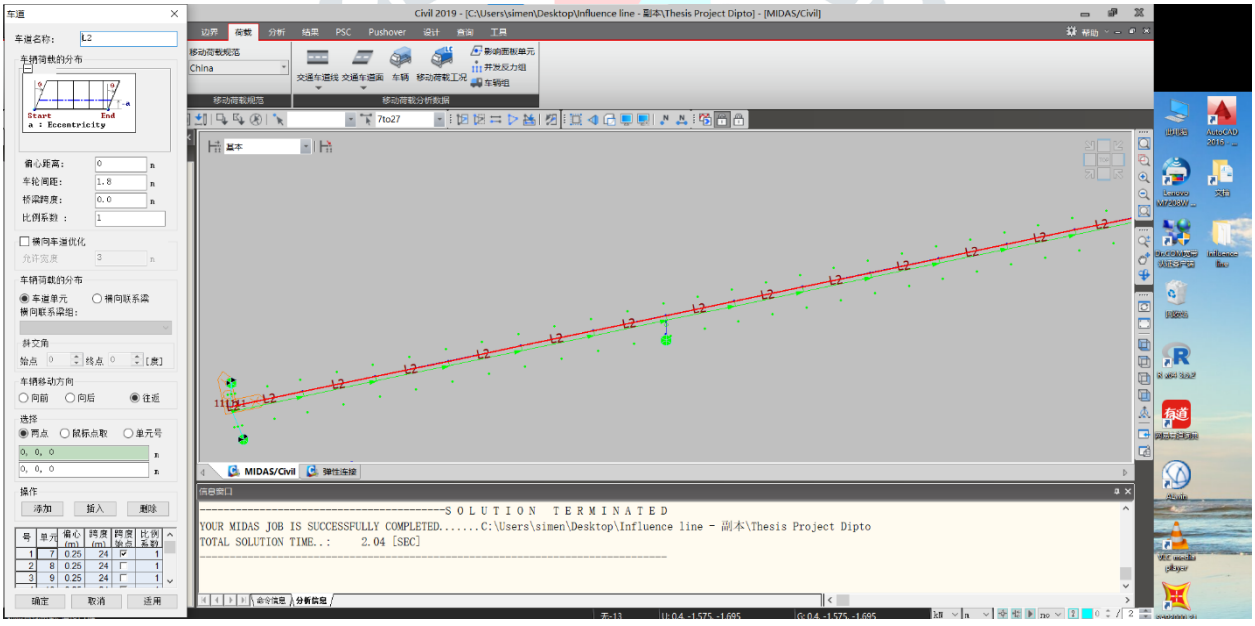


Figure 42 Defining Lane-2

5.10 Defining Load

Many kinds of loads act on a bridge such as dead load, live load, wind load, earthquake load, live load and other applicable loads. Among all kind of loads the dead load and live loads are the main concern of this research. The bridge having overturning tendency while vehicles moves on the bridge deck. So, in this research only the dead load and live load have been considered for evaluating the condition of the bridge as well as to develop the strengthening scheme.

Static Load

The dead load refers to the self-weight of the bridge components which are permanently attached to the bridge such as the girders, the beams, the piers and so on. In addition to that the other components of a bridge which are replaceable such as Cross Barriers should also be defined as dead load. The dead load is a type of Static Load and the load of the barrier has been defined as element load in this model.

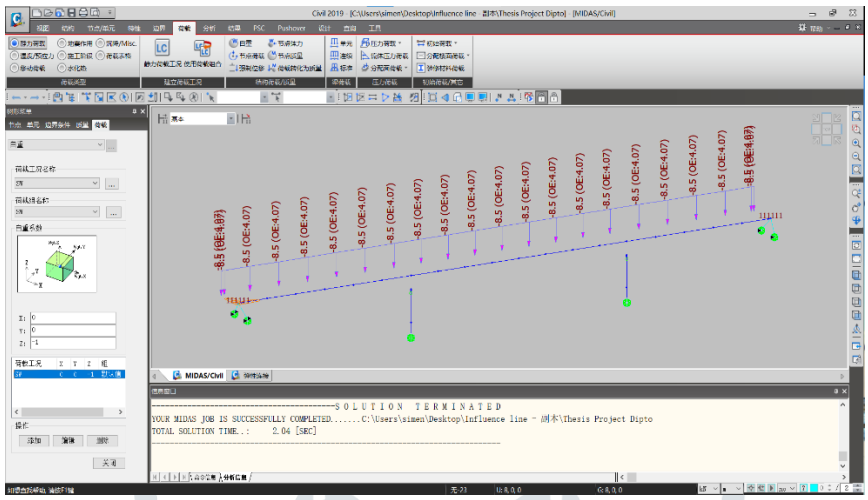


Figure 43 Defining Self-weight

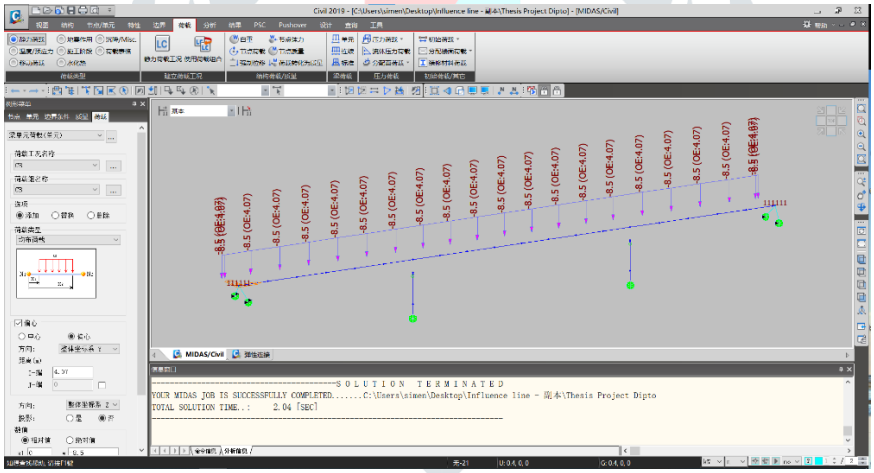


Figure 44 Defining the Load of the Barrier

Live Load

Several standards can be used to define the live loads. In this research, the two wheels of a vehicle were spaced apart by 1.8 meters in accordance with Chinese norms. The Chinese code of JTG D60-2015 has been used in this study for defining vehicle type and among the two types of the vehicles in this code, the class 1 heavy truck has been taken. The load cases have been constructed in such a way that two vehicles will serve as the live load on two designated lanes when the minimum loading case is only one lane loaded and the maximum loading case is the loading of both lanes simultaneously.

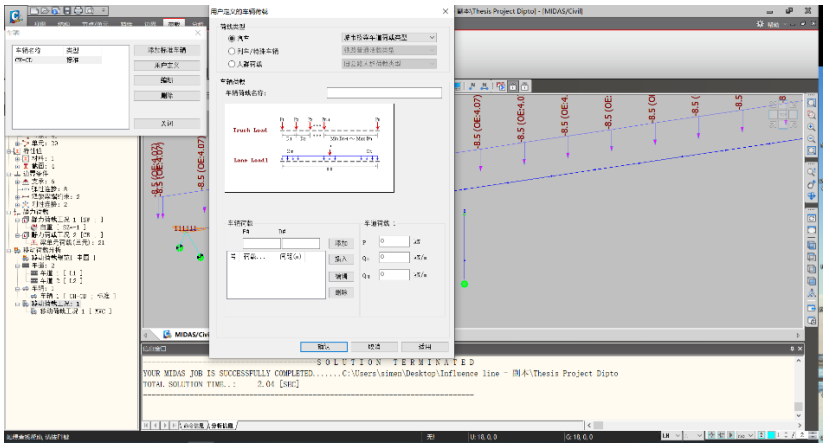


Figure 45 Properties of the Vehicle

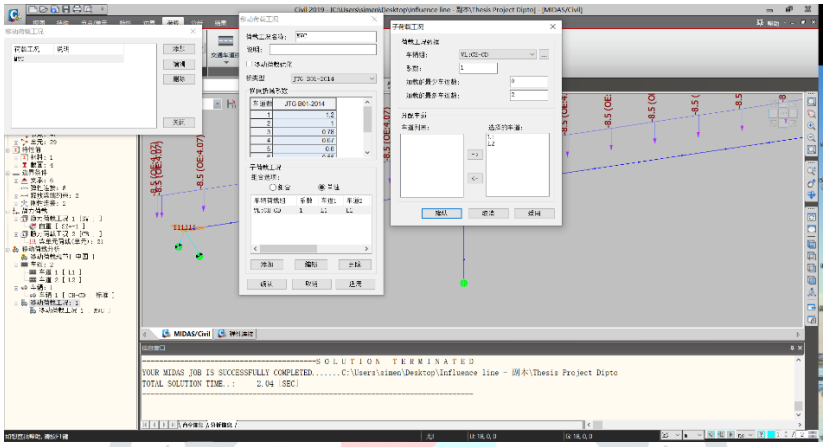


Figure 46 Constructing the Load Case

5.11 Load Combination

In order to achieve the necessary safety and economy in the construction of a structure, a load combination is a collection of several loading circumstances functioning jointly in the structure. The structure should be stable against different types of loads. If a bridge can bear the dead load it may collapse due to the impact of live load at a same time. So, a combination of both dead load and live load has been introduced for structural analysis in this research.

The load combination is:

1.4 x DL + 1.0 x LL

DL = Dead Load (including the self-weight of the bridge and the load of Cross Barrier)

LL = Live Load (Live Load)

6. Structural Analysis Before Strengthening

The structural analysis has been conducted two times. One is before applying the strengthening scheme and other has been conducted after applying the strengthening scheme. During the second analysis the previous models has been modified significantly to introduce the additional supports according to the strengthening scheme.

6.1 Beam Forces

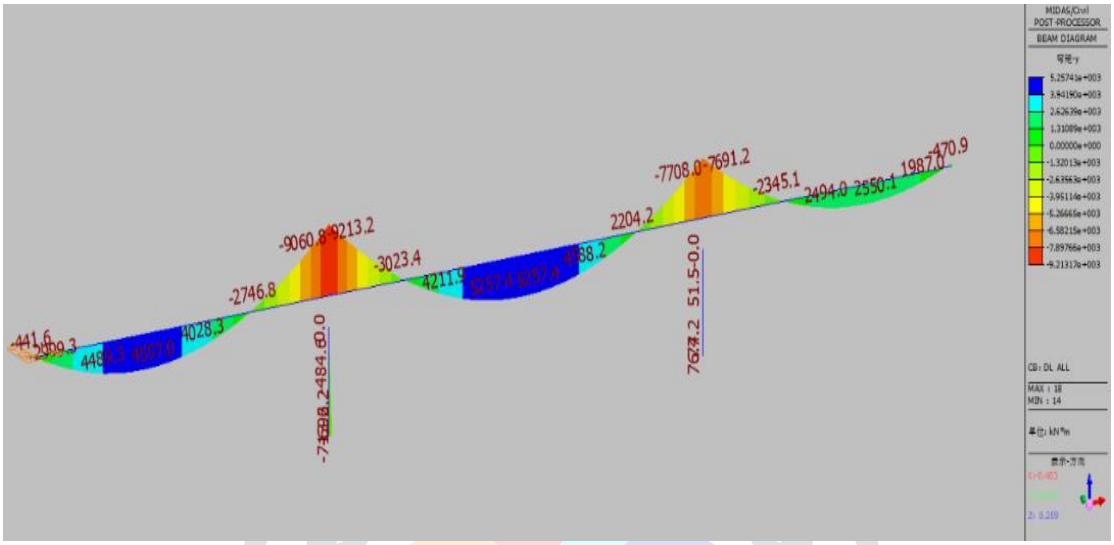


Figure 47 Bending Moment Diagram Due to Dead Load

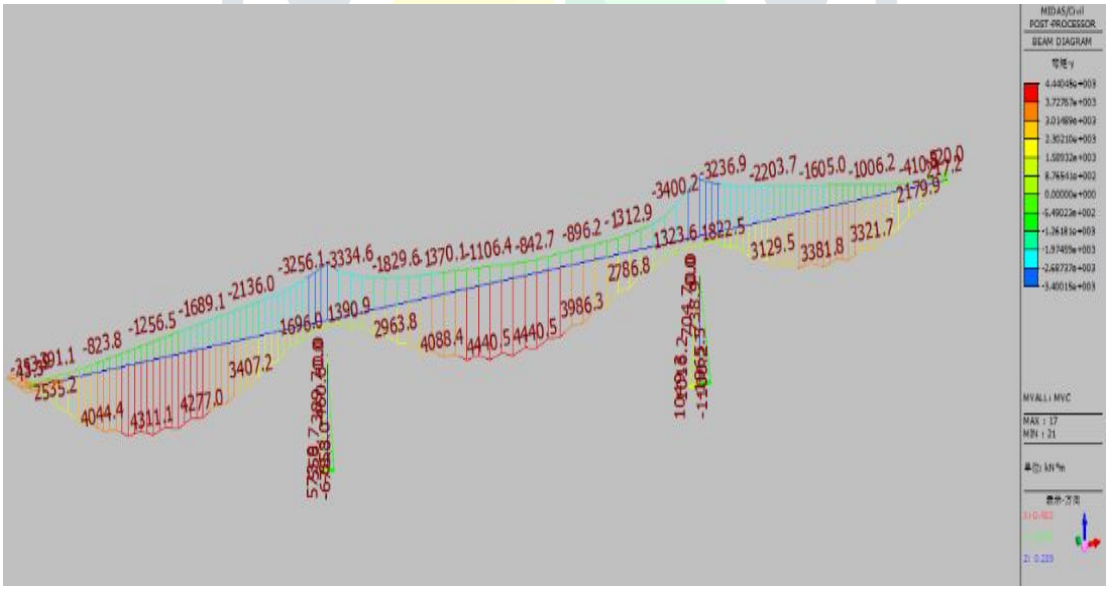


Figure 48 Bending Moment Diagram Due to Live Load (all)

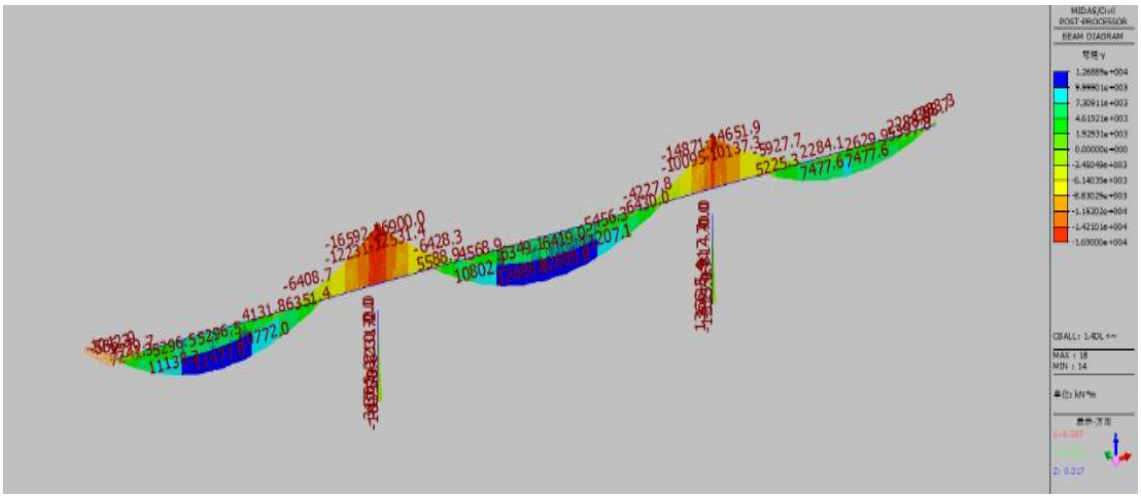


Figure 49 Bending Moment Diagram Due to Load Combination

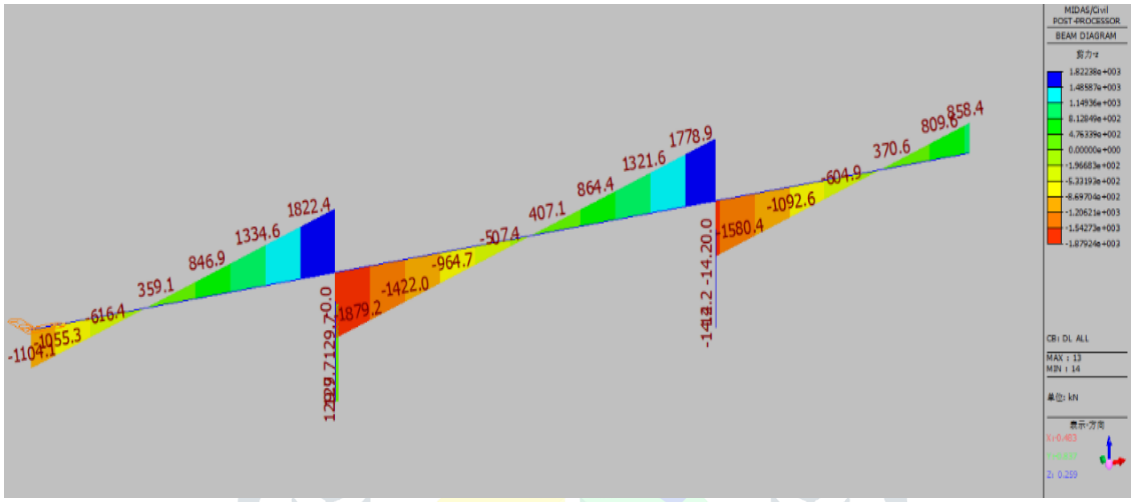


Figure 50 Share Force Diagram for Dead Load

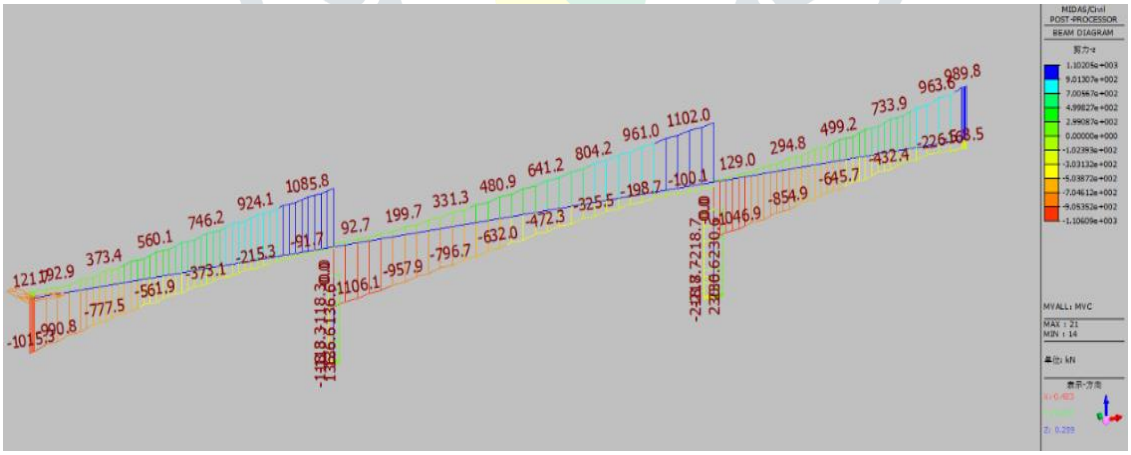


Figure 51 Share Force Diagram Due to Live Load

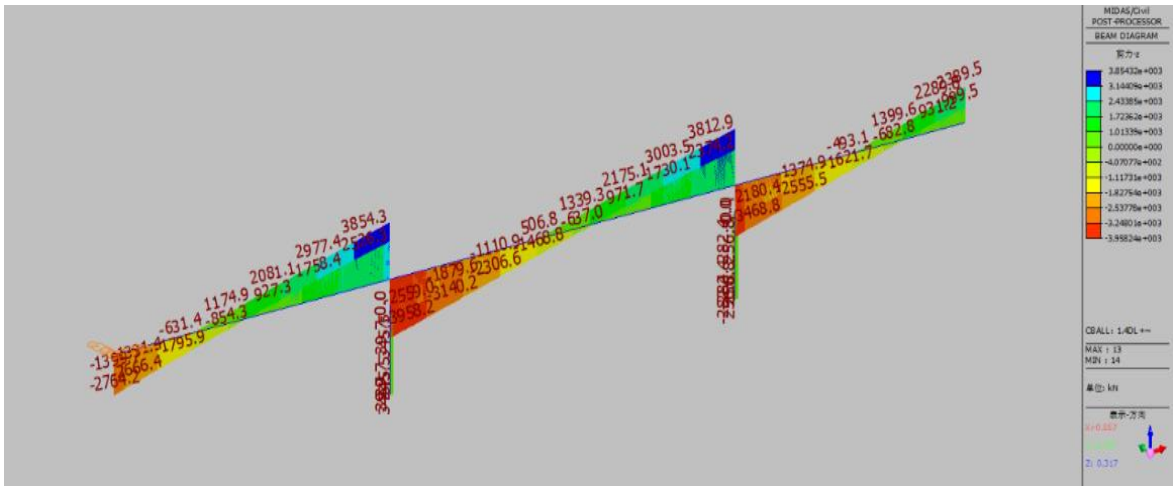


Figure 52 Share Force Diagram Due to the Load Combination

The bending moment diagrams and the share forces diagrams look like normal. So, no abnormal behavior can be noticed. As to the overturning possibility, it will be calculated according to the reaction forces in the next part.

6.2 Displacement

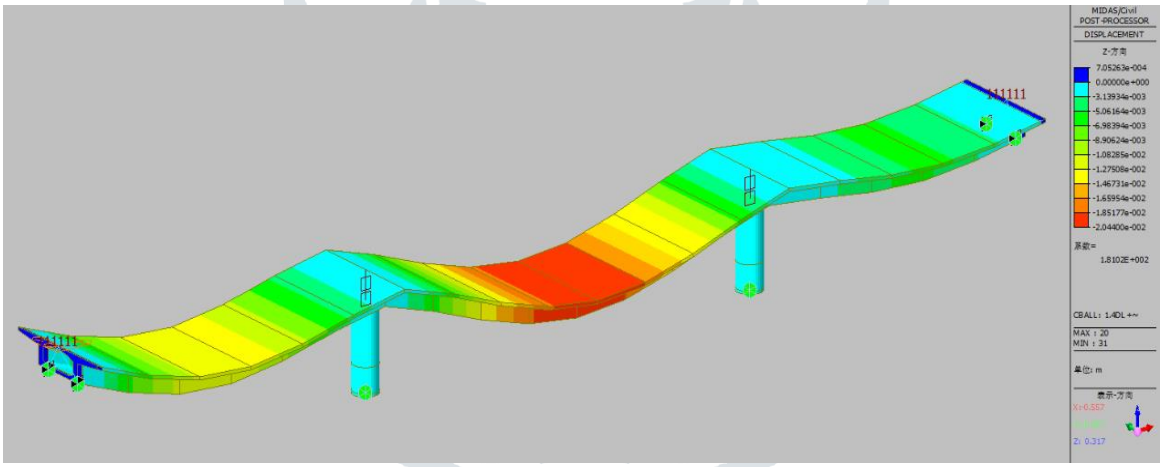


Figure 53 Displacement Due to the Load Combination

6.3 Reaction Forces

The stability of a bridge depends on the reaction forces. In this research the bridge has the overturning tendency which means the deck girder of the bridge has the tendency to turn over its supports and during this phenomenon the supports at the left side loose connections with the deck girder as the overturning effect pulls the bridge deck girder and try to rotate the girders while vehicles move. As a result, in that particular moment no reactions produced from the supports at the left. So, the forces are the crucial factors in this research as the calculation for finding the coefficient of the overturning stability depends on the reaction forces. The 1st verification for overturning stability has been calculated using these reactions forces.

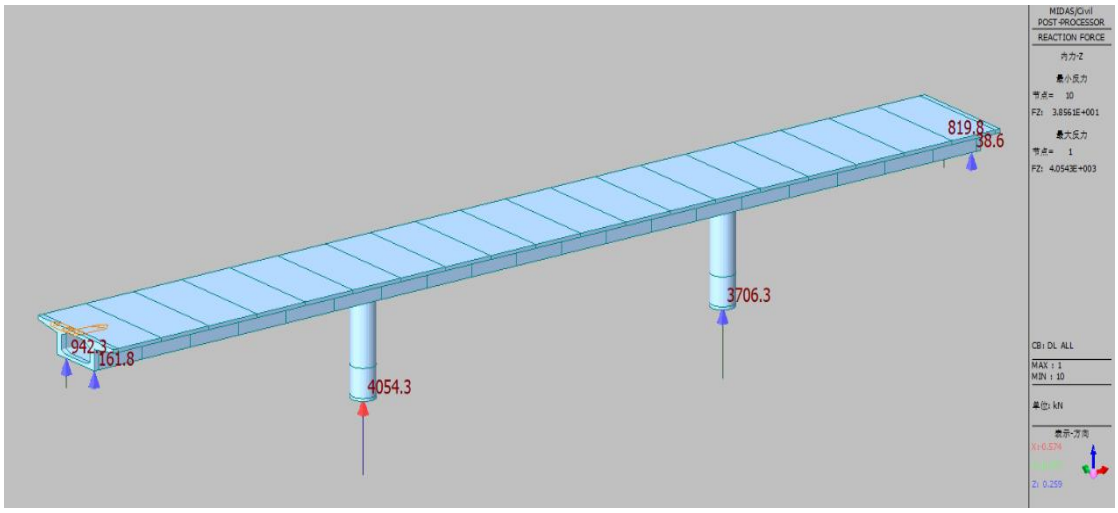


Figure 54 Reaction Forces Due to DL

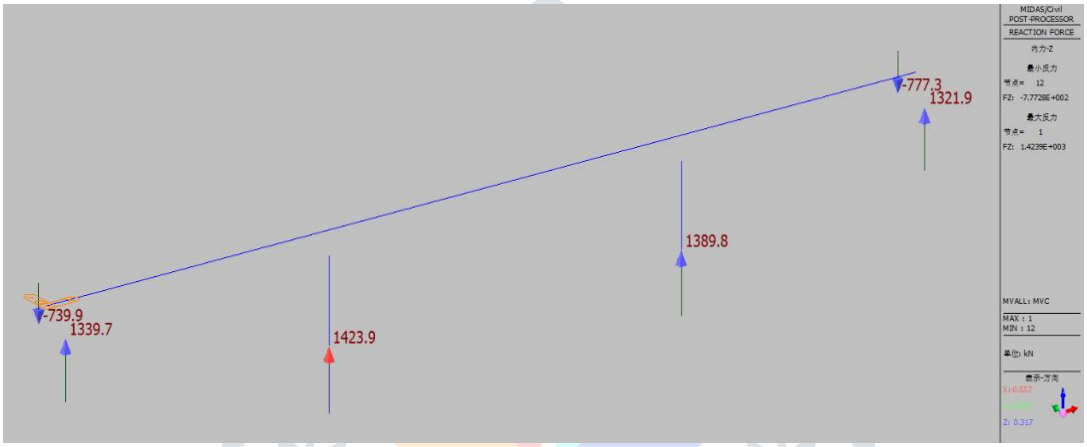


Figure 55 Reaction Forces Due to Live Load (all)

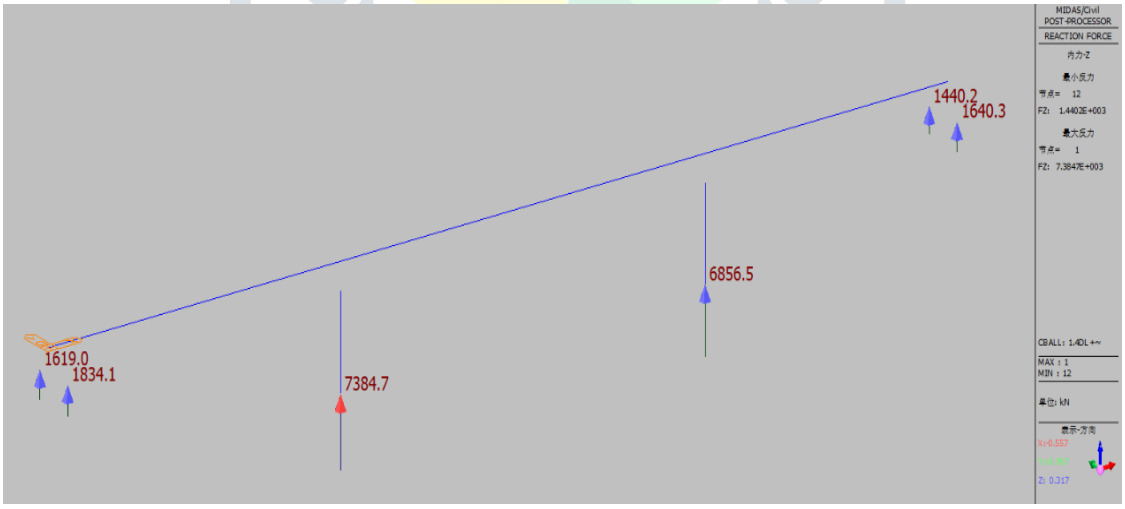


Figure 56 Reaction Forces Due to Load Combination (1.4DL + 1.0xLL)

Table 17 Table of Reaction Forces Before Strengthening

Node	Load	FX (kN)	FY (kN)	FZ (kN)	MX (kN*m)	MY (kN*m)	MZ (kN*m)	Mb (kN*m^2)
1	SW	120.717	0	3796.25	0	663.942	0	0
2	SW	-13.227	0	3472.09	0	-71.294	0	0
9	SW	0	0	513.578	0	0	0	0
10	SW	-53.745	0	399.267	0	0	0	0
11	SW	0	0	513.578	0	0	0	0
12	SW	-53.745	0	399.267	0	0	0	0
1	CB	9.02506	72.7187	258.034	-399.95	49.6378	-24.176	0
2	CB	-0.9948	74.2066	234.176	-399.97	-5.3618	28.8124	0
9	CB	0	-34.038	-351.78	22.2654	0	-527.06	0
10	CB	330.905	-39.424	-360.71	22.5404	0	36.2995	0
11	CB	0	-34.038	428.739	22.2654	0	-527.06	0
12	CB	-338.94	-39.424	420.534	22.5404	0	36.2995	0
1	MVC(Max)	123.328	0	1423.91	946.438	678.305	46.7153	0
2	MVC(Max)	204.128	0	1389.79	956.405	1100.25	0	0
9	MVC(Max)	0	81.2225	1339.68	0	0	1119.02	0
10	MVC(Max)	13.5732	93.1972	1321.89	0	0	0	0
11	MVC(Max)	0	81.2225	249.799	0	0	1119.02	0
12	MVC(Max)	698.873	93.1972	243.76	0	0	0	0
1	MVC(Min)	-104.35	-188.81	-78.313	0	-573.91	0	0
2	MVC(Min)	-194.67	-194.9	-123.64	0	-1049.3	-56.651	0
9	MVC(Min)	0	0	-8.041	-48.065	0	-4E-06	0
10	MVC(Min)	-701.37	0	-17.898	-48.398	0	-75.329	0
11	MVC(Min)	0	0	-739.93	-48.065	0	-4E-06	0
12	MVC(Min)	-63.132	0	-777.28	-48.398	0	-75.329	0
1	MVC(All)	123.328	-188.81	1423.91	946.438	678.305	46.7153	0
2	MVC(All)	204.128	-194.9	1389.79	956.405	1100.25	-56.651	0
9	MVC(All)	0	81.2225	1339.68	-48.065	0	1119.02	0

10	MVC(All)	-701.37	93.1972	1321.89	-48.398	0	-75.329	0
11	MVC(All)	0	81.2225	-739.93	-48.065	0	1119.02	0
12	MVC(All)	698.873	93.1972	-777.28	-48.398	0	-75.329	0

Combined Reaction Rorce								
	Load	FX (kN)	FY (kN)	FZ (kN)				
	SW	2E-06	0	9094.03				
	CB	0	0	629				
	MVC(All)	N/A	N/A	N/A				
	MVC(Max)	N/A	N/A	N/A				
	MVC(Min)	N/A	N/A	N/A				

6.4 Calculating the Impact Factor and Total Impact

When a vehicle moves on a bridge it creates some impacts on the support. As the vehicles moves and changes its position time to time so the impact changes on each support at the same time due to the location of the vehicle. For calculating the impact of the vehicle one support has to be considered for drawing the influence line. And then according to this influence line the impact on other supports at the same time has to be calculated. This process should be repeated for the critical supports (4L, 7L).

Table 18 Finding the position for pk and qk when the influence line is taken

on Support 4L Before Strengthening

	f	**Impact Factor**	当 $1.5\text{Hz} \leqslant f \leqslant 14\text{Hz}$ 时，$\mu = 0.1767\ln f - 0.0157$				
	4.52	**1.2507**					
				Positions			**MIN**
Elements		**Distance**	**Influence**	**qk**	**pk**		-1.398386
7		0	-0.241982	1	0	-1.03682	
7		0.2	-0.245249	1	0	-1.041861	
7		0.4	-0.248516	1	0	-1.046903	
8		0.4	-0.248516	1	0	-1.046903	
8		2.2	-0.277866	1	0	-1.092171	
8		4	-0.306882	1	0	-1.136771	
9		4	-0.306882	1	0	-1.136771	
9		6	-0.338322	1	0	-1.184727	
9		8	-0.368478	1	0	-1.230114	
10		8	-0.368478	1	0	-1.230114	
10		10	-0.396888	1	0	-1.27201	
10		12	-0.423098	1	0	-1.309505	
11		12	-0.423098	1	0	-1.309505	
11		14	-0.446641	1	0	-1.341664	
11		16	-0.46707	1	0	-1.367598	
12		16	-0.46707	1	0	-1.367598	

12		18	-0.483896	1	0	-1.38631	
12		20	-0.496713	1	0	-1.397025	
13		20	-0.496713	1	0	-1.397025	
13		22	-0.504901	1	111	-1.398386	
13		24	-0.508302	1	0	-1.390296	
14		24	-0.508302	1	0	-1.390296	
14		25.875	-0.505404	1	0	-1.369896	
14		27.75	-0.498822	1	0	-1.342252	
15		27.75	-0.498822	1	0	-1.342252	
15		29.625	-0.488598	1	0	-1.307226	
15		31.5	-0.475232	1	0	-1.265939	
16		31.5	-0.475232	1	0	-1.265939	
16		33.375	-0.459015	1	0	-1.218933	
16		35.25	-0.440316	1	0	-1.166967	
17		35.25	-0.440316	1	0	-1.166967	
17		37.125	-0.419468	1	0	-1.110699	
17		39	-0.396815	1	0	-1.050823	
18		39	-0.396815	1	0	-1.050823	
18		40.875	-0.3727	1	0	-0.988023	
18		42.75	-0.347462	1	0	-0.922975	
19		42.75	-0.347462	1	0	-0.922975	
19		44.625	-0.321452	1	0	-0.85639	
19		46.5	-0.294991	1	0	-0.788895	
20		46.5	-0.294991	1	0	-0.788895	
20		48.375	-0.268487	1	0	-0.721353	
20		50.25	-0.242157	1	0	-0.654108	
21		50.25	-0.242157	1	0	-0.654108	
21		52.125	-0.216727	1	0	-0.588895	
21		54	-0.191819	1	0	-0.52443	
22		54	-0.191819	1	0	-0.52443	
22		56	-0.169084	1	0	-0.464975	
22		58	-0.146996	1	0	-0.406519	
23		58	-0.146996	1	0	-0.406519	
23		60	-0.126194	1	0	-0.350866	
23		62	-0.106208	1	0	-0.296795	
24		62	-0.106208	1	0	-0.296795	
24		64	-0.087081	1	0	-0.244481	
24		66	-0.068663	1	0	-0.193576	
25		66	-0.068663	1	0	-0.193576	
25		68	-0.050892	1	0	-0.143972	
25		70	-0.033674	1	0	-0.095473	
26		70	-0.033674	1	0	-0.095473	
26		71.8	-0.018586	1	0	-0.052641	
26		73.6	-0.00382	1	0	-0.010453	
27		73.6	-0.00382	1	0	-0.010453	
27		73.8	-0.002197	1	0	-0.0058	
27		74	-0.000576	1	0	-0.001153	
7		0	-0.794838	1	0	-1.03682	
7		0.2	-0.796612	1	0	-1.041861	

7		0.4	-0.798387	1	0	-1.046903	
8		0.4	-0.798387	1	0	-1.046903	
8		2.2	-0.814305	1	0	-1.092171	
8		4	-0.829889	1	0	-1.136771	
9		4	-0.829889	1	0	-1.136771	
9		6	-0.846405	1	0	-1.184727	
9		8	-0.861636	1	0	-1.230114	
10		8	-0.861636	1	0	-1.230114	
10		10	-0.875122	1	0	-1.27201	
10		12	-0.886407	1	0	-1.309505	
11		12	-0.886407	1	0	-1.309505	
11		14	-0.895023	1	0	-1.341664	
11		16	-0.900528	1	0	-1.367598	
12		16	-0.900528	1	0	-1.367598	
12		18	-0.902414	1	0	-1.38631	
12		20	-0.900312	1	0	-1.397025	
13		20	-0.900312	1	0	-1.397025	
13		22	-0.893485	1	111	-1.398386	
13		24	-0.881994	1	0	-1.390296	
14		24	-0.881994	1	0	-1.390296	
14		25.875	-0.864492	1	0	-1.369896	
14		27.75	-0.84343	1	0	-1.342252	
15		27.75	-0.84343	1	0	-1.342252	
15		29.625	-0.818628	1	0	-1.307226	
15		31.5	-0.790707	1	0	-1.265939	
16		31.5	-0.790707	1	0	-1.265939	
16		33.375	-0.759918	1	0	-1.218933	
16		35.25	-0.726651	1	0	-1.166967	
17		35.25	-0.726651	1	0	-1.166967	
17		37.125	-0.691231	1	0	-1.110699	
17		39	-0.654008	1	0	-1.050823	
18		39	-0.654008	1	0	-1.050823	
18		40.875	-0.615323	1	0	-0.988023	
18		42.75	-0.575513	1	0	-0.922975	
19		42.75	-0.575513	1	0	-0.922975	
19		44.625	-0.534938	1	0	-0.85639	
19		46.5	-0.493904	1	0	-0.788895	
20		46.5	-0.493904	1	0	-0.788895	
20		48.375	-0.452866	1	0	-0.721353	
20		50.25	-0.411951	1	0	-0.654108	
21		50.25	-0.411951	1	0	-0.654108	
21		52.125	-0.372168	1	0	-0.588895	
21		54	-0.332611	1	0	-0.52443	
22		54	-0.332611	1	0	-0.52443	
22		56	-0.295891	1	0	-0.464975	
22		58	-0.259523	1	0	-0.406519	
23		58	-0.259523	1	0	-0.406519	
23		60	-0.224672	1	0	-0.350866	
23		62	-0.190587	1	0	-0.296795	

24		62	-0.190587	1	0	-0.296795	
24		64	-0.1574	1	0	-0.244481	
24		66	-0.124913	1	0	-0.193576	
25		66	-0.124913	1	0	-0.193576	
25		68	-0.09308	1	0	-0.143972	
25		70	-0.061799	1	0	-0.095473	
26		70	-0.061799	1	0	-0.095473	
26		71.8	-0.034055	1	0	-0.052641	
26		73.6	-0.006633	1	0	-0.010453	
27		73.6	-0.006633	1	0	-0.010453	
27		73.8	-0.003603	1	0	-0.0058	**Min**
27		74	-0.000577	1	0	-0.001153	-0.182489
7		0	0.710159	0	0	0.867462	
7		0.2	0.704322	0	0	0.85728	
7		0.4	0.698484	0	0	0.847097	
8		0.4	0.698484	0	0	0.847097	
8		2.2	0.646001	0	0	0.755563	
8		4	0.593853	0	0	0.664699	
9		4	0.593853	0	0	0.664699	
9		6	0.536709	0	0	0.565336	
9		8	0.48085	0	0	0.468542	
10		8	0.48085	0	0	0.468542	
10		10	0.426735	0	0	0.375237	
10		12	0.374823	0	0	0.286337	
11		12	0.374823	0	0	0.286337	
11		14	0.325571	0	0	0.202761	
11		16	0.279441	0	0	0.125424	
12		16	0.279441	0	0	0.125424	
12		18	0.236885	0	0	0.055252	
12		20	0.198374	1	0	-0.006851	
13		20	0.198374	1	0	-0.006851	
13		22	0.164326	1	0	-0.059932	
13		24	0.135278	1	0	-0.103135	
14		24	0.135278	1	0	-0.103135	
14		25.875	0.113025	1	0	-0.133038	
14		27.75	0.094669	1	0	-0.15527	
15		27.75	0.094669	1	0	-0.15527	
15		29.625	0.079789	1	0	-0.170453	
15		31.5	0.068087	1	0	-0.179302	
16		31.5	0.068087	1	0	-0.179302	
16		33.375	0.059207	1	111	-0.182489	
16		35.25	0.052816	1	0	-0.180703	
17		35.25	0.052816	1	0	-0.180703	
17		37.125	0.048569	1	0	-0.174625	
17		39	0.046128	1	0	-0.164937	
18		39	0.046128	1	0	-0.164937	
18		40.875	0.045149	1	0	-0.152324	
18		42.75	0.045292	1	0	-0.137466	
19		42.75	0.045292	1	0	-0.137466	

19		44.625	0.046218	1	0	-0.12105	
19		46.5	0.04758	1	0	-0.103752	
20		46.5	0.04758	1	0	-0.103752	
20		48.375	0.049054	1	0	-0.08627	
20		50.25	0.050267	1	0	-0.069261	
21		50.25	0.050267	1	0	-0.069261	
21		52.125	0.050978	1	0	-0.053486	
21		54	0.050655	1	0	-0.039482	
22		54	0.050655	1	0	-0.039482	
22		56	0.049307	1	0	-0.028193	
22		58	0.046801	1	0	-0.018926	
23		58	0.046801	1	0	-0.018926	
23		60	0.043408	1	0	-0.011662	
23		62	0.03911	1	0	-0.006158	
24		62	0.03911	1	0	-0.006158	
24		64	0.034023	1	0	-0.002272	
24		66	0.028212	0	0	0.000174	
25		66	0.028212	0	0	0.000174	
25		68	0.021766	0	0	0.001343	
25		70	0.014763	0	0	0.001401	
26		70	0.014763	0	0	0.001401	
26		71.8	0.008054	0	0	0.00064	
26		73.6	0.001024	1	0	-0.000765	
27		73.6	0.001024	1	0	-0.000765	
27		73.8	0.000225	1	0	-0.000956	
27		74	-0.000576	1	0	-0.001152	
7		0	0.157303	0	0	0.867462	
7		0.2	0.152958	0	0	0.85728	
7		0.4	0.148613	0	0	0.847097	
8		0.4	0.148613	0	0	0.847097	
8		2.2	0.109562	0	0	0.755563	
8		4	0.070846	0	0	0.664699	
9		4	0.070846	0	0	0.664699	
9		6	0.028627	0	0	0.565336	
9		8	-0.012308	0	0	0.468542	
10		8	-0.012308	0	0	0.468542	
10		10	-0.051498	0	0	0.375237	
10		12	-0.088486	0	0	0.286337	
11		12	-0.088486	0	0	0.286337	
11		14	-0.12281	0	0	0.202761	
11		16	-0.154017	0	0	0.125424	
12		16	-0.154017	0	0	0.125424	
12		18	-0.181633	0	0	0.055252	
12		20	-0.205225	1	0	-0.006851	
13		20	-0.205225	1	0	-0.006851	
13		22	-0.224258	1	0	-0.059932	
13		24	-0.238413	1	0	-0.103135	
14		24	-0.238413	1	0	-0.103135	
14		25.875	-0.246063	1	0	-0.133038	

14		27.75	-0.249939	1	0	-0.15527	
15		27.75	-0.249939	1	0	-0.15527	
15		29.625	-0.250242	1	0	-0.170453	
15		31.5	-0.247389	1	0	-0.179302	
16		31.5	-0.247389	1	0	-0.179302	
16		33.375	-0.241696	1	111	-0.182489	
16		35.25	-0.233519	1	0	-0.180703	
17		35.25	-0.233519	1	0	-0.180703	
17		37.125	-0.223194	1	0	-0.174625	
17		39	-0.211065	1	0	-0.164937	
18		39	-0.211065	1	0	-0.164937	
18		40.875	-0.197473	1	0	-0.152324	
18		42.75	-0.182758	1	0	-0.137466	
19		42.75	-0.182758	1	0	-0.137466	
19		44.625	-0.167268	1	0	-0.12105	
19		46.5	-0.151332	1	0	-0.103752	
20		46.5	-0.151332	1	0	-0.103752	
20		48.375	-0.135324	1	0	-0.08627	
20		50.25	-0.119528	1	0	-0.069261	
21		50.25	-0.119528	1	0	-0.069261	
21		52.125	-0.104464	1	0	-0.053486	
21		54	-0.090137	1	0	-0.039482	
22		54	-0.090137	1	0	-0.039482	
22		56	-0.0775	1	0	-0.028193	
22		58	-0.065727	1	0	-0.018926	
23		58	-0.065727	1	0	-0.018926	
23		60	-0.05507	1	0	-0.011662	
23		62	-0.045268	1	0	-0.006158	
24		62	-0.045268	1	0	-0.006158	
24		64	-0.036295	1	0	-0.002272	
24		66	-0.028038	0	0	0.000174	
25		66	-0.028038	0	0	0.000174	
25		68	-0.020423	0	0	0.001343	
25		70	-0.013362	0	0	0.001401	
26		70	-0.013362	0	0	0.001401	
26		71.8	-0.007414	0	0	0.00064	
26		73.6	-0.001789	1	0	-0.000765	
27		73.6	-0.001789	1	0	-0.000765	
27		73.8	-0.001181	1	0	-0.000956	
27		74	-0.000576	1	0	-0.001152	

After finding the positions of placing pk and qk, the impact of these loads on the other influence lines have to be calculated.

Table 19 Calculating Total Impact on Support 5

Total Impact		**925.8978**
94.294644		677.2868462
Influence on Bearing 5	**Duplicate Value Reduction**	**Impact**
-0.024715	1	0
-0.012206	1	-0.0242429287
0.000305	1	-0.0078143900
0.000305	0	0.0000000000
0.112693	1	0.6677669122
0.223808	1	1.9885682375
0.223808	0	0.0000000000
0.344228	1	3.7298167097
0.459758	1	5.2791027632
0.459758	0	0.0000000000
0.568652	1	6.7527072271
0.669164	1	8.1277010619
0.669164	0	0.0000000000
0.759547	1	9.3811486617
0.838055	1	10.4901144208
0.838055	0	0.0000000000
0.902942	1	11.4316692995
0.952462	1	12.1828842582
0.952462	0	0.0000000000
0.984867	1	12.7208171251
0.998413	1	13.0225388604
0.998413	0	0.0000000000
0.989536	1	12.2373715062
0.964294	1	12.0273425375
0.964294	0	0.0000000000
0.924667	1	11.6280234140
0.872636	1	11.0637971700
0.872636	0	0.0000000000
0.81018	1	10.3590406840
0.73928	1	9.5381308344
0.73928	0	0.0000000000
0.661916	1	8.6254506554
0.580069	1	7.6453831814
0.580069	0	0.0000000000
0.495717	1	6.6222991350
0.410842	1	5.5805753947
0.410842	0	0.0000000000
0.327424	1	4.5446011504
0.247443	1	3.5387532807
0.247443	0	0.0000000000
0.172878	1	2.5874025082
0.105711	1	1.7149318672
0.105711	0	0.0000000000

0.04792	1	0.9457182362
0.001488	1	0.3041446493
0.001488	0	0.0000000000
-0.031571	1	-0.1975298680
-0.053088	1	-0.5558847552
-0.053088	0	0.0000000000
-0.064629	1	-0.7729489568
-0.067758	1	-0.8692745614
-0.067758	0	0.0000000000
-0.064042	1	-0.8654202240
-0.055047	1	-0.7819577318
-0.055047	0	0.0000000000
-0.042337	1	-0.6394391737
-0.027479	1	-0.4584232045
-0.027479	0	0.0000000000
-0.013564	1	-0.2425455086
-0.000318	1	-0.0820363217
-0.000318	0	0.0000000000
0.001063	1	0.0004891791
0.002419	1	0.0022863378
-0.024715	1	5.4167689272
-0.012206	1	-0.0242429287
0.000305	1	-0.0078143900
0.000305	0	0.0000000000
0.112693	1	0.6677669122
0.223808	1	1.9885682375
0.223808	0	0.0000000000
0.344228	1	3.7298167097
0.459758	1	5.2791027632
0.459758	0	0.0000000000
0.568652	1	6.7527072271
0.669164	1	8.1277010619
0.669164	0	0.0000000000
0.759547	1	9.3811486617
0.838055	1	10.4901144208
0.838055	0	0.0000000000
0.902942	1	11.4316692995
0.952462	1	12.1828842582
0.952462	0	0.0000000000
0.984867	1	12.7208171251
0.998413	1	13.0225388604
0.998413	0	0.0000000000
0.989536	1	12.2373715062
0.964294	1	12.0273425375
0.964294	0	0.0000000000
0.924667	1	11.6280234140
0.872636	1	11.0637971700
0.872636	0	0.0000000000
0.81018	1	10.3590406840

0.73928	1	9.5381308344
0.73928	0	0.0000000000
0.661916	1	8.6254506554
0.580069	1	7.6453831814
0.580069	0	0.0000000000
0.495717	1	6.6222991350
0.410842	1	5.5805753947
0.410842	0	0.0000000000
0.327424	1	4.5446011504
0.247443	1	3.5387532807
0.247443	0	0.0000000000
0.172878	1	2.5874025082
0.105711	1	1.7149318672
0.105711	0	0.0000000000
0.04792	1	0.9457182362
0.001488	1	0.3041446493
0.001488	0	0.0000000000
-0.031571	1	-0.1975298680
-0.053088	1	-0.5558847552
-0.053088	0	0.0000000000
-0.064629	1	-0.7729489568
-0.067758	1	-0.8692745614
-0.067758	0	0.0000000000
-0.064042	1	-0.8654202240
-0.055047	1	-0.7819577318
-0.055047	0	0.0000000000
-0.042337	1	-0.6394391737
-0.027479	1	-0.4584232045
-0.027479	0	0.0000000000
-0.013564	1	-0.2425455086
-0.000318	1	-0.0820363217
-0.000318	0	0.0000000000
0.001063	1	0.0004891791
0.002419	1	0.0022863378
-0.024715	1	-0.5876912466
-0.012206	1	0.0000000000
0.000305	1	0.0000000000
0.000305	0	0.0000000000
0.112693	1	0.0000000000
0.223808	1	0.0000000000
0.223808	0	0.0000000000
0.344228	1	0.0000000000
0.459758	1	0.0000000000
0.459758	0	0.0000000000
0.568652	1	0.0000000000
0.669164	1	0.0000000000
0.669164	0	0.0000000000
0.759547	1	0.0000000000
0.838055	1	0.0000000000

0.838055	0	0.0000000000
0.902942	1	0.0000000000
0.952462	1	6.2540203138
0.952462	0	0.0000000000
0.984867	1	12.7208171251
0.998413	1	13.0225388604
0.998413	0	0.0000000000
0.989536	1	12.2373715062
0.964294	1	12.0273425375
0.964294	0	0.0000000000
0.924667	1	11.6280234140
0.872636	1	11.0637971700
0.872636	0	0.0000000000
0.81018	1	10.3590406840
0.73928	1	9.5381308344
0.73928	0	0.0000000000
0.661916	1	8.6254506554
0.580069	1	7.6453831814
0.580069	0	0.0000000000
0.495717	1	6.6222991350
0.410842	1	5.5805753947
0.410842	0	0.0000000000
0.327424	1	4.5446011504
0.247443	1	3.5387532807
0.247443	0	0.0000000000
0.172878	1	2.5874025082
0.105711	1	1.7149318672
0.105711	0	0.0000000000
0.04792	1	0.9457182362
0.001488	1	0.3041446493
0.001488	0	0.0000000000
-0.031571	1	-0.1975298680
-0.053088	1	-0.5558847552
-0.053088	0	0.0000000000
-0.064629	1	-0.7729489568
-0.067758	1	-0.8692745614
-0.067758	0	0.0000000000
-0.064042	1	-0.8654202240
-0.055047	1	-0.4205101820
-0.055047	0	0.0000000000
-0.042337	1	0.0000000000
-0.027479	1	0.0000000000
-0.027479	0	0.0000000000
-0.013564	1	0.0000000000
-0.000318	1	-0.0018792357
-0.000318	0	0.0000000000
0.001063	1	0.0004891791
0.002419	1	0.0022863378
-0.024715	1	-0.5876912466

-0.012206	1	0.0000000000
0.000305	1	0.0000000000
0.000305	0	0.0000000000
0.112693	1	0.0000000000
0.223808	1	0.0000000000
0.223808	0	0.0000000000
0.344228	1	0.0000000000
0.459758	1	0.0000000000
0.459758	0	0.0000000000
0.568652	1	0.0000000000
0.669164	1	0.0000000000
0.669164	0	0.0000000000
0.759547	1	0.0000000000
0.838055	1	0.0000000000
0.838055	0	0.0000000000
0.902942	1	0.0000000000
0.952462	1	6.2540203138
0.952462	0	0.0000000000
0.984867	1	12.7208171251
0.998413	1	13.0225388604
0.998413	0	0.0000000000
0.989536	1	12.2373715062
0.964294	1	12.0273425375
0.964294	0	0.0000000000
0.924667	1	11.6280234140
0.872636	1	11.0637971700
0.872636	0	0.0000000000
0.81018	1	10.3590406840
0.73928	1	9.5381308344
0.73928	0	0.0000000000
0.661916	1	8.6254506554
0.580069	1	7.6453831814
0.580069	0	0.0000000000
0.495717	1	6.6222991350
0.410842	1	5.5805753947
0.410842	0	0.0000000000
0.327424	1	4.5446011504
0.247443	1	3.5387532807
0.247443	0	0.0000000000
0.172878	1	2.5874025082
0.105711	1	1.7149318672
0.105711	0	0.0000000000
0.04792	1	0.9457182362
0.001488	1	0.3041446493
0.001488	0	0.0000000000
-0.031571	1	-0.1975298680
-0.053088	1	-0.5558847552
-0.053088	0	0.0000000000
-0.064629	1	-0.7729489568

-0.067758	1	-0.8692745614
-0.067758	0	0.0000000000
-0.064042	1	-0.8654202240
-0.055047	1	-0.4205101820
-0.055047	0	0.0000000000
-0.042337	1	0.0000000000
-0.027479	1	0.0000000000
-0.027479	0	0.0000000000
-0.013564	1	0.0000000000
-0.000318	1	-0.0018792357
-0.000318	0	0.0000000000
0.001063	1	0.0004891791
0.002419	1	0.0022863378

The impact on the other supports have been calculated in the same way and all the results have been filled into the table for calculating the coefficient.

6.5 Calculation of the Coefficient Before Strengthening

First the influence line due to the live load has been considered at bearing 4L and 7L as these two bearings will act critically when overturning phenomenon will occur. And the positions for placing qk and pk has been found by calculating the impact factor in “Microsoft Excel” software. While placing the pk and qk on the influence line of bearing 4L the impact of these loads on the other influence lines of rest of the bearings have been calculated and then the data has been filled to the calculation table for calculating the overturning coefficient and same process has been done for bearing 7L.

Table 20 The Calculation of Overturning Coefficient Before Strengthening

Project			Support Bearings					
			4L	4R	5	6	7L	7R
Distance from the corresponsing bearing, li (m)			0	3.15	0	0	0	3.15
Support Vertical Force in KN	R(Gki)(Dead Load Standard Value Effect)		942.8949	164.8371	3688.1779	3330.8109	824.4716	44.4744
	Standard Value Effects of Failed Supports Corresponding to the Most Unfavorable Vehicle Loads	R4L	-383.8529	255.0534	925.8978	971.4666	-529.8058	-190.9690
		R7L	-574.1583	12.0912	1101.8647	847.2167	-343.4267	-134.4748
1st verification	1.0 R(Gki)+1.4 R(Qki,4L)		405.5008	521.9119	4984.4348	4690.8641	82.7435	-222.8822
	1.0 R(Gki)+1.4 R(Qki,7L)		139.0733	181.7648	5230.7885	4516.9143	343.6742	-143.7903
			Does not meet the requirements					
	∑R（Gki）li(kN.m)		0	519.2369	0	0	0	140.0944
2nd verification	Destabilization Effect	∑ R(Qki,4L)li	0	803.4182	0	0	0	601.5524
		∑ R(Qki,7L)li	0	38.08728	0	0	0	423.5956
	Stability Factor	∑R（Gki）li/∑ R(Qki,4L)li		0.4693				
		∑R（Gki）li/∑ R(Qki,7L)li		1.428				
	Checking Result		Does not meet the requirements					

According to the calculation the evaluation of the bridge can done using two verification methods. After calculating the overturning coefficient, if the value is much less than 2.5 then the bridge or structure will be considered having overturning instability. On the other hand, if the calculated value of overturning coefficient is greater than or equal 0, the bridge should be safe.

In this case according to the table the value of overturning coefficient calculated which is very smaller than 2.5. So, it is very easy to make the statement that the bridge is having significant amount of overturning instability and requires immediate treatment to mitigate the risks.

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7. Structural Analysis After Strengthening

After finishing the analysis of the existing bridge another model has been designed which includes the scheme for strengthening the bridge. This second model then analyzed and the result has been described in this chapter. Due to apply the strengthening scheme some changes have been done in nodes, supports and so on. So, only the items which has been modified have been given in this chapter and for the unchanged items such as the data about elements can be found in the previous chapter.

7.1 Beam Forces

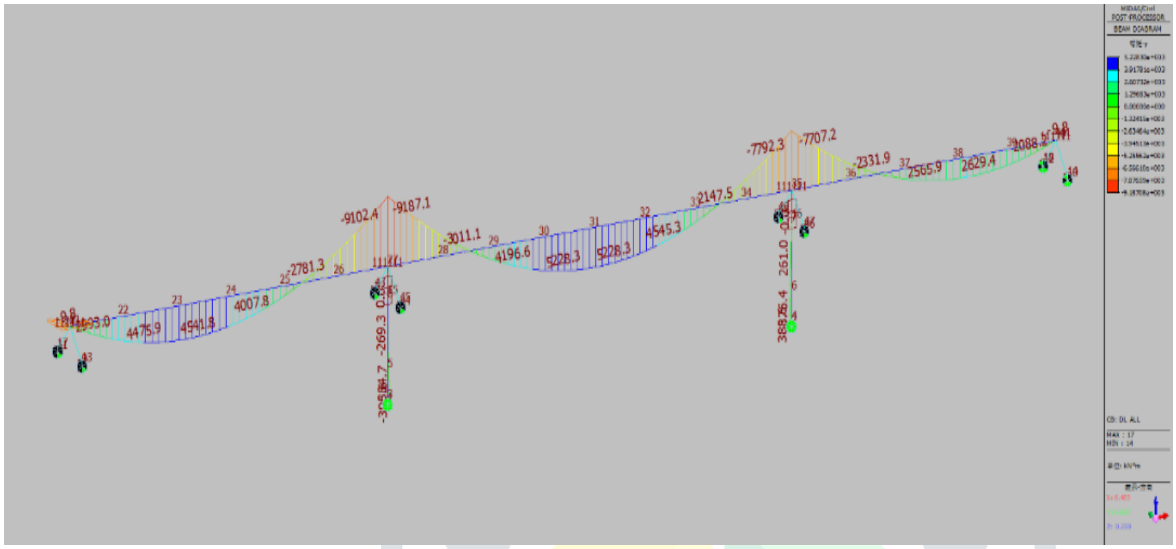


Figure 57 Bending Moment Diagram Due to DL After Strengthening

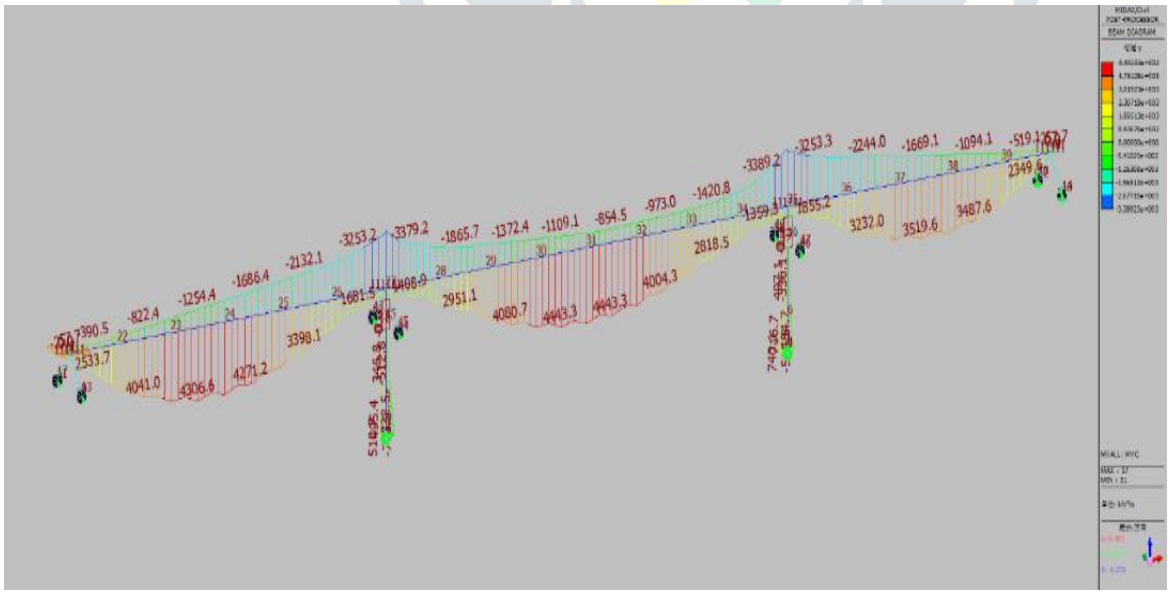


Figure 58 Bending Moment Diagram Due to Live Load After Strengthening

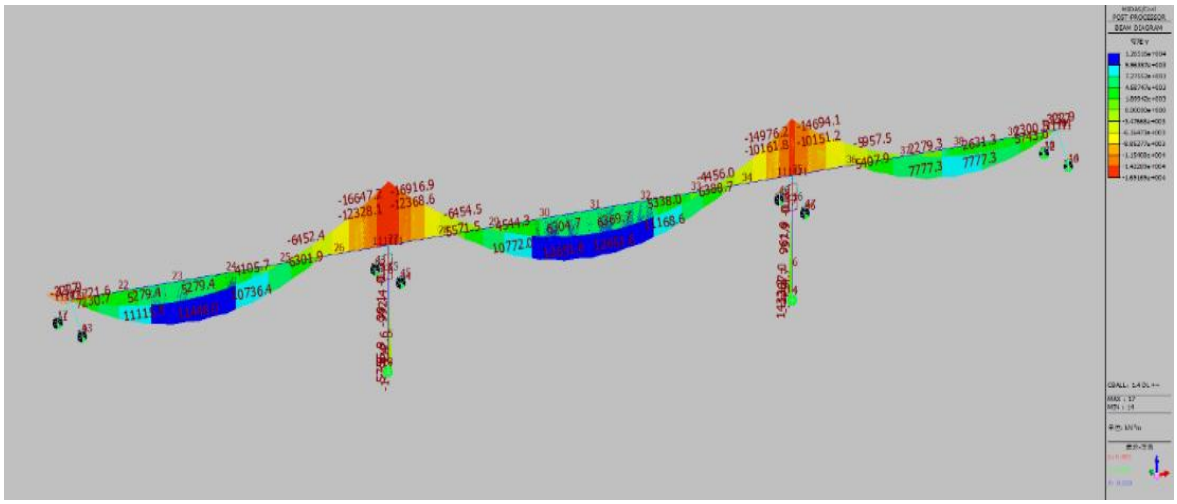


Figure 59 Bending Moment Diagram Due to The Load Combination After Strengthening

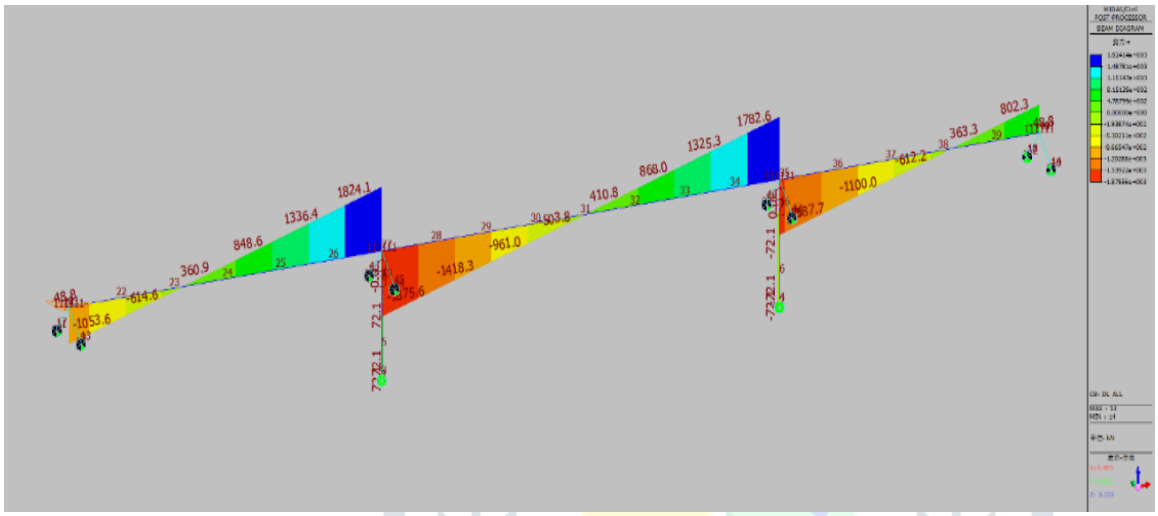


Figure 60 Share Force Diagram Due to Dead Load After Strengthening

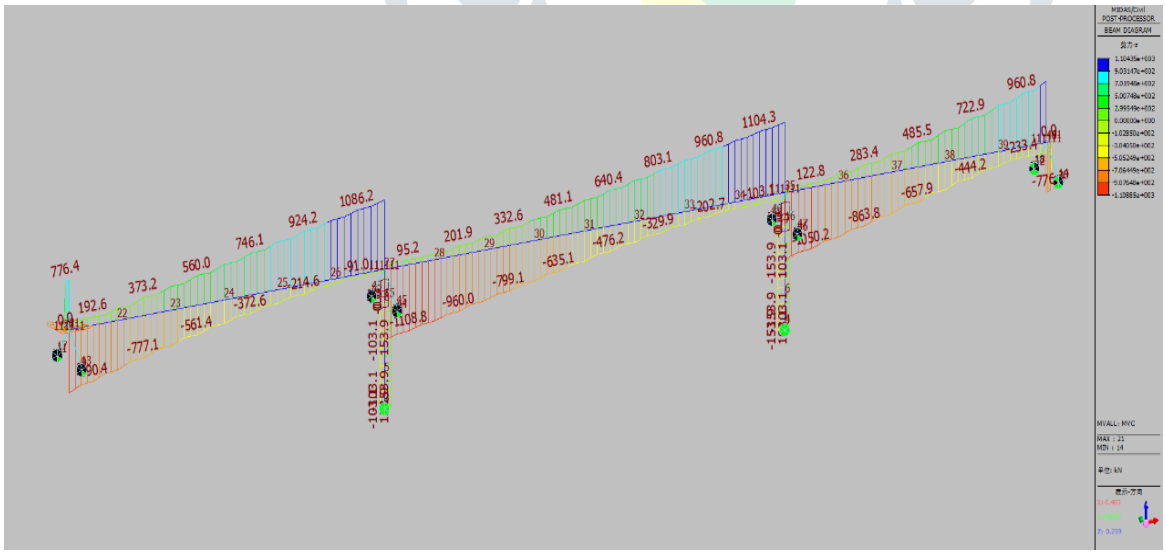


Figure 61 Share Force Diagram Due to Live Load After Strengthening

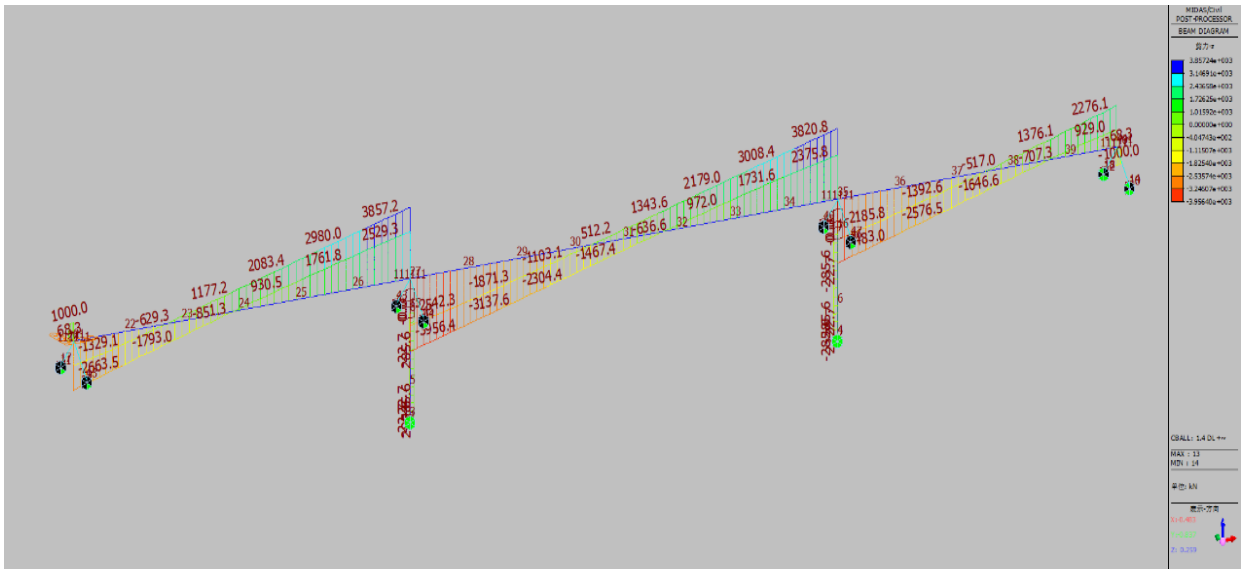


Figure 62 Share Force Diagram Due to the Load Combination After Strengthening

The bending moment diagrams and the share force diagrams look like normal, so no abnormal behavior can be noticed.

7.2 Displacement

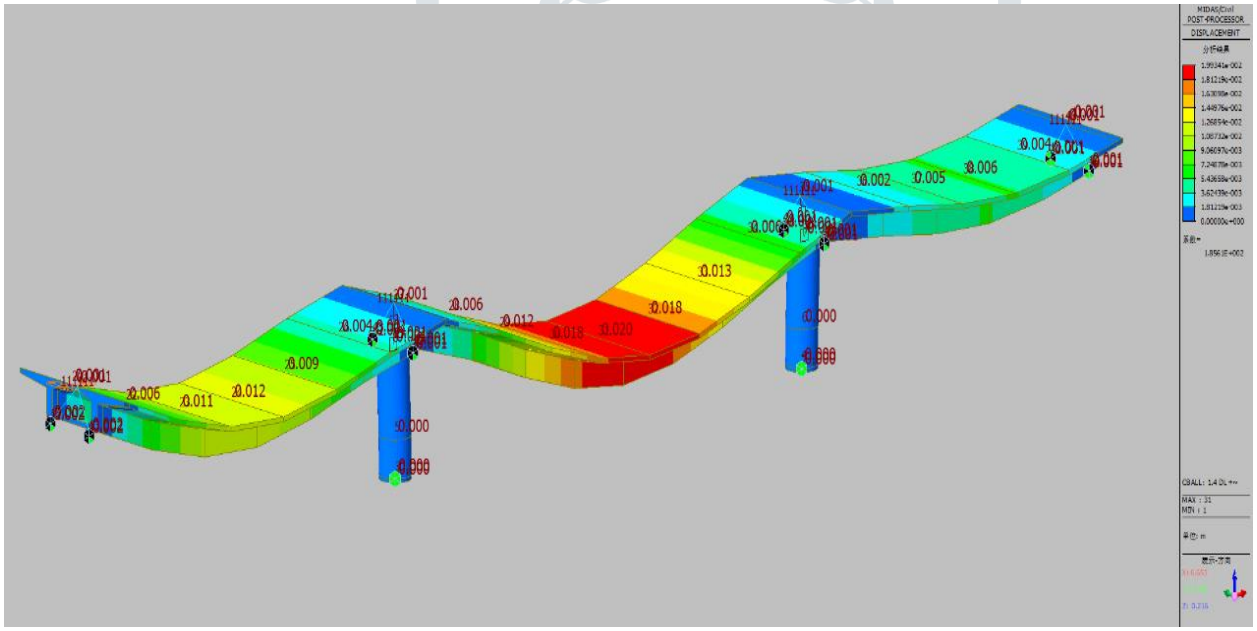


Figure 63 Displacement Due to the Load Combination After Strengthening

7.3 Reaction Forces

These reactions forces have been considered carefully to calculate the coefficient of overturning instability of the bridge as like the previous calculation.

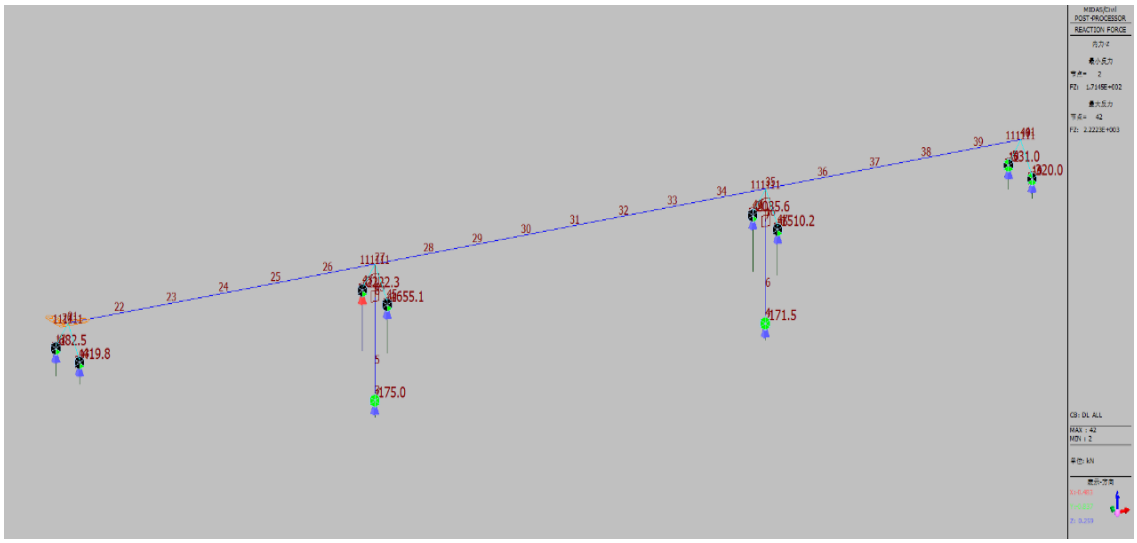


Figure 64 Reaction Forces Due to DL After Strengthening

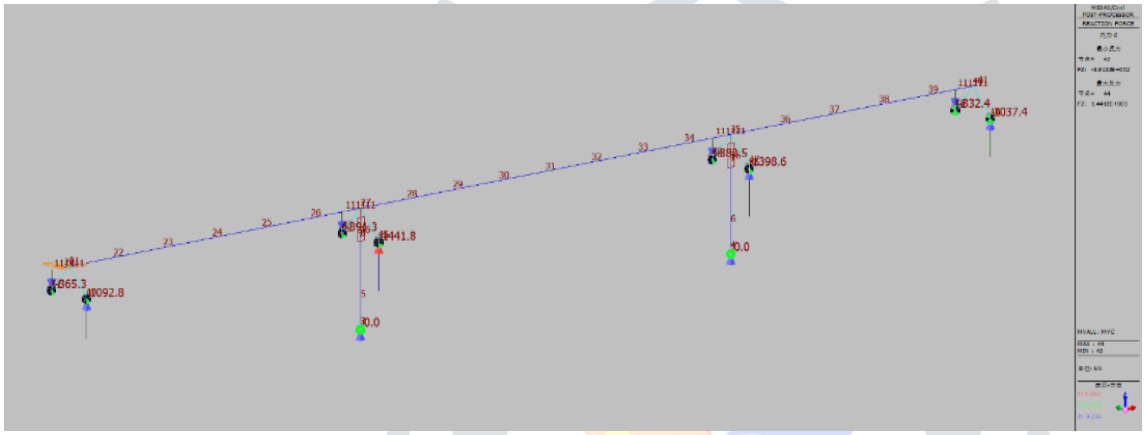


Figure 65 Reaction Forces Due to Live load After Strengthening

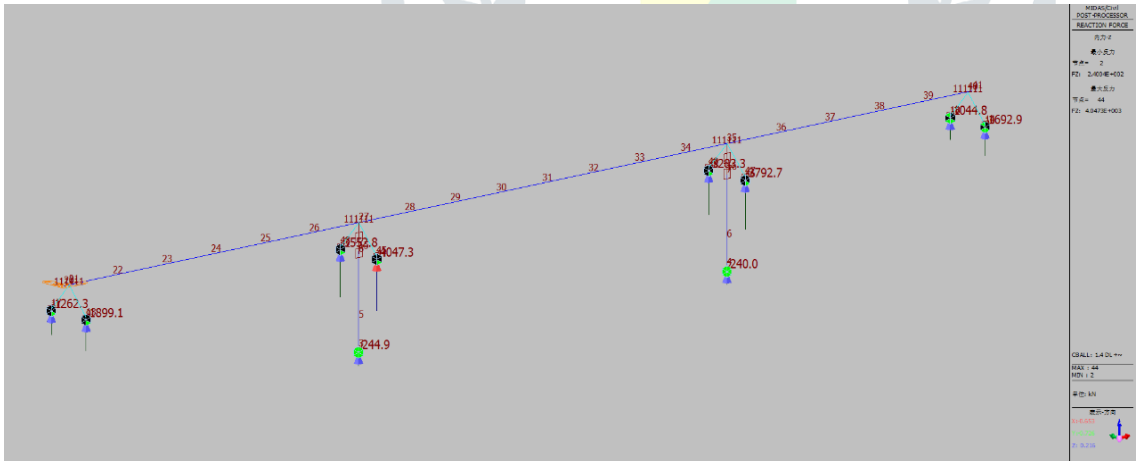


Figure 66 Reaction Forces Due to the Load Combination After Strengthening

Table 21 Table of Reaction Forces After Strengthening

Node	Load	FX (kN)	FY (kN)	FZ (kN)	MX (kN*m)	MY (kN*m)	MZ (kN*m)	Mb (kN*m^2)
1	SW	67.0752	0	174.953	0	368.913	0	0
2	SW	-67.075	0	171.454	0	-361.54	0	0
9	SW	0	0	512.756	0	0	0	0
10	SW	0	0	395.856	0	0	0	0
11	SW	0	0	512.756	0	0	0	0
12	SW	0	0	395.856	0	0	0	0
42	SW	0	0	1809.76	0	0	0	0
44	SW	0	0	1809.76	0	0	0	0
46	SW	0	0	1655.44	0	0	0	0
48	SW	0	0	1655.44	0	0	0	0
1	CB	5.02602	0	0.00015	0	27.6431	0	0
2	CB	-5.026	0	0.00014	0	-27.09	0	0
9	CB	0	0	-92.918	0	0	0	0
10	CB	0	0	-75.837	5.581973	0	0	0
11	CB	0	0	169.76	0	0	0	0
12	CB	0	0	135.161	5.581973	0	0	0
42	CB	0	0	412.589	0	0	0	0
44	CB	0	0	-154.69	0	0	0	0
46	CB	0	0	-145.2	0	0	0	0
48	CB	0	0	380.138	0	0	0	0
1	MVC(Max)	137.308	1E-06	0.00082	0.000005	755.192	3E-06	0
2	MVC(Max)	92.8505	1E-06	0.00084	0.000005	500.464	2E-06	0
9	MVC(Max)	0	0	1092.79	0	0	0	0
10	MVC(Max)	0	0	1037.41	0.2683	0	1.1E-05	0
11	MVC(Max)	0	0	255.677	0	0	0	0
12	MVC(Max)	0	0	251.15	0.2683	0	1.1E-05	0
42	MVC(Max)	0	0	367.931	0	0	0	0
44	MVC(Max)	0	0	1441.81	0	0	0	0
46	MVC(Max)	0	0	1398.63	0	0	0	0
48	MVC(Max)	0	0	361.208	0	0	0	0
1								
2	MVC(Min)	-137.31	-1E-06	-8E-05	-0.000005	-740.09	-2E-06	0
9	MVC(Min)	0	0	-64.668	0	0	0	0
10	MVC(Min)	0	0	-85.416	-27.919541	0	-1E-05	0
11	MVC(Min)	0	0	-365.28	0	0	0	0

12	MVC(Min)	0	0	-332.4	-27.919541	0	-1E-05	0
42	MVC(Min)	0	0	-391.33	0	0	0	0
44	MVC(Min)	**0**	**0**	**-45.486**	**0**	**0**	**0**	**0**
46	MVC(Min)	0	0	-67.723	0	0	0	0
48	MVC(Min)	0	0	-382.54	0	0	0	0
1	MVC(All)	137.308	1E-06	0.00082	0.000005	755.192	-3E-06	0
2	MVC(All)	-137.31	-1E-06	0.00084	-0.000005	-740.09	-2E-06	0
9	MVC(All)	0	0	1092.79	0	0	0	0
10	MVC(All)	0	0	1037.41	-27.919541	0	-1E-05	0
11	MVC(All)	0	0	-365.28	0	0	0	0
12	MVC(All)	0	0	-332.4	-27.919541	0	-1E-05	0
42	MVC(All)	0	0	-391.33	0	0	0	0
44	MVC(All)	0	0	1441.81	0	0	0	0
46	MVC(All)	0	0	1398.63	0	0	0	0
48	MVC(All)	0	0	-382.54	0	0	0	0
1	1.4 DL+ LL(all)	265.711	1E-06	244.935	-0.000006	1461.41	3E-06	0
2	1.4 DL+ LL(all)	-265.71	-1E-06	240.037	0.000006	-1432.2	2E-06	0
9	1.4 DL+ LL(all)	0	0	1899.12	0	0	0	0
10	1.4 DL+ LL(all)	0	0	1692.92	-25.688687	0	1.3E-05	0
11	1.4 DL+ LL(all)	0	0	1262.34	0	0	0	0
12	1.4 DL+ LL(all)	0	0	1044.8	-25.688687	0	1.3E-05	0
42	1.4 DL+ LL(all)	0	0	3552.81	0	0	0	0
44	1.4 DL+ LL(all)	0	0	4047.27	0	0	0	0
46	1.4 DL+ LL(all)	0	0	3792.68	0	0	0	0
48	1.4 DL+ LL(all)	0	0	3283.26	0	0	0	0
Combined Reaction Rorce								
	Load	FX (kN)	FY (kN)	FZ (kN)				
	SW	1E-06	0	9094.03				
	CB	0	0	629				
	MVC(all)	N/A	N/A	N/A				
	MVC(Max)	N/A	N/A	N/A				
	MVC(Min)	N/A	N/A	N/A				
	1.4 DL+ LL(all)	N/A	N/A	N/A				

7.4 Calculating the Impact Factor and Total Impact

The previous calculation method is repeated and the value of total impact has been determined by considering the influence lines of the critical supports (4L, 5a, 6a, 7L).

Table 22 Finding the position for pk and qk when the influence line is taken

on Support 4L After Strengthening

	f	Impact Factor	当1.5Hz≤f≤14Hz时，$\mu = 0.1767\ln f - 0.0157$			
	4.516	**1.2507**				
				Positions		MIN
Elements		**Distance**	**Influence**	**qk**	**pk**	-1.032908
7		0	-0.240026	1	111	-1.032908
7		0.2	-0.240008	1	0	-1.028221
7		0.4	-0.239992	1	0	-1.023537
8		0.4	-0.239992	1	0	-1.023537
8		2.2	-0.23974	1	0	-0.981168
8		4	-0.238833	1	0	-0.937489
9		4	-0.238833	1	0	-0.937489
9		6	-0.236273	1	0	-0.885858
9		8	-0.231193	1	0	-0.829179
10		8	-0.231193	1	0	-0.829179
10		10	-0.222759	1	0	-0.765829
10		12	-0.209958	1	0	-0.693698
11		12	-0.209958	1	0	-0.693698
11		14	-0.192255	1	0	-0.611979
11		16	-0.168083	1	0	-0.517044
12		16	-0.168083	1	0	-0.517044
12		18	-0.138634	1	0	-0.412816
12		20	-0.099107	1	0	-0.286819
15		27.75	0.005111	0	0	0.013978
15		29.625	0.004073	0	0	0.011139
15		31.5	0.005229	0	0	0.0143
16		31.5	0.005229	0	0	0.0143
16		33.375	0.004671	0	0	0.012774
16		35.25	0.00449	0	0	0.012279
17		35.25	0.00449	0	0	0.012279
17		37.125	0.004015	0	0	0.010979
17		39	0.003604	0	0	0.009855
18		39	0.003604	0	0	0.009855
18		40.875	0.003143	0	0	0.008595
18		42.75	0.002693	0	0	0.007364
19		42.75	0.002693	0	0	0.007364
19		44.625	0.002236	0	0	0.006115
19		46.5	0.001778	0	0	0.004863
20		46.5	0.001778	0	0	0.004863
20		48.375	0.001332	0	0	0.003643
20		50.25	0.00087	0	0	0.002379
23		58	-0.000035	1	0	-0.000096
23		60	-0.000025	1	0	-0.000069
23		62	-0.000032	1	0	-0.000088
24		62	-0.000032	1	0	-0.000088

24		64	-0.000026	1	0	-0.000071	
24		66	-0.000022	1	0	-0.000061	
25		66	-0.000022	1	0	-0.000061	
25		68	-0.000017	1	0	-0.000046	
25		70	-0.000011	1	0	-0.00003	
26		70	-0.000011	1	0	-0.00003	
26		71.8	-0.000006	1	0	-0.000017	
26		73.6	-0.000001	1	0	-0.000003	
27		73.6	-0.000001	1	0	-0.000003	
27		73.8	-0.000001	1	0	-0.000002	
27		74	0	0	0	0	
7		0	-0.792882	1	111	-1.032908	
7		0.2	-0.788213	1	0	-1.028221	
7		0.4	-0.783545	1	0	-1.023537	
8		0.4	-0.783545	1	0	-1.023537	
8		2.2	-0.741428	1	0	-0.981168	
8		4	-0.698656	1	0	-0.937489	
9		4	-0.698656	1	0	-0.937489	
9		6	-0.649585	1	0	-0.885858	
9		8	-0.597986	1	0	-0.829179	
10		8	-0.597986	1	0	-0.829179	
10		10	-0.54307	1	0	-0.765829	
10		12	-0.48374	1	0	-0.693698	
11		12	-0.48374	1	0	-0.693698	
11		14	-0.419724	1	0	-0.611979	
11		16	-0.348961	1	0	-0.517044	
12		16	-0.348961	1	0	-0.517044	
12		18	-0.274182	1	0	-0.412816	
12		20	-0.187712	1	0	-0.286819	
15		27.75	0.008867	0	0	0.013978	
15		29.625	0.007066	0	0	0.011139	
15		31.5	0.009071	0	0	0.0143	
16		31.5	0.009071	0	0	0.0143	
16		33.375	0.008103	0	0	0.012774	
16		35.25	0.007789	0	0	0.012279	
17		35.25	0.007789	0	0	0.012279	
17		37.125	0.006964	0	0	0.010979	
17		39	0.006251	0	0	0.009855	
18		39	0.006251	0	0	0.009855	
18		40.875	0.005452	0	0	0.008595	
18		42.75	0.004671	0	0	0.007364	
19		42.75	0.004671	0	0	0.007364	
19		44.625	0.003879	0	0	0.006115	
19		46.5	0.003085	0	0	0.004863	
20		46.5	0.003085	0	0	0.004863	
20		48.375	0.002311	0	0	0.003643	
20		50.25	0.001509	0	0	0.002379	
23		58	-0.000061	1	0	-0.000096	
23		60	-0.000044	1	0	-0.000069	

23		62	-0.000056	1	0	-0.000088	
24		62	-0.000056	1	0	-0.000088	
24		64	-0.000045	1	0	-0.000071	
24		66	-0.000039	1	0	-0.000061	
25		66	-0.000039	1	0	-0.000061	
25		68	-0.000029	1	0	-0.000046	
25		70	-0.000019	1	0	-0.00003	
26		70	-0.000019	1	0	-0.00003	
26		71.8	-0.000011	1	0	-0.000017	
26		73.6	-0.000002	1	0	-0.000003	
27		73.6	-0.000002	1	0	-0.000003	
27		73.8	-0.000001	1	0	-0.000002	
27		74	0	0	0	0	-0.000008
7		0	0.712115	0	0	0.871374	
7		0.2	0.704121	0	0	0.860038	
7		0.4	0.696126	0	0	0.8487	
8		0.4	0.696126	0	0	0.8487	
8		2.2	0.624279	0	0	0.74687	
8		4	0.553085	0	0	0.646347	
9		4	0.553085	0	0	0.646347	
9		6	0.475543	0	0	0.537773	
9		8	0.400506	0	0	0.434219	
10		8	0.400506	0	0	0.434219	
10		10	0.328889	0	0	0.337466	
10		12	0.261555	0	0	0.249328	
11		12	0.261555	0	0	0.249328	
11		14	0.199496	0	0	0.171524	
11		16	0.143431	0	0	0.105983	
12		16	0.143431	0	0	0.105983	
12		18	0.094809	0	0	0.05407	
12		20	0.05349	0	0	0.018376	
15		27.75	-0.001356	0	0	0.001043	
15		29.625	-0.001081	0	0	0.000831	
15		31.5	-0.001388	0	0	0.001066	
16		31.5	-0.001388	0	0	0.001066	
16		33.375	-0.00124	0	0	0.000952	
16		35.25	-0.001191	0	0	0.000916	
17		35.25	-0.001191	0	0	0.000916	
17		37.125	-0.001065	0	0	0.000819	
17		39	-0.000956	0	0	0.000735	
18		39	-0.000956	0	0	0.000735	
18		40.875	-0.000834	0	0	0.000641	
18		42.75	-0.000715	0	0	0.000549	
19		42.75	-0.000715	0	0	0.000549	
19		44.625	-0.000593	0	0	0.000456	
19		46.5	-0.000472	0	0	0.000363	
20		46.5	-0.000472	0	0	0.000363	
20		48.375	-0.000354	0	0	0.000271	

20		50.25	-0.000231	0	0	0.000177	
23		58	0.000009	1	111	-0.000008	
23		60	0.000007	1	0	-0.000005	
23		62	0.000009	1	0	-0.000006	
24		62	0.000009	1	0	-0.000006	
24		64	0.000007	1	0	-0.000005	
24		66	0.000006	1	0	-0.000004	
25		66	0.000006	1	0	-0.000004	
25		68	0.000004	1	0	-0.000004	
25		70	0.000003	1	0	-0.000002	
26		70	0.000003	1	0	-0.000002	
26		71.8	0.000002	1	0	-0.000001	
26		73.6	0	1	0	-0.000001	
27		73.6	0	1	0	-0.000001	
27		73.8	0	0	0	0	
27		74	0	0	0	0	
7		0	0.159259	0	0	0.871374	
7		0.2	0.155917	0	0	0.860038	
7		0.4	0.152574	0	0	0.8487	
8		0.4	0.152574	0	0	0.8487	
8		2.2	0.122591	0	0	0.74687	
8		4	0.093262	0	0	0.646347	
9		4	0.093262	0	0	0.646347	
9		6	0.06223	0	0	0.537773	
9		8	0.033713	0	0	0.434219	
10		8	0.033713	0	0	0.434219	
10		10	0.008577	0	0	0.337466	
10		12	-0.012227	0	0	0.249328	
11		12	-0.012227	0	0	0.249328	
11		14	-0.027972	0	0	0.171524	
11		16	-0.037448	0	0	0.105983	
12		16	-0.037448	0	0	0.105983	
12		18	-0.040739	0	0	0.05407	
12		20	-0.035114	0	0	0.018376	
15		27.75	0.002399	0	0	0.001043	
15		29.625	0.001912	0	0	0.000831	
15		31.5	0.002454	0	0	0.001066	
16		31.5	0.002454	0	0	0.001066	
16		33.375	0.002192	0	0	0.000952	
16		35.25	0.002107	0	0	0.000916	
17		35.25	0.002107	0	0	0.000916	
17		37.125	0.001884	0	0	0.000819	
17		39	0.001691	0	0	0.000735	
18		39	0.001691	0	0	0.000735	
18		40.875	0.001475	0	0	0.000641	
18		42.75	0.001264	0	0	0.000549	
19		42.75	0.001264	0	0	0.000549	
19		44.625	0.001049	0	0	0.000456	
19		46.5	0.000835	0	0	0.000363	

20		46.5	0.000835	0	0	0.000363	
20		48.375	0.000625	0	0	0.000271	
20		50.25	0.000408	0	0	0.000177	
23		58	-0.000017	1	111	-0.000008	
23		60	-0.000012	1	0	-0.000005	
23		62	-0.000015	1	0	-0.000006	
24		62	-0.000015	1	0	-0.000006	
24		64	-0.000012	1	0	-0.000005	
24		66	-0.00001	1	0	-0.000004	
25		66	-0.00001	1	0	-0.000004	
25		68	-0.000008	1	0	-0.000004	
25		70	-0.000005	1	0	-0.000002	
26		70	-0.000005	1	0	-0.000002	
26		71.8	-0.000003	1	0	-0.000001	
26		73.6	-0.000001	1	0	-0.000001	
27		73.6	-0.000001	1	0	-0.000001	
27		73.8	0	0	0	0	
27		74	0	0	0	0	

The Impacts on all the supports have been calculated according to the position of qk and pk on the influence line of support 4L.

Table 23 Calculating Total Impact on Support 7L

Total Impact		**-3.909E+01**
-2.8583280		-29.7132
Influence on Bearing 7L	Duplicate Value Reduction	**Impact**
0	1	0
-0.000001	1	-0.000000657
-0.000001	0	0.000000000
-0.000001	0	0.000000000
-0.000006	1	-0.000041367
-0.000011	1	-0.000100462
-0.000011	0	0.000000000
-0.000017	1	-0.000183853
-0.000022	1	-0.000256080
-0.000022	0	0.000000000
-0.000028	1	-0.000328308
-0.000033	1	-0.000400536
-0.000033	0	0.000000000
-0.000037	1	-0.000459631
-0.000043	1	-0.000525293
-0.000043	0	0.000000000
-0.000034	1	-0.000505595
-0.000045	1	-0.000518727
0.001046	1	-0.001144975
0.001602	1	0.000000000

0.002138	1	0.000000000
0.002138	0	0.000000000
0.002688	1	0.000000000
0.003237	1	0.000000000
0.003237	0	0.000000000
0.003778	1	0.000000000
0.004332	1	0.000000000
0.004332	0	0.000000000
0.004826	1	0.000000000
0.005398	1	0.000000000
0.005398	0	0.000000000
0.005616	1	0.000000000
0.006287	1	0.000000000
0.006287	0	0.000000000
0.004897	1	0.000000000
0.006145	1	0.000000000
-0.100561	1	-2.558662004
-0.13188	1	-1.526245389
-0.149839	1	-1.849812747
-0.149839	0	0.000000000
-0.162738	1	-2.052431391
-0.171664	1	-2.195737889
-0.171664	0	0.000000000
-0.181023	1	-2.315800171
-0.193985	1	-2.462363485
-0.193985	0	0.000000000
-0.211826	1	-2.398158891
-0.238178	1	-2.659319471
-0.238178	0	0.000000000
-0.241747	1	-0.315126556
-0.245457	1	-0.158735010
0	1	0.000000000
-0.000001	1	-0.000000657
-0.000002	1	-0.000001970
-0.000002	0	0.000000000
-0.000011	1	-0.000076824
-0.00002	1	-0.000183196
-0.00002	0	0.000000000
-0.000029	1	-0.000321742
-0.000039	1	-0.000446499
-0.000039	0	0.000000000
-0.000048	1	-0.000571256
-0.000058	1	-0.000696013
-0.000058	0	0.000000000
-0.000063	1	-0.000794506
-0.000075	1	-0.000906130
-0.000075	0	0.000000000
-0.000059	1	-0.000879866
-0.000078	1	-0.000899564

0.001814	1	-0.001984623
0.002779	1	0.000000000
0.003709	1	0.000000000
0.003709	0	0.000000000
0.004663	1	0.000000000
0.005616	1	0.000000000
0.005616	0	0.000000000
0.006555	1	0.000000000
0.007516	1	0.000000000
0.007516	0	0.000000000
0.008373	1	0.000000000
0.009364	1	0.000000000
0.009364	0	0.000000000
0.009742	1	0.000000000
0.010906	1	0.000000000
0.010906	0	0.000000000
0.008495	1	0.000000000
0.010661	1	0.000000000
-0.207093	1	-5.269249416
-0.294852	1	-3.295852461
-0.367314	1	-4.347889590
-0.367314	0	0.000000000
-0.436229	1	-5.276193953
-0.500839	1	-6.152940808
-0.500839	0	0.000000000
-0.56614	1	-7.005957550
-0.634989	1	-7.886808256
-0.634989	0	0.000000000
-0.703167	1	-7.907894831
-0.779849	1	-8.763951707
-0.779849	0	0.000000000
-0.789011	1	-1.030138978
-0.798314	1	-0.518077448
0	1	0.000000000
0	0	0.000000000
0	0	0.000000000
0	0	0.000000000
0.000002	1	0.000000000
0.000003	1	0.000000000
0.000003	0	0.000000000
0.000004	1	0.000000000
0.000006	1	0.000000000
0.000006	0	0.000000000
0.000007	1	0.000000000
0.000009	1	0.000000000
0.000009	0	0.000000000
0.00001	1	0.000000000
0.000011	1	0.000000000
0.000011	0	0.000000000

0.000009	1	0.000000000
0.000012	1	0.000000000
-0.000278	1	0.000000000
-0.000425	1	0.000000000
-0.000568	1	0.000000000
-0.000568	0	0.000000000
-0.000714	1	0.000000000
-0.000859	1	0.000000000
-0.000859	0	0.000000000
-0.001003	1	0.000000000
-0.00115	1	0.000000000
-0.00115	0	0.000000000
-0.001281	1	0.000000000
-0.001433	1	0.000000000
-0.001433	0	0.000000000
-0.001491	1	0.000000000
-0.001669	1	0.000000000
-0.001669	0	0.000000000
-0.0013	1	0.000000000
-0.001631	1	0.000000000
0.08291	1	2.109552081
0.148795	1	1.521412693
0.224701	1	2.452435447
0.224701	0	0.000000000
0.308274	1	3.499600485
0.395248	1	4.619439809
0.395248	0	0.000000000
0.482236	1	5.761702578
0.565523	1	6.879755906
0.565523	0	0.000000000
0.634373	1	7.090840960
0.694699	1	7.854212512
0.694699	0	0.000000000
0.700762	1	0.456150656
0.706684	1	0.000000000
0	1	0.000000000
0	0	0.000000000
-0.000001	1	0.000000000
-0.000001	0	0.000000000
-0.000003	1	0.000000000
-0.000005	1	0.000000000
-0.000005	0	0.000000000
-0.000008	1	0.000000000
-0.000011	1	0.000000000
-0.000011	0	0.000000000
-0.000013	1	0.000000000
-0.000016	1	0.000000000
-0.000016	0	0.000000000
-0.000017	1	0.000000000

-0.00002	1	0.000000000
-0.00002	0	0.000000000
-0.000016	1	0.000000000
-0.000021	1	0.000000000
0.000491	1	0.000000000
0.000752	1	0.000000000
0.001003	1	0.000000000
0.001003	0	0.000000000
0.001262	1	0.000000000
0.001519	1	0.000000000
0.001519	0	0.000000000
0.001773	1	0.000000000
0.002033	1	0.000000000
0.002033	0	0.000000000
0.002265	1	0.000000000
0.002533	1	0.000000000
0.002533	0	0.000000000
0.002636	1	0.000000000
0.00295	1	0.000000000
0.00295	0	0.000000000
0.002298	1	0.000000000
0.002884	1	0.000000000
-0.023621	1	-0.601009887
-0.014177	1	-0.248187812
0.007226	1	-0.045641396
0.007226	0	0.000000000
0.034783	1	0.275837923
0.066073	1	0.662236890
0.066073	0	0.000000000
0.097118	1	1.071538633
0.124519	1	1.455304569
0.124519	0	0.000000000
0.143032	1	1.581105021
0.153028	1	1.749580276
0.153028	0	0.000000000
0.153498	1	0.100480672
0.153828	1	0.000000000

As like previous, the impacts on other supports have been calculated using the same method and all the data has been filled into the table for calculating the overturning coefficient after strengthening the bridge.

7.5 Calculation of the Coefficient After Strengthening

Table 24 The Calculation for Overturning Stability After Strengthening

Project		4L	4R	5a	5	5b	6a	6	6b	7L	7R
Distance from the corresponsing bearing, li (m)		0	3.15	0	1.65	3.3	0	1.65	3.3	0	3.15
R(Gki)(Dead Load Standard Value Effect)		682.5167	419.8388	2222.349	175.0000	1655.0680	2035.5780	172.0000	1510.2370	531.0167	320.0181
Standard Value Effects of Failed Supports Corresponding to the Most Unfavorable Vehicle Loads	R (4L)	-288.1417	-203.0346	-62.0047	0.00003496	378.7849	7.6449	0.00005552	398.4079	-39.0859	368.3412
	R (5a)	235.8111	-536.9228	-173.4738	0.00004973	743.0780	-117.8649	0.00003877	425.2406	-0.8889	47.0645
	R (6a)	48.5043	52.4618	-114.9897	0.00003397	435.1580	-178.6016	0.00005453	666.7628	11.7439	-687.2746
	R (7L)	-387.126969	410.79322	34.594901	5.07176E-05	502.72095	-61.249111	3.976E-05	306.96597	206.49349	-606.8803
1st Verification	1.0 R(Gki)+1.4 R(Qki,4L)	279.1184	135.5904	2135.5424	175.0000	2185.3669	2046.2809	172.0001	2068.0080	476.2965	835.6958
	1.0 R(Gki)+1.4 R(Qki,5a)	1012.6523	-331.8531	1979.4857	175.0001	2695.3773	1870.5671	172.0001	2105.5739	529.7722	385.9084
	1.0 R(Gki)+1.4 R(Qki,6a)	750.4227	493.2853	2061.3634	175.0000	2264.2891	1785.5357	172.0001	2443.7049	547.4582	-642.1664
	1.0 R(Gki)+1.4 R(Qki,7L)	140.5389	994.9493	2270.7819	175.0001	2358.8773	1949.8292	172.0001	1939.9894	820.1076	-529.6144
	∑R（Gki）li(kN.m)	0	1322.4922	0	288.75	5461.7244	0	283.8	4983.7821	0	1008.057
2nd Verification	∑ R(Qki,4L)li	0	639.55886	0	5.7682E-05	1249.9902	0	9.16E-05	1314.746	0	1160.2749
	∑ R(Qki,5a)li	0	1691.3067	0	8.20589E-05	2452.1575	0	6.398E-05	1403.294	0	148.25321
	∑ R(Qki,6a)li		165.25466	0	5.60569E-05	1436.0212	0	8.998E-05	2200.3173	0	2164.9151
	∑ R(Qki,7L)li		1293.9986	0	8.3684E-05	1658.9791	0	6.56E-05	1012.9877	0	1911.6731
	∑R（Gki）li/∑ R(Qki,4L)li		3.0584								
	∑R（Gki）li/∑ R(Qki,5a)li		2.3439								
	∑R（Gki）li/∑ R(Qki,6a)li		2.2373								
	∑R（Gki）li/∑ R(Qki,7L)li		2.3439								

First the influence line due to the live load has been considered at bearing 4L, 7L and the two newly defined bearings no. 5a and 6a as these four bearings will act critically when overturning phenomenon will occur. And the positions for placing qk and pk has been calculated using “Microsoft Excel”. While placing the value of the loads pk and qk on the influence line of bearing 4L the impact of these loads on the other influence lines of rest of the bearings have been calculated and then the data has been filled to the calculation table for calculating the overturning coefficient and same process has been done for bearing 5a, 6a and 7L respectively.

After evaluating the calculated results, the previous result can be compared to the new calculation which is calculated after applying the scheme. According to the outcomes it can easily be understand that after applying a strengthening scheme the value of the overturning coefficient has been come so closer to the standard value as the coefficient values for different bearings are near 2.5. For getting the precise result to clearly state that the bridge is safe some counter measures can be implemented and some modification in the strengthening scheme can done. Some effective modifications have been described in the next which will help to reduce the calculation difference.

7.6 Suggestions for Getting safest value of overturning coefficient

After applying the selected strengthening scheme, the significant reduction in the overturning coefficient has been achieved. The value of the coefficient on the critical supports were very near to the standard value which is 2.5. But to make the structure safest some counter measures can be taken to reduce this calculation difference.

If the distance between the two additional piers is increased by moving the additional piers outward, the value of the coefficient can be increased to 2.5 or more than that. For making the connection between the additional piers and the box girders composite schemes can be used such as a composition of scheme 2 and scheme 3 can be chosen where the steel stringer will connect the additional piers with the girder and the existing pier.

Table 25 Suggestion Scheme for increasing the Overturning Coefficient

Project		4L	4R	5a	5	5b	6a	6	6b	7L	7R
Distance from the corresponsing bearing, li (m)		0	3.15	0	3.1	6.2	0	3.1	6.2	0	3.15
R(Gki)(Dead Load Standard Value Effect)		682.5167	419.8388	2222.349	175.0000	1655.0680	2035.5780	172.0000	1510.2370	531.0167	320.0181
Standard Value Effects of Failed Supports Corresponding to the Most Unfavorable Vehicle Loads	R (4L)	-288.1417	-203.0346	-62.0047	0.00003496	378.7849	7.6449	0.00005552	398.4079	-39.0859	368.3412
	R (5a)	235.8111	-536.9228	-173.4738	0.00004973	743.0780	-117.8649	0.00003877	425.2406	-0.8889	47.0645
	R (6a)	48.5043	52.4618	-114.9897	0.00003397	435.1580	-178.6016	0.00005453	666.7628	11.7439	-687.2746
	R (7L)	-387.126969	410.79322	34.594901	5.07176E-05	502.72095	-61.249111	3.976E-05	306.96597	206.49349	-606.8803
1st Verification	1.0 R(Gki)+1.4 R(Qki,4L)	279.1184	135.5904	2135.5424	175.0000	2185.3669	2046.2809	172.0001	2068.0080	476.2965	835.6958
	1.0 R(Gki)+1.4 R(Qki,5a)	1012.6523	-331.8531	1979.4857	175.0001	2695.3773	1870.5671	172.0001	2105.5739	529.7722	385.9084
	1.0 R(Gki)+1.4 R(Qki,6a)	750.4227	493.2853	2061.3634	175.0000	2264.2891	1785.5357	172.0001	2443.7049	547.4582	-642.1664
	1.0 R(Gki)+1.4 R(Qki,7L)	140.5389	994.9493	2270.7819	175.0001	2358.8773	1949.8292	172.0001	1939.9894	820.1076	-529.6144
		Passed									
	∑R（Gki）li(kN.m)	0	1322.4922	0	542.5	10261.422	0	533.2	9363.4694	0	1008.057
2nd Verification	∑ R(Qki,4L)li	0	639.55886	0	0.000108372	2348.4664	0	0.0001721	2470.1288	0	1160.2749
	∑ R(Qki,5a)li	0	1691.3067	0	0.000154171	4607.0839	0	0.0001202	2636.4918	0	148.25321
	∑ R(Qki,6a)li		165.25466	0	0.000105319	2697.9793	0	0.0001691	4133.9295	0	2164.9151
	∑ R(Qki,7L)li		1293.9986	0	0.000157224	3116.8699	0	0.0001233	1903.189	0	1911.6731
	∑R（Gki）li/∑R(Qki,4L)li		3.4798								
	∑R（Gki）li/∑R(Qki,5a)li		2.5356		Passed						
	∑R（Gki）li/∑R(Qki,6a)li		2.5137								
	∑R（Gki）li/∑R(Qki,7L)li		2.5356								

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8. Construction Organization Design

In this chapter the process of construction will be discussed and the construction steps for constructing the additional CFST piers will be listed in a construction flow chart. Then the estimation of required construction materials has been added in the last part.

8.1 Initial Survey

Before manufacturing the steel tubes for additional CFST piers, the precise survey data is required. First the location of the Additional piers will be marked and then the exact height required for the additional piers should be determined by leveling. Any obstacles on the pile caps should be identified and categorized as the additional piers will be constructed directly on the pile caps. If needed, excavation should be done for exposing the pile caps. The survey about the available space for placing construction equipment is necessary.

8.2 Fabrication of Steel Tube

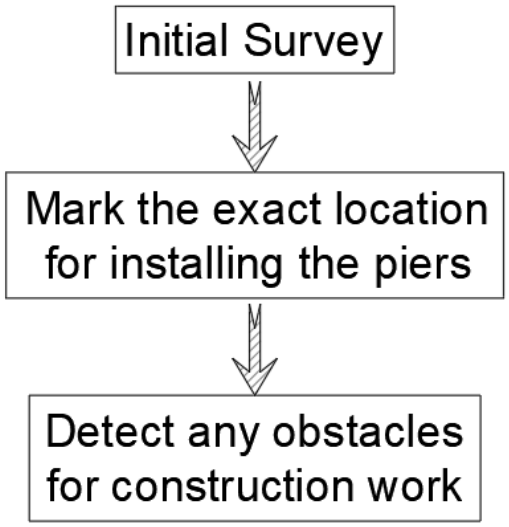
Steel plates will be used for manufacturing the steel tubes for both spirally and straight seam welded steel tubes. And in case of seamless steel tubes, a solid round billet of steel should be used for manufacturing the steel tubes. Joints assembly should be taken place in the factory or in the workshop. Before welding it is important to remove the rusting on the inner surface of the steel tubes.

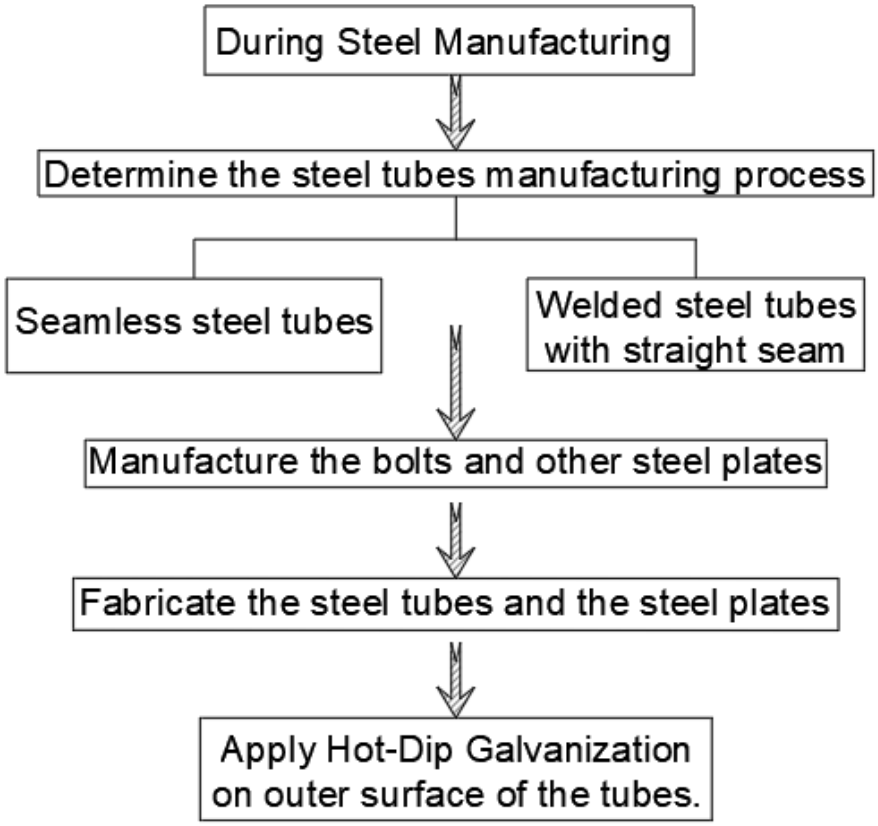
8.3 Casting of The Concrete

The inner concrete must have satisfactory strength, durability, workability, rigidity and no segregation or corrosion. Prior to construction the concrete mix proportion design should be tested. The inner surface of the steel tubes must be cleaned for casting the concrete into the steel tubes.

After casting the concrete, the quality of the concrete filling must be checked. For checking there are several methods, but the most common method is hammering. Use a hammer for striking on the outer surface of the steel tubes which will create noises. According to different types of noises the flaw of the concrete can be located. In case of abnormality, the ultrasonic equipment can also be used to address the noises more precisely. For curing the flaw, a hole in the tube should be made and the high strength cement should be introduced. After the process seal the hole and thus the flaw will be mitigated.

8.4 Construction Flow Chart





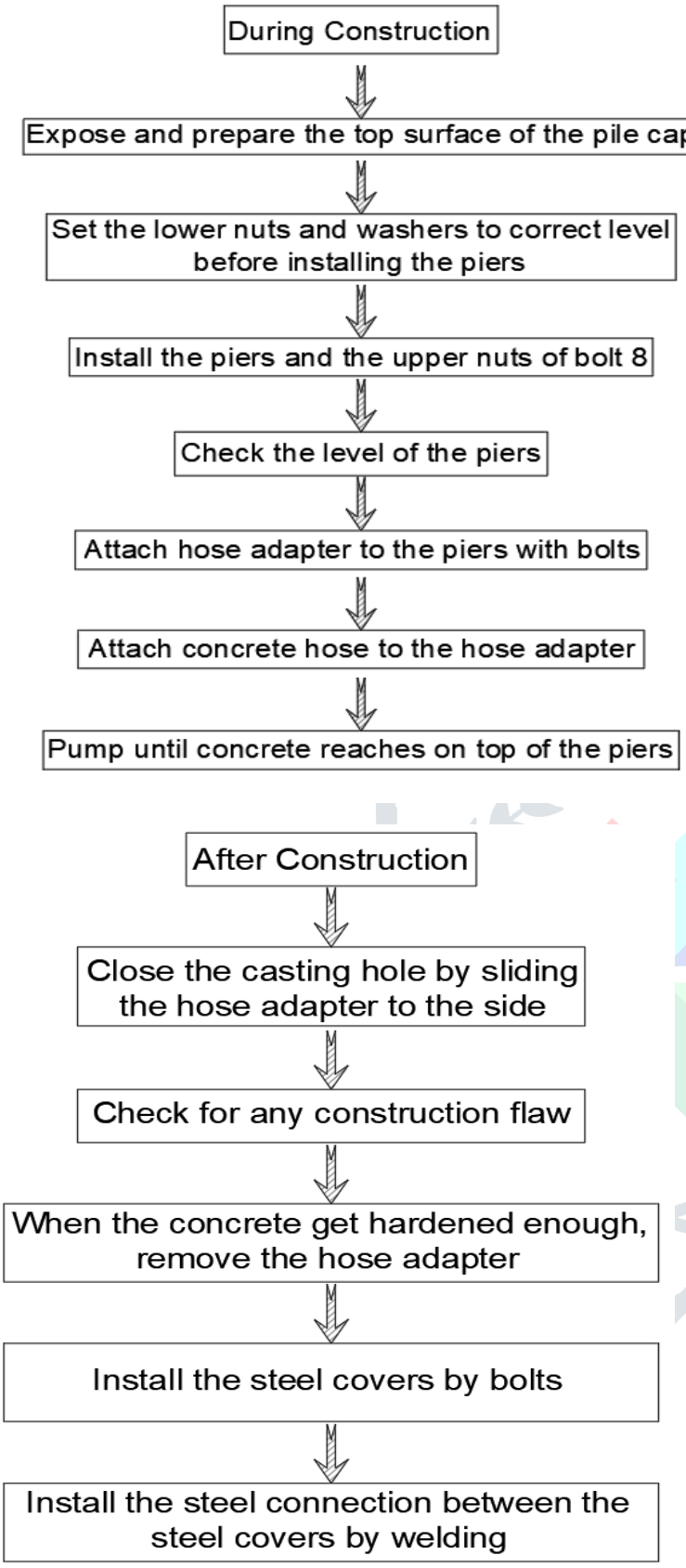


Figure 67 Construction Flow Chart

8.5 The Estimation of Materials

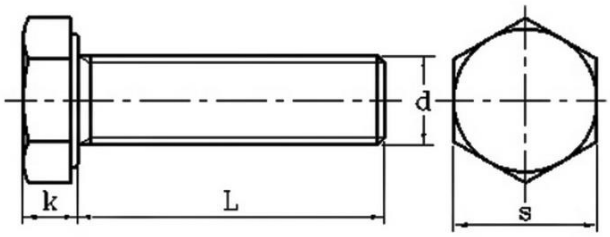


Figure 68 The Diagram of a Bolt

Table 26 Types of Bolts

Bolt No.	Model No.	Hose Model	S	Depth of the Head (K)	Total Length (L)	Diameter (d)	Ultimate Pull (KN)	Ultimate Share (KN)
Bolt 1	M8	RM-8	**20 mm**	**10 mm**	50 mm	10 mm	28.3	11.4
Bolt 2	M8	RM-8	**20 mm**	**10 mm**	60 mm	10 mm	28.3	11.4
Bolt 3	M30	RM-30	**40 mm**	**10 mm**	80 mm	30 mm	231.2	175
Bolt 4	M14	RM-20	**20 mm**	**10 mm**	150 mm	16 mm	66.3	47.2
Bolt 5	M20	RM-20	**40 mm**	**10 mm**	260 mm	22 mm	135.4	76.4
Bolt 6	M14	RM-14	**20 mm**	**10 mm**	140 mm	16 mm	66.3	47.2
Bolt 7	M10	RM-10	**20 mm**	**10.1 mm**	110 mm	12 mm	34.5	18.1
Bolt 8	M16	RM-16	**20 mm**	**10 mm**	330 mm	18 mm	90.5	49
Bolt 9	M12	RM-12	**20 mm**	**10 mm**	150 mm	14 mm	46.1	26.3

Table 27 Estimation of Steel in Bolts

Amount of Steel Bolts					
CFST Piers	**Bolt Type**	**Model**	**Amount of Bolts**	**weight of a single bolt**	**Weight in (Kg)**
Pier 1	Bolt 7	M10	160	0.12	19.2
	Bolt 8	M16	56	0.68	38.08
	Bolt 9	M12	4	0.206	0.824
Pier 2	Bolt 7	M10	160	0.12	19.2
	Bolt 8	M16	56	0.68	38.08
	Bolt 9	M12	4	0.206	0.824
Pier 3	Bolt 7	M10	160	0.12	19.2
	Bolt 8	M16	56	0.68	38.08
	Bolt 9	M12	4	0.206	0.824
Pier 4	Bolt 7	M10	160	0.12	19.2
	Bolt 8	M16	56	0.68	38.08
	Bolt 9	M12	4	0.206	0.824
			Grand Total		**232.416**

Table 28 Estimation of Steel in Piers

Steel Calculation of the Piers					
CFST Piers	Area (m3)	Height (m)	Volume (m3)	Density kg/m3	Weight (kg)
Pier 1	0.0553	5.46	0.3019	7850	2369.9
Pier 2	0.0553	5.46	0.3019	7850	2369.9
Pier 3	0.0553	5.35	0.2958	7850	2322.1
Pier 4	0.0553	5.35	0.2958	7850	2322.1
		Total	1.1954	Total	9384

Table 29 Estimation of Steel In Steel Plates

Calculation of Steel Plates							
CFST Piers	No. of Plates	Length (m)	Width (m)	Height (m)	Volume (m3)	Density (kg/m3	Weight (kg)
Pier 1	2	1.8	1.5	0.02	0.054	7850	847.8
Pier 2	2	1.8	1.5	0.02	0.054	7850	847.8
Pier 3	2	1.8	1.5	0.02	0.054	7850	847.8
Pier 4	2	1.8	1.5	0.02	0.054	7850	847.8
						Total	3391.2

Table 30 Estimation of Steel in Steel Covers

Calculation of Steel Covers						
Sl No.	Location	Area (m2)	Height (m)	Volume (m3)	Density (kg/m3)	Weight (kg)
1	ON CFST 1	0.028589	0.6	0.017153	7850	134.6521
	ON Pier 5	0.056863	1.2	0.068236	7850	535.6491
	ON CFST 2	0.028589	0.6	0.017153	7850	134.6521
2	ON CFST 3	0.028589	0.6	0.017153	7850	134.6521
	ON Pier 6	0.056863	1.2	0.068236	7850	535.6491
	ON CFST 4	0.028589	0.6	0.017153	7850	134.6521
					Total	1609.9

Table 31 Estimation of Steel in Connecting Plates

Calculation of Steel Connecting Plates						
No. of Plates	Length (m)	Width (m)	Thickness (m)	Volume (m3)	Density (kg/m3)	Weight (kg)
2	0.28	0.4	0.04	0.00448	7850	**70.336**

Table 32 Estimation of Total Steel

Total Weight of Steel				
CFST Piers	Steel Plates	Steel Covers	Connecting Plates	Bolts
9384.02	3391.2	1609.91	70.336	232.42
	Grand Total (kg)			
	14687.88			

Table 33 Estimation of Concrete

Calculation of Concrete			
CFST Piers	Area (m2)	Height (m)	Volume (m3)
Pier 1	0.5809	5.46	3.1716
Pier 2	0.5809	5.46	3.1716
Pier 3	0.5809	5.35	3.1077
Pier 4	0.5809	5.35	3.1077
		Total	12.559

Conclusion

The reduction of a bridge's overturning instability is a significant technical challenge in bridge engineering, particularly for bridges with single column piers. The overturning instability of a box girder section of the Hainan Ring Expressway, consisting of three spans with a total length of (24m + 30m + 20m) 74m, has been analyzed. From the analysis report, the present condition of the bridge has been evaluated according to the Chinese standards for overturning by calculating the overturning coefficient. The calculated overturning coefficient was 0.4693 for support 4L and 1.428 for support 7L, which was much less than the standard value of 2.5, and this proves the bridge has the tendency to turn over its supports. The priority of the research was to reduce the overturning possibility by increasing the coefficient. To achieve the target, three initial design schemes were proposed. The first scheme was to enlarge the pier and install two additional supports. The second scheme was to install 4 steel tie plates and some steel stringers with transverse beams beneath the box girder. And the third scheme was to install 4 additional CFST piers with 4 additional supports. After considering factors such as cost, construction difficulty and so on the third scheme finally selected. According to the structural analysis of the strengthened model, the calculated coefficients are 3.0584, 2.3439, 2.2373 and 2.3439 for support 4L, 5a, 6a and 7L respectively, where 5a and 6a are additional supports on additional CFST piers. By evaluating the outcomes of the analysis, the increments in the value of the overturning coefficients are calculated to be 84.65% for critical support 4L and 39.08% for critical support 7L. So, it can be concluded that the significant reduction in overturning tendency of the bridge has been achieved using the

applied scheme. Due to lack of time and some other constraints the model has been simplified. Although a significant increment in coefficient value can be noticed, if the calculated coefficients of support 5a, 6a and 7L can be increased more, the bridge will be more stable. So, a possible countermeasure has been proposed, which is to increase the distance between two additional CFST piers by 6.2m, which has increased the value of the coefficient by more than 2.5. Throughout this research, the methods of bridge strengthening against overturning instability have been described to determine whether it is safe or not, and if not, what type of measures should be taken to make the bridge safe for traffic. The research has been conducted to understand the importance of bridge strengthening against overturning and to give motivation for further research in this field. In addition to this, the methods of strengthening developed and proposed in this thesis paper can be applied to similar kinds of bridges with overturning instability.

Acknowledgement

Prima facie, I am grateful to the Almighty Lord Krisna for protecting me and for the good health and wellbeing which was highly required to complete this research.

I am so grateful to my supervisor, Pro. Dr. Liu Simeng, for giving me the opportunity to work with him on this thesis. Without his continuous guidelines and necessary instructions, it was impossible for me to complete this thesis. The way he motivated me was exclusive and helped me give the best possible output within the limited time. He cultivated curiosity in my mind about solving engineering problems. Words cannot express my gratitude to my supervisor for his invaluable patience and feedback and for giving me the ultimate degree of freedom to use all the equipment in the lab.

I am also grateful to my friend Mr. Wang Yi, whose continuous support has simplified my work. He was my ultimate faith for translating the Chinese resources into English. His unparalleled assistance in collecting information helped me complete this thesis.

I place on record my sincere thanks to Mr. Sun Jie and Mr. Liu Yang Fu for their supports regarding software.

I am also thankful to Mrs. Peng Shiyuan, Lecturer, Department of Environment Engineering, Pro. Li Hexing, Pro. Chun Lian, Department of Physics, Chongqing Jiaotong University, for their continuous encouragement to finish my thesis.

If I didn't acknowledge my family, I would be remiss. The role of my family in completing my thesis as well as my undergraduate study is indefeasible. Throughout my thesis, their faith in me has kept me inspired and motivated.

May the Almighty God richly bless all of us.

Ethical Approval and Consent to Participate

Not applicable.

Code Availability

Not applicable.

Funding

Not applicable.

Data availability

The dataset and materials for this study are taken from multiple public datasets and research. which is mentioned in the data collection section.

Declarations

Conflict of Interest

The authors declare no conflict of interest.

Consent for Publication

Not applicable.

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Appendix-A

Table 34 Table of Section Properties Before Strengthening

No.	Type	Shape	Name	Area (m^2)	Asy (m^2)	Asz (m^2)	Ixx (m^4)	Iyy (m^4)	Izz (m^4)	Cyp (m)	Cym (m)	Czp (m)	Czm (m)	Qyb (m^2)	Qzb (m^2)	Perimeter (outer) (m)	Perimeter (inner) (m)
1	Design Section	VALU	3…3	4.538	2.7805	0.987	3.085	1.4158	20.5	4.25	4.25	0.59	1.009	1.137	10.729	19.729	8.1307
2	User Defined	SR	Existing Pier	2.545	2.2902	2.29	1.031	0.5153	0.515	0.9	0.9	0.9	0.9	0.27	0.27	5.6549	0
3	User Defined	SB	Bearing	0.672	0.5603	0.56	0.064	0.0377	0.038	0.41	0.41	0.41	0.41	0.0841	0.0841	3.28	0
4	User Defined	SB	Bearing for 6	0.962	0.8017	0.802	0.129	0.0867	0.069	0.46	0.46	0.52	0.52	0.1352	0.107	3.93	0
5	Design Section	VALU	2…2	5.558	4.2989	0.91	3.874	1.6776	21.1	4.25	4.25	0.62	0.981	1.3846	5.783	19.729	7.9766
6	Design Section	VALU	1…1	8.118	7.0446	3.006	4.524	1.9079	23.28	4.25	4.25	0.69	0.908	0.4126	3.5314	19.729	0
7	tapered	VALU	3…2	5.558	4.2989	0.91	3.874	1.6776	21.1	4.25	4.25	0.62	0.981	1.3846	5.783	19.729	7.9766
8	Tapered	VALU	2…3	4.538	2.7805	0.987	3.085	1.4158	20.5	4.25	4.25	0.59	1.009	1.137	10.729	19.729	8.1307

Table 35 Table of Displacements Before Strengthening

Node	Load	DX (m)	DY (m)	DZ (m)	RX ([rad])	RY ([rad])	RZ ([rad])	RW (rad/m)
1	SW	0	0	0	0	0	0	0
2	SW	0	0	0	0	0	0	0
3	SW	-1E-06	0	-0.000008	0	-0.000007	0	0
4	SW	0	0	-0.000007	0	0.000001	0	0
5	SW	-6.4E-05	0	-0.000082	0	-0.000061	0	0
6	SW	0.000007	0	-0.000075	0	0.000006	0	0
7	SW	0.000045	0	-0.000222	0	-0.000297	0	0
8	SW	-0.00044	0	-0.000248	0	0.000131	0	0
9	SW	-0.00104	0	0	0	0.000683	0	0
10	SW	0	0	0	0	-0.00029	0	0
11	SW	-0.00104	0	0	0	0.000683	0	0
12	SW	0	0	0	0	-0.00029	0	0
13	SW	-0.00097	0	0	0	0.000683	0	0
14	SW	-2.8E-05	0	0	0	-0.00029	0	0
15	SW	-0.00041	0	-0.000248	0	0.000131	0	0
16	SW	-6E-06	0	-0.000222	0	-0.000297	0	0

17	SW	-0.00097	0	0	0	0.000683	0	0
18	SW	-2.8E-05	0	0	0	-0.00029	0	0
19	SW	0	0	0	0	0	0	0
20	SW	0.000123	0	0.000273	0	0.000683	0	0
21	SW	0.000124	0	-0.000031	0	0.000685	0	0
22	SW	0.000052	0	-0.002561	0	0.000563	0	0
23	SW	-0.00014	0	-0.004308	0	0.000237	0	0
24	SW	-0.00036	0	-0.00447	0	-0.000132	0	0
25	SW	-0.00051	0	-0.003203	0	-0.000381	0	0
26	SW	-0.00049	0	-0.00131	0	-0.000348	0	0
27	SW	-0.0002	0	-0.000248	0	0.000131	0	0
28	SW	0.00007	0	-0.002213	0	0.000599	0	0
29	SW	0.000097	0	-0.004983	0	0.000649	0	0
30	SW	-4.4E-05	0	-0.007246	0	0.000416	0	0
31	SW	-0.00027	0	-0.008192	0	0.000035	0	0
32	SW	-0.00051	0	-0.007515	0	-0.000361	0	0
33	SW	-0.00068	0	-0.005411	0	-0.000638	0	0
34	SW	-0.00069	0	-0.002579	0	-0.000662	0	0
35	SW	-0.00048	0	-0.000222	0	-0.000297	0	0
36	SW	-0.00025	0	-0.000376	0	0.000108	0	0
37	SW	-0.00022	0	-0.001226	0	0.000148	0	0
38	SW	-0.00032	0	-0.001641	0	-0.000013	0	0
39	SW	-0.00044	0	-0.001137	0	-0.000214	0	0
40	SW	-0.00049	0	-0.000025	0	-0.000293	0	0
41	SW	-0.00049	0	0.000116	0	-0.00029	0	0
1	CB	0	0	0	0	0	0	0
2	CB	0	0	0	0	0	0	0
3	CB	0	-0.000001	-0.000001	0.000004	0	0	0
4	CB	0	-0.000001	0	0.000004	0	0	0
5	CB	-5E-06	-0.000039	-0.000006	0.000037	-0.000005	0.000003	0
6	CB	0.000001	-0.000039	-0.000005	0.000036	0	-0.000004	0
7	CB	0.000003	-0.000252	-0.000016	-0.000417	-0.000022	-0.000011	0
8	CB	-3.2E-05	-0.000262	-0.000018	-0.000465	0.00001	0.00001	0
9	CB	-7.7E-05	0	0	0	0.000051	0	0
10	CB	0	0	0	0	-0.000022	0	0

11	CB	-7.7E-05	0	0	0	0.000051	0	0
12	CB	0	0	0	0	-0.000022	0	0
13	CB	-7.3E-05	0	0	0	0.000051	0	0
14	CB	-2E-06	0	0	0	-0.000022	0	0
15	CB	-3.1E-05	-0.000185	-0.000018	-0.000465	0.00001	0.00001	0
16	CB	0	-0.000181	-0.000016	-0.000417	-0.000022	-0.000011	0
17	CB	-7.3E-05	0	0	0	0.000051	0	0
18	CB	-2E-06	0	0	0	-0.000022	0	0
19	CB	0	0	0	0	0	0	0
20	CB	0.000009	0	0.00002	0	0.000051	0	0.00003
21	CB	0.000009	0.000008	-0.000002	-0.000012	0.000051	0.000001	0.000029
22	CB	0.000004	0.000086	-0.000192	-0.000112	0.000042	0.000006	0.000026
23	CB	-1.1E-05	0.000183	-0.000322	-0.000209	0.000018	0.00001	0.000023
24	CB	-2.7E-05	0.000286	-0.000334	-0.000294	-0.00001	0.000013	0.000019
25	CB	-3.8E-05	0.000387	-0.000239	-0.000364	-0.000029	0.000013	0.000016
26	CB	-3.6E-05	0.000481	-0.000097	-0.000421	-0.000026	0.000012	0.000013
27	CB	-1.5E-05	0.000559	-0.000018	-0.000465	0.00001	0.00001	0.00001
28	CB	0.000005	0.000611	-0.000165	-0.000501	0.000045	0.000007	0.000008
29	CB	0.000007	0.000644	-0.000372	-0.000524	0.000049	0.000004	0.000005
30	CB	-3E-06	0.00066	-0.000542	-0.000536	0.000031	0.000001	0.000002
31	CB	-0.00002	0.000659	-0.000613	-0.000536	0.000003	-0.000002	-0.000002
32	CB	-3.8E-05	0.00064	-0.000562	-0.000524	-0.000027	-0.000004	-0.000005
33	CB	-5.1E-05	0.000605	-0.000404	-0.0005	-0.000048	-0.000007	-0.000008
34	CB	-5.2E-05	0.000553	-0.000192	-0.000464	-0.00005	-0.000009	-0.000011
35	CB	-3.6E-05	0.000486	-0.000016	-0.000417	-0.000022	-0.000011	-0.000013
36	CB	-1.8E-05	0.000394	-0.000027	-0.00036	0.000008	-0.000013	-0.000016
37	CB	-1.7E-05	0.000292	-0.000091	-0.000291	0.000011	-0.000013	-0.000019
38	CB	-2.4E-05	0.000187	-0.000123	-0.000207	-0.000001	-0.00001	-0.00002

								3
39	CB	-3.3E-05	0.000087	-0.000085	-0.000111	-0.000016	-0.000006	-0.000026
40	CB	-3.7E-05	0.000008	-0.000002	-0.000012	-0.000022	-0.000001	-0.000029
41	CB	-3.7E-05	0	0.000009	0	-0.000022	0	-0.000029
1	MVC(Max)	0	0	0	0	0	0	0
2	MVC(Max)	0	0	0	0	0	0	0
3	MVC(Max)	0.000001	0.000002	0	0	0.000006	0	0
4	MVC(Max)	0.000002	0.000002	0	0	0.000011	0.000001	0
5	MVC(Max)	0.000055	0.000091	0.000002	0	0.000052	0	0
6	MVC(Max)	0.000102	0.000093	0.000002	0	0.000096	0.000007	0
7	MVC(Max)	0.000661	0.000602	0.000007	0.000923	0.000284	0.000023	0
8	MVC(Max)	0.000376	0.000619	0.000005	0.00103	0.000462	0	0
9	MVC(Max)	0.000418	0	0	0	0.000613	0	0
10	MVC(Max)	0	0	0	0	0.00017	0	0
11	MVC(Max)	0.000418	0	0	0	0.000613	0	0
12	MVC(Max)	0	0	0	0	0.00017	0	0
13	MVC(Max)	0.000398	0	0	0	0.000613	0	0
14	MVC(Max)	0.000016	0	0	0	0.00017	0	0
15	MVC(Max)	0.000312	0.000449	0.000005	0.00103	0.000462	0	0
16	MVC(Max)	0.00059	0.000445	0.000007	0.000923	0.000284	0.000023	0

17	MVC(Max)	0.000398	0	0	0	0.000613	0	0
18	MVC(Max)	0.000016	0	0	0	0.00017	0	0
19	MVC(Max)	0	0	0	0	0	0	0
20	MVC(Max)	0.000311	0	0.000245	0	0.000613	0	0.00002
21	MVC(Max)	0.000311	0	0.000003	0.000026	0.000614	0	0.000012
22	MVC(Max)	0.000268	0	0.000787	0.000246	0.000538	0	0
23	MVC(Max)	0.000144	0	0.00152	0.000468	0.000312	0	0
24	MVC(Max)	0.000162	0	0.001957	0.000657	0.000061	0	0.000002
25	MVC(Max)	0.000234	0	0.001944	0.000814	0.000081	0	0.000004
26	MVC(Max)	0.000331	0	0.001324	0.000938	0.000252	0	0.000007
27	MVC(Max)	0.000453	0	0.000005	0.00103	0.000462	0	0.000009
28	MVC(Max)	0.000522	0	0.001174	0.001113	0.000578	0	0.000011
29	MVC(Max)	0.000484	0	0.001885	0.001169	0.000511	0	0.000014
30	MVC(Max)	0.000371	0	0.002165	0.001198	0.00032	0.000003	0.000018
31	MVC(Max)	0.000219	0	0.002095	0.001198	0.000128	0.000007	0.000021
32	MVC(Max)	0.000086	0	0.00176	0.001171	0.000112	0.000011	0.000025
33	MVC(Max)	0.000038	0	0.001431	0.001116	0.00015	0.000015	0.000029
34	MVC(Max)	0.000034	0	0.000849	0.001033	0.000197	0.000019	0.000034

35	MVC(Max)	0.00003	0	0.000007	0.000923	0.000284	0.000023	0.000037
36	MVC(Max)	0.000064	0	0.00109	0.000802	0.000294	0.000026	0.00004
37	MVC(Max)	0.000166	0	0.001449	0.00065	0.000146	0.000026	0.000044
38	MVC(Max)	0.000238	0	0.001233	0.000464	0.000097	0.000021	0.00005
39	MVC(Max)	0.000279	0	0.000656	0.000245	0.00016	0.000013	0.000055
40	MVC(Max)	0.000288	0	0.000005	0.000026	0.000171	0.000001	0.000058
41	MVC(Max)	0.000288	0	0.00015	0	0.00017	0	0.000062
1	MVC(Min)	0	0	0	0	0	0	0
2	MVC(Min)	0	0	0	0	0	0	0
3	MVC(Min)	-1E-06	0	-0.000003	-0.000009	-0.000007	-0.000001	0
4	MVC(Min)	-2E-06	0	-0.000003	-0.00001	-0.000011	0	0
5	MVC(Min)	-6.5E-05	0	-0.000029	-0.000086	-0.000062	-0.000006	0
6	MVC(Min)	-0.00011	0	-0.000028	-0.000087	-0.0001	0	0
7	MVC(Min)	-0.00069	0	-0.000085	0	-0.000416	0	0
8	MVC(Min)	-0.00044	0	-0.000089	0	-0.000409	-0.000019	0
9	MVC(Min)	-0.00085	0	0	0	-0.000215	0	0
10	MVC(Min)	0	0	0	0	-0.000375	0	0
11	MVC(Min)	-0.00085	0	0	0	-0.000215	0	0
12	MVC(Min)	0	0	0	0	-0.000375	0	0
13	MVC(Min)	-0.00079	0	0	0	-0.000215	0	0
14	MVC(Min)	-3.6E-05	0	0	0	-0.000375	0	0
15	MVC(Min)	-0.00038	0	-0.000089	0	-0.000409	-0.000019	0
16	MVC(Min)	-0.00065	0	-0.000085	0	-0.000416	0	0
17	MVC(Min)	-0.00079	0	0	0	-0.000215	0	0

18	MVC(Min)	-3.6E-05	0	0	0	-0.000375	0	0
19	MVC(Min)	0	0	0	0	0	0	0
20	MVC(Min)	-0.00033	0	-0.000086	0	-0.000215	0	-0.000062
21	MVC(Min)	-0.00033	-0.000016	-0.000027	0	-0.000215	-0.000001	-0.000059
22	MVC(Min)	-0.00033	-0.000174	-0.002278	0	-0.000199	-0.000012	-0.000056
23	MVC(Min)	-0.00033	-0.000371	-0.004126	0	-0.000144	-0.000021	-0.000051
24	MVC(Min)	-0.00037	-0.000588	-0.004739	0	-0.000112	-0.000026	-0.000045
25	MVC(Min)	-0.00044	-0.00081	-0.003878	0	-0.000329	-0.000027	-0.00004
26	MVC(Min)	-0.00048	-0.001019	-0.002087	0	-0.000467	-0.000025	-0.000035
27	MVC(Min)	-0.00049	-0.001199	-0.000089	0	-0.000409	-0.000019	-0.000032
28	MVC(Min)	-0.00047	-0.001296	-0.002269	0	-0.00026	-0.000014	-0.000029
29	MVC(Min)	-0.00044	-0.001352	-0.004508	0	-0.000134	-0.00001	-0.000025
30	MVC(Min)	-0.00041	-0.001375	-0.006159	0	-0.000074	-0.000006	-0.000021
31	MVC(Min)	-0.00038	-0.001367	-0.006761	0	-0.000131	-0.000003	-0.000018
32	MVC(Min)	-0.00036	-0.001329	-0.00607	0	-0.000334	0	-0.000014
33	MVC(Min)	-0.00036	-0.001261	-0.004371	0	-0.000512	0	-0.000011
34	MVC(Min)	-0.00033	-0.001163	-0.002159	0	-0.000559	0	-0.000008
35	MVC(Min)	-0.00026	-0.001031	-0.000085	0	-0.000416	0	-0.000007
36	MVC(Min)	-0.00023	-0.000829	-0.001453	0	-0.000191	0	-0.000005
37	MVC(Min)	-0.00031	-0.000607	-0.002462	0	-0.000021	0	-0.000002
38	MVC(Min)	-0.00047	-0.000382	-0.002505	0	-0.000143	0	0

39	MVC(Min)	-0.0006	-0.000177	-0.001469	0	-0.000324	0	0
40	MVC(Min)	-0.00064	-0.000017	-0.000026	0	-0.000378	0	-0.000012
41	MVC(Min)	-0.00064	0	-0.000068	0	-0.000375	0	-0.00002
1	MVC(All)	0	0	0	0	0	0	0
2	MVC(All)	0	0	0	0	0	0	0
3	MVC(All)	-1E-06	0.000002	-0.000003	-0.000009	-0.000007	-0.000001	0
4	MVC(All)	-2E-06	0.000002	-0.000003	-0.00001	-0.000011	0.000001	0
5	MVC(All)	-6.5E-05	0.000091	-0.000029	-0.000086	-0.000062	-0.000006	0
6	MVC(All)	-0.00011	0.000093	-0.000028	-0.000087	-0.0001	0.000007	0
7	MVC(All)	-0.00069	0.000602	-0.000085	0.000923	-0.000416	0.000023	0
8	MVC(All)	-0.00044	0.000619	-0.000089	0.00103	0.000462	-0.000019	0
9	MVC(All)	-0.00085	0	0	0	0.000613	0	0
10	MVC(All)	0	0	0	0	-0.000375	0	0
11	MVC(All)	-0.00085	0	0	0	0.000613	0	0
12	MVC(All)	0	0	0	0	-0.000375	0	0
13	MVC(All)	-0.00079	0	0	0	0.000613	0	0
14	MVC(All)	-3.6E-05	0	0	0	-0.000375	0	0
15	MVC(All)	-0.00038	0.000449	-0.000089	0.00103	0.000462	-0.000019	0
16	MVC(All)	-0.00065	0.000445	-0.000085	0.000923	-0.000416	0.000023	0
17	MVC(All)	-0.00079	0	0	0	0.000613	0	0
18	MVC(All)	-3.6E-05	0	0	0	-0.000375	0	0
19	MVC(All)	0	0	0	0	0	0	0
20	MVC(All)	-0.00033	0	0.000245	0	0.000613	0	-0.000062
21	MVC(All)	-0.00033	-0.000016	-0.000027	0.000026	0.000614	-0.000001	-0.000059
22	MVC(All)	-0.00033	-0.000174	-0.002278	0.000246	0.000538	-0.000012	-0.000056
23	MVC(All)	-0.00033	-0.0003	-0.004126	0.000468	0.000312	-0.000021	-0.00005

			71					1
24	MVC(All)	-0.00037	-0.000588	-0.004739	0.000657	-0.000112	-0.000026	-0.000045
25	MVC(All)	-0.00044	-0.00081	-0.003878	0.000814	-0.000329	-0.000027	-0.00004
26	MVC(All)	-0.00048	-0.001019	-0.002087	0.000938	-0.000467	-0.000025	-0.000035
27	MVC(All)	-0.00049	-0.001199	-0.000089	0.00103	0.000462	-0.000019	-0.000032
28	MVC(All)	0.000522	-0.001296	-0.002269	0.001113	0.000578	-0.000014	-0.000029
29	MVC(All)	0.000484	-0.001352	-0.004508	0.001169	0.000511	-0.00001	-0.000025
30	MVC(All)	-0.00041	-0.001375	-0.006159	0.001198	0.00032	-0.000006	-0.000021
31	MVC(All)	-0.00038	-0.001367	-0.006761	0.001198	-0.000131	0.000007	0.000021
32	MVC(All)	-0.00036	-0.001329	-0.00607	0.001171	-0.000334	0.000011	0.000025
33	MVC(All)	-0.00036	-0.001261	-0.004371	0.001116	-0.000512	0.000015	0.000029
34	MVC(All)	-0.00033	-0.001163	-0.002159	0.001033	-0.000559	0.000019	0.000034
35	MVC(All)	-0.00026	-0.001031	-0.000085	0.000923	-0.000416	0.000023	0.000037
36	MVC(All)	-0.00023	-0.000829	-0.001453	0.000802	0.000294	0.000026	0.00004
37	MVC(All)	-0.00031	-0.000607	-0.002462	0.00065	0.000146	0.000026	0.000044
38	MVC(All)	-0.00047	-0.000382	-0.002505	0.000464	-0.000143	0.000021	0.00005
39	MVC(All)	-0.0006	-0.000177	-0.001469	0.000245	-0.000324	0.000013	0.000055
40	MVC(All)	-0.00064	-0.000017	-0.000026	0.000026	-0.000378	0.000001	0.000058
41	MVC(All)	-0.00064	0	0.00015	0	-0.000375	0	0.000062

Table 36 Table of Beam Forces Before Strengthening

Element	Load	Part	Axial (kN)	share-y (kN)	Share-z (kN)	Torsion (kN*m)	Moment-y (kN*m)	Moment-z (kN*m)	Bi-Moment (kN*m^2)	T-Moment (kN*m)	W-Moment (kN*m)
1	SW	I[3]	-3785.76	0	120.72	0	-644.02	0	0	0	0
1	SW	J[1]	-3796.25	0	120.72	0	-663.94	0	0	0	0
2	SW	I[4]	-3461.27	0	-13.23	0	69.05	0	0	0	0
2	SW	J[2]	-3472.09	0	-13.23	0	71.29	0	0	0	0
3	SW	I[5]	-3683.97	0	120.72	0	-450.88	0	0	0	0
3	SW	J[3]	-3785.76	0	120.72	0	-644.02	0	0	0	0
4	SW	I[6]	-3359.48	0	-13.23	0	47.88	0	0	0	0
4	SW	J[4]	-3461.27	0	-13.23	0	69.05	0	0	0	0
5	SW	I[8]	-3446.36	0	120.72	0	0	0	0	0	0
5	SW	J[5]	-3683.97	0	120.72	0	-450.88	0	0	0	0
6	SW	I[7]	-3129.19	0	-13.23	0	0	0	0	0	0
6	SW	J[6]	-3359.48	0	-13.23	0	47.88	0	0	0	0
7	SW	I[20]	0	0	-1027.16	0	-410.86	0	0	0	0
7	SW	J[21]	0	0	-981.78	0	-9.08	0	0	0	0
8	SW	I[21]	0	0	-981.78	0	-9.08	0	0	0	0
8	SW	J[22]	0	0	-573.41	0	2790.26	0	0	0	0
9	SW	I[22]	0	0	-573.41	0	2790.26	0	0	0	0
9	SW	J[23]	0	0	-119.66	0	4176.39	0	0	0	0
10	SW	I[23]	0	0	-119.66	0	4176.39	0	0	0	0
10	SW	J[24]	0	0	334.09	0	3747.51	0	0	0	0
11	SW	I[24]	0	0	334.09	0	3747.51	0	0	0	0
11	SW	J[25]	0	0	787.84	0	1503.64	0	0	0	0
12	SW	I[25]	0	0	787.84	0	1503.64	0	0	0	0
12	SW	J[26]	0	0	1241.59	0	-2555.2	0	0	0	0
13	SW	I[26]	0	0	1241.59	0	-2555.2	0	0	0	0
13	SW	J[27]	0	0	1695.34	0	-8429.1	0	0	0	0
14	SW	I[27]	-120.72	0	-1748.24	0	-8570.9	0	0	0	0
14	SW	J[28]	-120.72	0	-1322.85	0	-2812.6	0	0	0	0
15	SW	I[28]	-120.72	0	-1322.85	0	-2812.6	0	0	0	0
15	SW	J[29]	-120.72	0	-897.46	0	1350.49	0	0	0	0
16	SW	I[29]	-120.72	0	-897.46	0	1350.49	0	0	0	0
16	SW	J[30]	-120.72	0	-472.07	0	3918.35	0	0	0	0
17	SW	I[30]	-120.72	0	-472.07	0	3918.35	0	0	0	0

17	SW	J[31]	-120.72	0	-46.68	0	4891	0	0	0	0
18	SW	I[31]	-120.72	0	-46.68	0	4891	0	0	0	0
18	SW	J[32]	-120.72	0	378.71	0	4268.44	0	0	0	0
19	SW	I[32]	-120.72	0	378.71	0	4268.44	0	0	0	0
19	SW	J[33]	-120.72	0	804.1	0	2050.66	0	0	0	0
20	SW	I[33]	-120.72	0	804.1	0	2050.66	0	0	0	0
20	SW	J[34]	-120.72	0	1229.49	0	-1762.3	0	0	0	0
21	SW	I[34]	-120.72	0	1229.49	0	-1762.3	0	0	0	0
21	SW	J[35]	-120.72	0	1654.88	0	-7170.6	0	0	0	0
22	SW	I[35]	-107.49	0	-1470.22	0	-7155	0	0	0	0
22	SW	J[36]	-107.49	0	-1016.47	0	-2181.6	0	0	0	0
23	SW	I[36]	-107.49	0	-1016.47	0	-2181.6	0	0	0	0
23	SW	J[37]	-107.49	0	-562.72	0	976.78	0	0	0	0
24	SW	I[37]	-107.49	0	-562.72	0	976.78	0	0	0	0
24	SW	J[38]	-107.49	0	-108.97	0	2320.15	0	0	0	0
25	SW	I[38]	-107.49	0	-108.97	0	2320.15	0	0	0	0
25	SW	J[39]	-107.49	0	344.78	0	1848.51	0	0	0	0
26	SW	I[39]	-107.49	0	344.78	0	1848.51	0	0	0	0
26	SW	J[40]	-107.49	0	753.16	0	-127.78	0	0	0	0
27	SW	I[40]	-107.49	0	753.16	0	-127.78	0	0	0	0
27	SW	J[41]	-107.49	0	798.53	0	-438.12	0	0	0	0
28	SW	I[8]	-1.42	0	0	0	0	0	0	0	0
28	SW	J[15]	1.35	0	0	0	0	0	0	0	0
29	SW	I[7]	-2.09	0	0	0	0	0	0	0	0
29	SW	J[16]	2	0	0	0	0	0	0	0	0
1	CB	I[3]	-258.03	72.72	9.03	24.18	-48.15	-387.95	0	0	0
1	CB	J[1]	-258.03	72.72	9.03	24.18	-49.64	-399.95	0	0	0
2	CB	I[4]	-234.18	74.21	-0.99	-28.81	5.19	-387.36	0	0	0
2	CB	J[2]	-234.18	74.21	-0.99	-28.81	5.36	-399.97	0	0	0
3	CB	I[5]	-258.03	72.72	9.03	24.18	-33.71	-271.6	0	0	0
3	CB	J[3]	-258.03	72.72	9.03	24.18	-48.15	-387.95	0	0	0
4	CB	I[6]	-234.18	74.21	-0.99	-28.81	3.6	-268.63	0	0	0
4	CB	J[4]	-234.18	74.21	-0.99	-28.81	5.19	-387.36	0	0	0
5	CB	I[8]	-258.03	72.72	9.03	24.18	0	0	0	0	0
5	CB	J[5]	-258.03	72.72	9.03	24.18	-33.71	-271.6	0	0	0
6	CB	I[7]	-234.18	74.21	-0.99	-28.81	0	0	0	0	0
6	CB	J[6]	-234.18	74.21	-0.99	-28.81	3.6	-268.63	0	0	0

7	CB	I[20]	0	68.08	-76.96	-1198.66	-30.78	1081.36	0	-1198.66	0
7	CB	J[21]	0	68.08	-73.56	-1184.82	-0.68	1054.13	0	-1184.82	0
8	CB	I[21]	0	68.08	-73.56	-1184.82	-0.68	1054.13	0	-1184.82	0
8	CB	J[22]	0	68.08	-42.96	-1060.28	209.06	809.05	0	-1060.29	-0.01
9	CB	I[22]	0	68.08	-42.96	-1060.28	209.06	809.05	0	-1060.29	-0.01
9	CB	J[23]	0	68.08	-8.96	-921.9	312.91	536.75	0.02	-921.94	-0.04
10	CB	I[23]	0	68.08	-8.96	-921.9	312.91	536.75	0.02	-921.94	-0.04
10	CB	J[24]	0	68.08	25.04	-783.52	280.76	264.44	0.1	-783.73	-0.21
11	CB	I[24]	0	68.08	25.04	-783.52	280.76	264.44	0.1	-783.73	-0.21
11	CB	J[25]	0	68.08	59.04	-645.14	112.61	-7.86	0.57	-646.36	-1.22
12	CB	I[25]	0	68.08	59.04	-645.14	112.61	-7.86	0.57	-646.36	-1.22
12	CB	J[26]	0	68.08	93.04	-506.76	-191.54	-280.17	3.34	-513.85	-7.09
13	CB	I[26]	0	68.08	93.04	-506.76	-191.54	-280.17	3.34	-513.85	-7.09
13	CB	J[27]	0	68.08	127.04	-368.38	-631.69	-552.47	19.48	-409.7	-41.32
14	CB	I[27]	-9.03	-4.64	-131	-453.78	-642.28	-528.3	19.48	-409.7	44.08
14	CB	J[28]	-9.03	-4.64	-99.12	-324.05	-210.81	-510.89	3.34	-316.49	7.56
15	CB	I[28]	-9.03	-4.64	-99.12	-324.05	-210.81	-510.89	3.34	-316.49	7.56
15	CB	J[29]	-9.03	-4.64	-67.25	-194.32	101.12	-493.48	0.57	-193.02	1.3
16	CB	I[29]	-9.03	-4.64	-67.25	-194.32	101.12	-493.48	0.57	-193.02	1.3
16	CB	J[30]	-9.03	-4.64	-35.37	-64.58	293.53	-476.07	0.1	-64.37	0.22
17	CB	I[30]	-9.03	-4.64	-35.37	-64.58	293.53	-476.07	0.1	-64.37	0.22

17	CB	J[31]	-9.03	-4.64	-3.5	65.15	366.41	-458.66	0.03	65.15	0
18	CB	I[31]	-9.03	-4.64	-3.5	65.15	366.41	-458.66	0.03	65.15	0
18	CB	J[32]	-9.03	-4.64	28.38	194.88	319.75	-441.25	0.1	194.66	-0.22
19	CB	I[32]	-9.03	-4.64	28.38	194.88	319.75	-441.25	0.1	194.66	-0.22
19	CB	J[33]	-9.03	-4.64	60.25	324.61	153.56	-423.85	0.59	323.28	-1.33
20	CB	I[33]	-9.03	-4.64	60.25	324.61	153.56	-423.85	0.59	323.28	-1.33
20	CB	J[34]	-9.03	-4.64	92.13	454.34	-132.15	-406.44	3.43	446.59	-7.75
21	CB	I[34]	-9.03	-4.64	92.13	454.34	-132.15	-406.44	3.43	446.59	-7.75
21	CB	J[35]	-9.03	-4.64	124	584.07	-537.4	-389.03	19.96	538.9	-45.17
22	CB	I[35]	-8.03	-78.85	-110.17	496.55	-536.23	-417.84	19.96	538.9	42.35
22	CB	J[36]	-8.03	-78.85	-76.17	634.93	-163.54	-102.45	3.43	642.2	7.27
23	CB	I[36]	-8.03	-78.85	-76.17	634.93	-163.54	-102.45	3.43	642.2	7.27
23	CB	J[37]	-8.03	-78.85	-42.17	773.31	73.14	212.95	0.59	774.56	1.25
24	CB	I[37]	-8.03	-78.85	-42.17	773.31	73.14	212.95	0.59	774.56	1.25
24	CB	J[38]	-8.03	-78.85	-8.17	911.69	173.83	528.35	0.1	911.91	0.21
25	CB	I[38]	-8.03	-78.85	-8.17	911.69	173.83	528.35	0.1	911.91	0.21
25	CB	J[39]	-8.03	-78.85	25.83	1050.07	138.51	843.74	0.02	1050.11	0.04
26	CB	I[39]	-8.03	-78.85	25.83	1050.07	138.51	843.74	0.02	1050.11	0.04

26	CB	J[40]	-8.03	-78.85	56.43	1174.62	-9.55	1127.6	0	1174.63	0.01
27	CB	I[40]	-8.03	-78.85	56.43	1174.62	-9.55	1127.6	0	1174.63	0.01
27	CB	J[41]	-8.03	-78.85	59.83	1188.45	-32.8	1159.14	0	1188.46	0
28	CB	I[8]	0	0	0	0	0	0	0	0	0
28	CB	J[15]	0	0	0	0	0	0	0	0	0
29	CB	I[7]	0	0	0	0	0	0	0	0	0
29	CB	J[16]	0	0	0	0	0	0	0	0	0
1	MVC(Max)	I[3]	68.59	0	136.59	0	556.7	918.04	0	0	0
1	MVC(Max)	J[1]	68.59	0	136.59	0	573.91	946.44	0	0	0
2	MVC(Max)	I[4]	109.1	0	230.63	56.65	1016.2	926.24	0	0	0
2	MVC(Max)	J[2]	109.1	0	230.63	56.65	1049.3	956.4	0	0	0
3	MVC(Max)	I[5]	68.59	0	136.59	0	389.74	642.72	0	0	0
3	MVC(Max)	J[3]	68.59	0	136.59	0	556.7	918.04	0	0	0
4	MVC(Max)	I[6]	109.1	0	230.63	56.65	704.72	642.33	0	0	0
4	MVC(Max)	J[4]	109.1	0	230.63	56.65	1016.2	926.24	0	0	0
5	MVC(Max)	I[8]	68.59	0	136.59	0	0	0	0	0	0
5	MVC(Max)	J[5]	68.59	0	136.59	0	389.74	642.72	0	0	0
6	MVC(Max)	I[7]	109.1	0	230.63	56.65	0	0	0	0	0
6	MVC(Max)	J[6]	109.1	0	230.63	56.65	704.72	642.33	0	0	0
7	MVC(Max)	I[20]	0	0	121.75	2749.28	43.3	0	0	2523.39	0
7	MVC(Max)	J[21]	0	0	121.75	2724.26	0	0	84.8	2373.82	153.45

8	MVC(Max)	I[21]	0	0	121.75	2724.26	0	0	84.8	2373.82	153.45
8	MVC(Max)	J[22]	0	0	192.9	2503.97	2535.2	0	485.61	2265.8	831.02
9	MVC(Max)	I[22]	0	0	192.9	2503.97	2535.2	0	485.61	2265.8	831.02
9	MVC(Max)	J[23]	0	0	373.42	2269.41	4044.38	0	537.56	2057.04	1025.96
10	MVC(Max)	I[23]	0	0	373.42	2269.41	4044.38	0	537.56	2057.04	1025.96
10	MVC(Max)	J[24]	0	0	560.14	2045.59	4277.01	0	541.64	1819.9	1044.83
11	MVC(Max)	I[24]	0	0	560.14	2045.59	4277.01	0	541.64	1819.9	1044.83
11	MVC(Max)	J[25]	0	0	746.19	1832.52	3407.24	131.32	541.38	1599.87	1047.79
12	MVC(Max)	I[25]	0	0	746.19	1832.52	3407.24	131.32	541.38	1599.87	1047.79
12	MVC(Max)	J[26]	0	0	924.1	1630.29	1695.96	685.56	535.53	1422.62	1058.91
13	MVC(Max)	I[26]	0	0	924.1	1630.29	1695.96	685.56	535.53	1422.62	1058.91
13	MVC(Max)	J[27]	0	0	1085.82	1439.35	377.83	1282.22	489.14	1313.01	1160.29
14	MVC(Max)	I[27]	104.35	32.69	59.98	1602.39	305.88	1235.8	489.14	1313.01	1019.85
14	MVC(Max)	J[28]	104.35	32.69	92.65	1426	1390.93	1149.87	499.7	1190.56	1035.59
15	MVC(Max)	I[28]	104.35	32.69	92.65	1426	1390.93	1149.87	499.7	1190.56	1035.59
15	MVC(Max)	J[29]	104.35	32.69	199.71	1257.89	2963.84	1063.93	501.97	1028.28	1038.38
16	MVC(Max)	I[29]	104.35	32.69	199.71	1257.89	2963.84	1063.93	501.97	1028.28	1038.38
16	MVC(Max)	J[30]	104.35	32.69	331.28	1098.46	4088.37	978	502.7	868.44	1039.61
17	MVC(Max)	I[30]	104.35	32.69	331.28	1098.46	4088.37	978	502.7	868.44	1039.61
17	MVC(Max)	J[31]	104.35	32.69	480.86	947.77	4440.45	892.26	502.8	717.94	1039.87
18	MVC(Max)	I[31]	104.35	32.69	480.86	947.77	4440.45	892.26	502.8	717.94	1039.87
18	MVC(Max)	J[32]	104.35	32.69	641.18	805.85	3986.33	894.26	502.69	578.05	1040.17
19	MVC(Max)	I[32]	104.35	32.69	641.18	805.85	3986.33	894.26	502.69	578.05	1040.17
19	MVC(Max)	J[33]	104.35	32.69	804.16	672.7	2786.78	917.3	501.91	449.79	1041.9
20	MVC(Max)	I[33]	104.35	32.69	804.16	672.7	2786.78	917.3	501.91	449.79	1041.9

20	MVC(Max)	J[34]	104.35	32.69	960.99	548.36	1323.57	940.33	499.43	342.97	1052.68
21	MVC(Max)	I[34]	104.35	32.69	960.99	548.36	1323.57	940.33	499.43	342.97	1052.68
21	MVC(Max)	J[35]	104.35	32.69	1102.05	433.15	580.05	963.36	488.31	271.13	1097
22	MVC(Max)	I[35]	147.26	186.39	26.76	570.16	525.31	1017.43	488.31	271.13	945.58
22	MVC(Max)	J[36]	147.26	186.39	128.96	434.41	1822.47	358.96	535.63	182.81	1028.07
23	MVC(Max)	I[36]	147.26	186.39	128.96	434.41	1822.47	358.96	535.63	182.81	1028.07
23	MVC(Max)	J[37]	147.26	186.39	294.78	309	3129.55	0	540.71	75.08	1044.19
24	MVC(Max)	I[37]	147.26	186.39	294.78	309	3129.55	0	540.71	75.08	1044.19
24	MVC(Max)	J[38]	147.26	186.39	499.16	194.72	3321.74	0	537.42	5.23	1048.42
25	MVC(Max)	I[38]	147.26	186.39	499.16	194.72	3321.74	0	537.42	5.23	1048.42
25	MVC(Max)	J[39]	147.26	186.39	733.94	91.72	2179.94	0	485.6	0	1126.29
26	MVC(Max)	I[39]	147.26	186.39	733.94	91.72	2179.94	0	485.6	0	1126.29
26	MVC(Max)	J[40]	147.26	186.39	963.65	8.66	162.47	0	84.8	495.5	1894.69
27	MVC(Max)	I[40]	147.26	186.39	963.65	8.66	162.47	0	84.8	495.5	1894.69
27	MVC(Max)	J[41]	147.26	186.39	989.82	0	217.19	0	0	815.15	2171.28
28	MVC(Max)	I[8]	0	0	0	0	0	0	0	0	0
28	MVC(Max)	J[15]	0	0	0	0	0	0	0	0	0
29	MVC(Max)	I[7]	0	0	0	0	0	0	0	0	0
29	MVC(Max)	J[16]	0	0	0	0	0	0	0	0	0
1	MVC(Min)	I[3]	-1296.11	-188.81	-118.26	-46.72	-657.96	0	0	0	0
1	MVC(Min)	J[1]	-1296.11	-188.81	-118.26	-46.72	-678.31	0	0	0	0
2	MVC(Min)	I[4]	-1260.59	-194.9	-218.72	0	-1065.6	0	0	0	0
2	MVC(Min)	J[2]	-1260.59	-194.9	-218.72	0	-1100.3	0	0	0	0
3	MVC(Min)	I[5]	-1296.11	-188.81	-118.26	-46.72	-460.63	0	0	0	0
3	MVC(Min)	J[3]	-1296.11	-188.81	-118.26	-46.72	-657.96	0	0	0	0

4	MVC(Min)	I[6]	-1260.59	-194.9	-218.72	0	-738.94	0	0	0	0
4	MVC(Min)	J[4]	-1260.59	-194.9	-218.72	0	-1065.6	0	0	0	0
5	MVC(Min)	I[8]	-1296.11	-188.81	-118.26	-46.72	0	0	0	0	0
5	MVC(Min)	J[5]	-1296.11	-188.81	-118.26	-46.72	-460.63	0	0	0	0
6	MVC(Min)	I[7]	-1260.59	-194.9	-218.72	0	0	0	0	0	0
6	MVC(Min)	J[6]	-1260.59	-194.9	-218.72	0	-738.94	0	0	0	0
7	MVC(Min)	I[20]	0	-162.45	-1015.33	0	-353.86	-2297.71	0	-814.94	-2171.29
7	MVC(Min)	J[21]	0	-162.45	-990.77	-8.24	-257.68	-2238.05	0	-493.05	-1894.7
8	MVC(Min)	I[21]	0	-162.45	-990.77	-8.24	-257.68	-2238.05	0	-493.05	-1894.7
8	MVC(Min)	J[22]	0	-162.45	-777.5	-87.21	-391.1	-1701.06	0	0	-1126.34
9	MVC(Min)	I[22]	0	-162.45	-777.5	-87.21	-391.1	-1701.06	0	0	-1126.34
9	MVC(Min)	J[23]	0	-162.45	-561.87	-185.15	-823.78	-1104.4	-0.02	-4.81	-1048.71
10	MVC(Min)	I[23]	0	-162.45	-561.87	-185.15	-823.78	-1104.4	-0.02	-4.81	-1048.71
10	MVC(Min)	J[24]	0	-162.45	-373.11	-293.84	-1256.5	-511	-0.12	-70.3	-1046.13
11	MVC(Min)	I[24]	0	-162.45	-373.11	-293.84	-1256.5	-511	-0.12	-70.3	-1046.13
11	MVC(Min)	J[25]	0	-162.45	-215.25	-413.24	-1689.2	-116.4	-0.67	-175.64	-1044.12
12	MVC(Min)	I[25]	0	-162.45	-215.25	-413.24	-1689.2	-116.4	-0.67	-175.64	-1044.12
12	MVC(Min)	J[26]	0	-162.45	-91.71	-543.26	-2136	0	-3.95	-292.01	-1028.39
13	MVC(Min)	I[26]	0	-162.45	-91.71	-543.26	-2136	0	-3.95	-292.01	-1028.39
13	MVC(Min)	J[27]	0	-162.45	-20.84	-683.25	-3256.1	0	-25.52	-382.12	-948.31
14	MVC(Min)	I[27]	-123.33	-20.47	-1106.09	-545.95	-3334.6	0	-25.52	-382.12	-1093.4
14	MVC(Min)	J[28]	-123.33	-20.47	-957.86	-669.23	-1829.7	0	-2.94	-459.52	-1052.09
15	MVC(Min)	I[28]	-123.33	-20.47	-957.86	-669.23	-1829.7	0	-2.94	-459.52	-1052.09
15	MVC(Min)	J[29]	-123.33	-20.47	-796.69	-801.64	-1370.1	0	-0.43	-575.58	-1041.81
16	MVC(Min)	I[29]	-123.33	-20.47	-796.69	-801.64	-1370.1	0	-0.43	-575.58	-1041.81

16	MVC(Min)	J[30]	-123.33	-20.47	-631.96	-942.86	-1106.4	0	-0.07	-713.48	-1040.16
17	MVC(Min)	I[30]	-123.33	-20.47	-631.96	-942.86	-1106.4	0	-0.07	-713.48	-1040.16
17	MVC(Min)	J[31]	-123.33	-20.47	-472.28	-1092.86	-842.74	0	-0.02	-863.03	-1039.87
18	MVC(Min)	I[31]	-123.33	-20.47	-472.28	-1092.86	-842.74	0	-0.02	-863.03	-1039.87
18	MVC(Min)	J[32]	-123.33	-20.47	-325.5	-1251.62	-805.97	0	-0.06	-1023.15	-1039.59
19	MVC(Min)	I[32]	-123.33	-20.47	-325.5	-1251.62	-805.97	0	-0.06	-1023.15	-1039.59
19	MVC(Min)	J[33]	-123.33	-20.47	-198.67	-1419.12	-896.19	0	-0.37	-1192.47	-1038.29
20	MVC(Min)	I[33]	-123.33	-20.47	-198.67	-1419.12	-896.19	0	-0.37	-1192.47	-1038.29
20	MVC(Min)	J[34]	-123.33	-20.47	-100.15	-1595.3	-1313	0	-3.11	-1363.4	-1035.12
21	MVC(Min)	I[34]	-123.33	-20.47	-100.15	-1595.3	-1313	0	-3.11	-1363.4	-1035.12
21	MVC(Min)	J[35]	-123.33	-20.47	-96.88	-1779.76	-3400.2	0	-26.89	-1490.16	-1018.55
22	MVC(Min)	I[35]	-262.24	0	-1046.92	-1604.56	-3236.9	0	-26.89	-1490.16	-1162.09
22	MVC(Min)	J[36]	-262.24	0	-854.87	-1807.81	-2203.7	-79.64	-4.36	-1603.74	-1058.65
23	MVC(Min)	I[36]	-262.24	0	-854.87	-1807.81	-2203.7	-79.64	-4.36	-1603.74	-1058.65
23	MVC(Min)	J[37]	-262.24	0	-645.74	-2023.04	-1605	-462.02	-0.75	-1791.63	-1046.19
24	MVC(Min)	I[37]	-262.24	0	-645.74	-2023.04	-1605	-462.02	-0.75	-1791.63	-1046.19
24	MVC(Min)	J[38]	-262.24	0	-432.36	-2249.68	-1006.2	-1038.15	-0.13	-2028.38	-1026.13
25	MVC(Min)	I[38]	-262.24	0	-432.36	-2249.68	-1006.2	-1038.15	-0.13	-2028.38	-1026.13
25	MVC(Min)	J[39]	-262.24	0	-226.47	-2487.64	-410.84	-1723.34	-0.02	-2240.83	-831.04
26	MVC(Min)	I[39]	-262.24	0	-226.47	-2487.64	-410.84	-1723.34	-0.02	-2240.83	-831.04
26	MVC(Min)	J[40]	-262.24	0	-168.51	-2711.47	-321.46	-2340.01	0	-2353.13	-153.45
27	MVC(Min)	I[40]	-262.24	0	-168.51	-2711.47	-321.46	-2340.01	0	-2353.13	-153.45
27	MVC(Min)	J[41]	-262.24	0	-168.51	-2736.9	-519.98	-2408.53	0	-2506.79	-0.01
28	MVC(Min)	I[8]	-0.01	0	0	0	0	0	0	0	0
28	MVC(Min)	J[15]	-0.01	0	0	0	0	0	0	0	0

29	MVC(Min)	I[7]	-0.02	0	0	0	0	0	0	0	0
29	MVC(Min)	J[16]	-0.02	0	0	0	0	0	0	0	0
1	MVC(All)	I[3]	-1296.11	-188.81	136.59	-46.72	-657.96	918.04	0	0	0
1	MVC(All)	J[1]	-1296.11	-188.81	136.59	-46.72	-678.31	946.44	0	0	0
2	MVC(All)	I[4]	-1260.59	-194.9	230.63	56.65	-1065.6	926.24	0	0	0
2	MVC(All)	J[2]	-1260.59	-194.9	230.63	56.65	-1100.3	956.4	0	0	0
3	MVC(All)	I[5]	-1296.11	-188.81	136.59	-46.72	-460.63	642.72	0	0	0
3	MVC(All)	J[3]	-1296.11	-188.81	136.59	-46.72	-657.96	918.04	0	0	0
4	MVC(All)	I[6]	-1260.59	-194.9	230.63	56.65	-738.94	642.33	0	0	0
4	MVC(All)	J[4]	-1260.59	-194.9	230.63	56.65	-1065.6	926.24	0	0	0
5	MVC(All)	I[8]	-1296.11	-188.81	136.59	-46.72	0	0	0	0	0
5	MVC(All)	J[5]	-1296.11	-188.81	136.59	-46.72	-460.63	642.72	0	0	0
6	MVC(All)	I[7]	-1260.59	-194.9	230.63	56.65	0	0	0	0	0
6	MVC(All)	J[6]	-1260.59	-194.9	230.63	56.65	-738.94	642.33	0	0	0
7	MVC(All)	I[20]	0	-162.45	-1015.33	2749.28	-353.86	-2297.71	0	2523.39	-2171.29
7	MVC(All)	J[21]	0	-162.45	-990.77	2724.26	-257.68	-2238.05	84.8	2373.82	-1894.7
8	MVC(All)	I[21]	0	-162.45	-990.77	2724.26	-257.68	-2238.05	84.8	2373.82	-1894.7
8	MVC(All)	J[22]	0	-162.45	-777.5	2503.97	2535.2	-1701.06	485.61	2265.8	-1126.34
9	MVC(All)	I[22]	0	-162.45	-777.5	2503.97	2535.2	-1701.06	485.61	2265.8	-1126.34
9	MVC(All)	J[23]	0	-162.45	-561.87	2269.41	4044.38	-1104.4	537.56	2057.04	-1048.71
10	MVC(All)	I[23]	0	-162.45	-561.87	2269.41	4044.38	-1104.4	537.56	2057.04	-1048.71
10	MVC(All)	J[24]	0	-162.45	560.14	2045.59	4277.01	-511	541.64	1819.9	-1046.13

11	MVC(All)	I[24]	0	-162.45	560.14	2045.59	4277.01	-511	541.64	1819.9	-1046.13
11	MVC(All)	J[25]	0	-162.45	746.19	1832.52	3407.24	131.32	541.38	1599.87	1047.79
12	MVC(All)	I[25]	0	-162.45	746.19	1832.52	3407.24	131.32	541.38	1599.87	1047.79
12	MVC(All)	J[26]	0	-162.45	924.1	1630.29	-2136	685.56	535.53	1422.62	1058.91
13	MVC(All)	I[26]	0	-162.45	924.1	1630.29	-2136	685.56	535.53	1422.62	1058.91
13	MVC(All)	J[27]	0	-162.45	1085.82	1439.35	-3256.1	1282.22	489.14	1313.01	1160.29
14	MVC(All)	I[27]	-123.33	32.69	-1106.09	1602.39	-3334.6	1235.8	489.14	1313.01	-1093.4
14	MVC(All)	J[28]	-123.33	32.69	-957.86	1426	-1829.7	1149.87	499.7	1190.56	-1052.09
15	MVC(All)	I[28]	-123.33	32.69	-957.86	1426	-1829.7	1149.87	499.7	1190.56	-1052.09
15	MVC(All)	J[29]	-123.33	32.69	-796.69	1257.89	2963.84	1063.93	501.97	1028.28	-1041.81
16	MVC(All)	I[29]	-123.33	32.69	-796.69	1257.89	2963.84	1063.93	501.97	1028.28	-1041.81
16	MVC(All)	J[30]	-123.33	32.69	-631.96	1098.46	4088.37	978	502.7	868.44	-1040.16
17	MVC(All)	I[30]	-123.33	32.69	-631.96	1098.46	4088.37	978	502.7	868.44	-1040.16
17	MVC(All)	J[31]	-123.33	32.69	480.86	-1092.86	4440.45	892.26	502.8	-863.03	1039.87
18	MVC(All)	I[31]	-123.33	32.69	480.86	-1092.86	4440.45	892.26	502.8	-863.03	1039.87
18	MVC(All)	J[32]	-123.33	32.69	641.18	-1251.62	3986.33	894.26	502.69	-1023.15	1040.17
19	MVC(All)	I[32]	-123.33	32.69	641.18	-1251.62	3986.33	894.26	502.69	-1023.15	1040.17
19	MVC(All)	J[33]	-123.33	32.69	804.16	-1419.12	2786.78	917.3	501.91	-1192.47	1041.9
20	MVC(All)	I[33]	-123.33	32.69	804.16	-1419.12	2786.78	917.3	501.91	-1192.47	1041.9
20	MVC(All)	J[34]	-123.33	32.69	960.99	-1595.3	1323.57	940.33	499.43	-1363.4	1052.68
21	MVC(All)	I[34]	-123.33	32.69	960.99	-1595.3	1323.57	940.33	499.43	-1363.4	1052.68

21	MVC(All)	J[35]	-123.33	32.69	1102.05	-1779.76	-3400.2	963.36	488.31	-1490.16	1097
22	MVC(All)	I[35]	-262.24	186.39	-1046.92	-1604.56	-3236.9	1017.43	488.31	-1490.16	-1162.09
22	MVC(All)	J[36]	-262.24	186.39	-854.87	-1807.81	-2203.7	358.96	535.63	-1603.74	-1058.65
23	MVC(All)	I[36]	-262.24	186.39	-854.87	-1807.81	-2203.7	358.96	535.63	-1603.74	-1058.65
23	MVC(All)	J[37]	-262.24	186.39	-645.74	-2023.04	3129.55	-462.02	540.71	-1791.63	-1046.19
24	MVC(All)	I[37]	-262.24	186.39	-645.74	-2023.04	3129.55	-462.02	540.71	-1791.63	-1046.19
24	MVC(All)	J[38]	-262.24	186.39	499.16	-2249.68	3321.74	-1038.15	537.42	-2028.38	1048.42
25	MVC(All)	I[38]	-262.24	186.39	499.16	-2249.68	3321.74	-1038.15	537.42	-2028.38	1048.42
25	MVC(All)	J[39]	-262.24	186.39	733.94	-2487.64	2179.94	-1723.34	485.6	-2240.83	1126.29
26	MVC(All)	I[39]	-262.24	186.39	733.94	-2487.64	2179.94	-1723.34	485.6	-2240.83	1126.29
26	MVC(All)	J[40]	-262.24	186.39	963.65	-2711.47	-321.46	-2340.01	84.8	-2353.13	1894.69
27	MVC(All)	I[40]	-262.24	186.39	963.65	-2711.47	-321.46	-2340.01	84.8	-2353.13	1894.69
27	MVC(All)	J[41]	-262.24	186.39	989.82	-2736.9	-519.98	-2408.53	0	-2506.79	2171.28
28	MVC(All)	I[8]	-0.01	0	0	0	0	0	0	0	0
28	MVC(All)	J[15]	-0.01	0	0	0	0	0	0	0	0
29	MVC(All)	I[7]	-0.02	0	0	0	0	0	0	0	0
29	MVC(All)	J[16]	-0.02	0	0	0	0	0	0	0	0
1	1.4DL+ LL(All)	I[3]	-7216.64	-124.77	345.55	33.85	-1758.6	558.52	0	0	0
1	1.4DL+ LL(All)	J[1]	-7231.33	-124.77	345.55	33.85	-1813	575.79	0	0	0
2	1.4DL+ LL(All)	I[4]	-6686.33	-129.99	-282.37	-40.34	1323.37	569.19	0	0	0

2	1.4DL+ LL(All)	J[2]	-6701.47	-129.99	-282.37	-40.34	1366.47	587.72	0	0	0
3	1.4DL+ LL(All)	I[5]	-7074.14	-124.77	345.55	33.85	-1231.2	391.01	0	0	0
3	1.4DL+ LL(All)	J[3]	-7216.64	-124.77	345.55	33.85	-1758.6	558.52	0	0	0
4	1.4DL+ LL(All)	I[6]	-6543.83	-129.99	-282.37	-40.34	917.74	394.72	0	0	0
4	1.4DL+ LL(All)	J[4]	-6686.33	-129.99	-282.37	-40.34	1323.37	569.19	0	0	0
5	1.4DL+ LL(All)	I[8]	-6741.48	-124.77	345.55	33.85	0	0	0	0	0
5	1.4DL+ LL(All)	J[5]	-7074.14	-124.77	345.55	33.85	-1231.2	391.01	0	0	0
6	1.4DL+ LL(All)	I[7]	-6221.42	-129.99	-282.37	-40.34	0	0	0	0	0
6	1.4DL+ LL(All)	J[6]	-6543.83	-129.99	-282.37	-40.34	917.74	394.72	0	0	0
7	1.4DL+ LL(All)	I[20]	0	-99.63	-2764.16	-1678.12	-1042.9	1513.9	0	-2656.05	-2605.54
7	1.4DL+ LL(All)	J[21]	0	-99.63	-2666.4	-1668.63	-322.87	1475.78	101.76	-2250.42	-2273.65
8	1.4DL+ LL(All)	I[21]	0	-99.63	-2666.4	-1668.63	-322.87	1475.78	101.76	-2250.42	-2273.65
8	1.4DL+ LL(All)	J[22]	0	-99.63	-1795.92	-1589.04	7241.29	1132.68	582.74	-1484.4	-1351.61
9	1.4DL+ LL(All)	I[22]	0	-99.63	-1795.92	-1589.04	7241.29	1132.68	582.74	-1484.4	-1351.61
9	1.4DL+ LL(All)	J[23]	0	-99.63	-854.3	-1512.84	11138.3	751.45	645.09	-1296.48	-1258.5
10	1.4DL+ LL(All)	I[23]	0	-99.63	-854.3	-1512.84	11138.3	751.45	645.09	-1296.48	-1258.5

10	1.4DL+ LL(All)	J[24]	0	-99.63	1174.95	-1449.53	10772	370.22	650.11	-1181.58	-1255.64
11	1.4DL+ LL(All)	I[24]	0	-99.63	1174.95	-1449.53	10772	370.22	650.11	-1181.58	-1255.64
11	1.4DL+ LL(All)	J[25]	0	-99.63	2081.06	-1399.09	6351.44	-150.69	650.45	-1115.67	1255.65
12	1.4DL+ LL(All)	I[25]	0	-99.63	2081.06	-1399.09	6351.44	-150.69	650.45	-1115.67	1255.65
12	1.4DL+ LL(All)	J[26]	0	-99.63	2977.41	-1361.37	-6408.7	430.44	647.32	-1069.8	1260.76
13	1.4DL+ LL(All)	I[26]	0	-99.63	2977.41	-1361.37	-6408.7	430.44	647.32	-1069.8	1260.76
13	1.4DL+ LL(All)	J[27]	0	-99.63	3854.32	-1335.64	-16592	-773.46	614.23	-1032.12	1334.5
14	1.4DL+ LL(All)	I[27]	-329.63	32.72	-3958.24	-1290.43	-16900	743.34	614.23	-1032.12	1285.53
14	1.4DL+ LL(All)	J[28]	-329.63	32.72	-3140.19	1257.53	-6428.3	-715.25	604.32	-994.51	1253.29
15	1.4DL+ LL(All)	I[28]	-329.63	32.72	-3140.19	1257.53	-6428.3	-715.25	604.32	-994.51	1253.29
15	1.4DL+ LL(All)	J[29]	-329.63	32.72	-2306.61	1237.43	5588.86	-690.87	603.16	963.71	-1248.35
16	1.4DL+ LL(All)	I[29]	-329.63	32.72	-2306.61	1237.43	5588.86	-690.87	603.16	963.71	-1248.35
16	1.4DL+ LL(All)	J[30]	-329.63	32.72	-1468.76	1227.73	10802.7	-666.5	603.38	952.02	-1247.88
17	1.4DL+ LL(All)	I[30]	-329.63	32.72	-1468.76	1227.73	10802.7	-666.5	603.38	952.02	-1247.88
17	1.4DL+ LL(All)	J[31]	-329.63	32.72	-636.98	1228.53	12688.9	-642.13	603.4	952.74	1247.85
18	1.4DL+ LL(All)	I[31]	-329.63	32.72	-636.98	1228.53	12688.9	-642.13	603.4	952.74	1247.85

18	1.4DL+ LL(All)	J[32]	-329.63	32.72	1339.34	1239.85	11207.1	-617.76	603.37	966.17	1247.89
19	1.4DL+ LL(All)	I[32]	-329.63	32.72	1339.34	1239.85	11207.1	-617.76	603.37	966.17	1247.89
19	1.4DL+ LL(All)	J[33]	-329.63	32.72	2175.1	1261.69	6430.05	-593.38	603.11	992.34	1248.42
20	1.4DL+ LL(All)	I[33]	-329.63	32.72	2175.1	1261.69	6430.05	-593.38	603.11	992.34	1248.42
20	1.4DL+ LL(All)	J[34]	-329.63	32.72	3003.46	1294.11	-4227.8	-569.01	604.11	1036.79	-1253
21	1.4DL+ LL(All)	I[34]	-329.63	32.72	3003.46	1294.11	-4227.8	-569.01	604.11	1036.79	-1253
21	1.4DL+ LL(All)	J[35]	-329.63	32.72	3812.9	1337.48	-14871	611.4	613.91	1079.82	-1285.49
22	1.4DL+ LL(All)	I[35]	-476.42	113.28	-3468.85	1379.37	-14652	635.94	613.91	1079.82	-1335.23
22	1.4DL+ LL(All)	J[36]	-476.42	113.28	-2555.53	1410.2	-5927.7	287.33	647.55	1118.45	-1260.2
23	1.4DL+ LL(All)	I[36]	-476.42	113.28	-2555.53	1410.2	-5927.7	287.33	647.55	1118.45	-1260.2
23	1.4DL+ LL(All)	J[37]	-476.42	113.28	-1621.73	1453.44	5225.35	298.13	649.68	1174.48	1254.77
24	1.4DL+ LL(All)	I[37]	-476.42	113.28	-1621.73	1453.44	5225.35	298.13	649.68	1174.48	1254.77
24	1.4DL+ LL(All)	J[38]	-476.42	113.28	-682.83	1510.04	7477.65	739.68	645.04	1282.95	1258.41
25	1.4DL+ LL(All)	I[38]	-476.42	113.28	-682.83	1510.04	7477.65	739.68	645.04	1282.95	1258.41
25	1.4DL+ LL(All)	J[39]	-476.42	113.28	1399.59	1580.16	5397.77	1181.24	582.74	1470.16	1351.6
26	1.4DL+ LL(All)	I[39]	-476.42	113.28	1399.59	1580.16	5397.77	1181.24	582.74	1470.16	1351.6

26	1.4DL+ LL(All)	J[40]	-476.42	113.28	2289.8	1654.86	-578.02	1578.64	101.76	2239.08	2273.65
27	1.4DL+ LL(All)	I[40]	-476.42	113.28	2289.8	1654.86	-578.02	1578.64	101.76	2239.08	2273.65
27	1.4DL+ LL(All)	J[41]	-476.42	113.28	2389.49	1663.84	-1283.3	1622.79	0	2642.02	2605.54
28	1.4DL+ LL(All)	I[8]	-2.01	0	0	0	0	0	0	0	0
28	1.4DL+ LL(All)	J[15]	1.89	0	0	0	0	0	0	0	0
29	1.4DL+ LL(All)	I[7]	-2.95	0	0	0	0	0	0	0	0
29	1.4DL+ LL(All)	J[16]	2.8	0	0	0	0	0	0	0	0

Table 37 Table of Displacements

节点	荷载	DX (m)	DY (m)	DZ (m)	RX ([rad])	RY ([rad])	RZ ([rad])	RW (rad/m)
1	SW	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	SW	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	SW	-0.000001	0.000000	-0.000000	0.000000	-0.000004	0.000000	0.000000
4	SW	0.000001	0.000000	-0.000000	0.000000	0.000004	0.000000	0.000000
5	SW	-0.000036	0.000000	-0.000003	0.000000	-0.000034	0.000000	0.000000
6	SW	0.000035	0.000000	-0.000003	0.000000	0.000033	0.000000	0.000000
7	SW	0.000228	0.000000	-0.000000	0.000000	-0.000281	0.000000	0.000000
8	SW	-0.000241	0.000000	-0.000000	0.000000	0.000129	0.000000	0.000000
9	SW	-0.000832	0.000000	0.000000	0.000000	0.000672	0.000000	0.000000
10	SW	0.000227	0.000000	0.000000	0.000000	-0.000300	0.000000	0.000000
11	SW	-0.000832	0.000000	0.000000	0.000000	0.000672	0.000000	0.000000
12	SW	0.000227	0.000000	0.000000	0.000000	-0.000300	0.000000	0.000000
13	SW	-0.000768	0.000000	0.000000	0.000000	0.000672	0.000000	0.000000
14	SW	0.000199	0.000000	0.000000	0.000000	-0.000300	0.000000	0.000000
15	SW	-0.000220	0.000000	-0.000000	0.000000	0.000129	0.000000	0.000000
16	SW	0.000180	0.000000	-0.000000	0.000000	-0.000281	0.000000	0.000000
17	SW	-0.000768	0.000000	0.000000	0.000000	0.000672	0.000000	0.000000

18	SW	0.000199	0.000000	0.000000	0.000000	-0.000300	0.000000	0.000000
19	SW	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
20	SW	0.000307	0.000000	0.000268	0.000000	0.000672	0.000000	0.000000
21	SW	0.000307	0.000000	0.000000	0.000000	0.000672	0.000000	0.000000
22	SW	0.000235	0.000000	-0.002484	0.000000	0.000550	0.000000	0.000000
23	SW	0.000043	0.000000	-0.004183	0.000000	0.000225	0.000000	0.000000
24	SW	-0.000174	0.000000	-0.004302	0.000000	-0.000142	0.000000	0.000000
25	SW	-0.000320	0.000000	-0.002998	0.000000	-0.000389	0.000000	0.000000
26	SW	-0.000298	0.000000	-0.001078	0.000000	-0.000353	0.000000	0.000000
27	SW	-0.000014	0.000000	-0.000000	0.000000	0.000129	0.000000	0.000000
28	SW	0.000260	0.000000	-0.001952	0.000000	0.000595	0.000000	0.000000
29	SW	0.000287	0.000000	-0.004706	0.000000	0.000645	0.000000	0.000000
30	SW	0.000149	0.000000	-0.006953	0.000000	0.000413	0.000000	0.000000
31	SW	-0.000077	0.000000	-0.007889	0.000000	0.000033	0.000000	0.000000
32	SW	-0.000312	0.000000	-0.007209	0.000000	-0.000360	0.000000	0.000000
33	SW	-0.000474	0.000000	-0.005115	0.000000	-0.000633	0.000000	0.000000
34	SW	-0.000487	0.000000	-0.002310	0.000000	-0.000652	0.000000	0.000000
35	SW	-0.000270	0.000000	-0.000000	0.000000	-0.000281	0.000000	0.000000
36	SW	-0.000031	0.000000	-0.000221	0.000000	0.000124	0.000000	0.000000
37	SW	-0.000008	0.000000	-0.001134	0.000000	0.000162	0.000000	0.000000
38	SW	-0.000106	0.000000	-0.001598	0.000000	-0.000004	0.000000	0.000000
39	SW	-0.000229	0.000000	-0.001118	0.000000	-0.000212	0.000000	0.000000
40	SW	-0.000281	0.000000	0.000000	0.000000	-0.000300	0.000000	0.000000
41	SW	-0.000281	0.000000	0.000119	0.000000	-0.000300	0.000000	0.000000
42	SW	-0.000241	0.000000	0.000000	0.000000	0.000129	0.000000	0.000000
43	SW	-0.000220	0.000000	-0.000000	0.000000	0.000129	0.000000	0.000000
44	SW	-0.000241	0.000000	0.000000	0.000000	0.000129	0.000000	0.000000
45	SW	-0.000220	0.000000	-0.000000	0.000000	0.000129	0.000000	0.000000
46	SW	0.000228	0.000000	0.000000	0.000000	-0.000281	0.000000	0.000000
47	SW	0.000180	0.000000	-0.000000	0.000000	-0.000281	0.000000	0.000000
48	SW	0.000228	0.000000	0.000000	0.000000	-0.000281	0.000000	0.000000
49	SW	0.000180	0.000000	-0.000000	0.000000	-0.000281	0.000000	0.000000
1	CB	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	CB	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	CB	-0.000000	0.000000	0.000000	0.000000	-0.000000	0.000000	0.000000
4	CB	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

5	CB	-0.000003	0.000000	0.000000	0.000000	-0.000003	0.000000	0.000000
6	CB	0.000003	0.000000	0.000000	0.000000	0.000002	0.000000	0.000000
7	CB	0.000017	0.000000	0.000000	0.000000	-0.000021	0.000000	0.000000
8	CB	-0.000018	0.000000	0.000000	0.000000	0.000010	0.000000	0.000000
9	CB	-0.000062	0.000000	0.000000	0.000000	0.000050	0.000000	0.000000
10	CB	0.000017	0.000000	0.000000	0.000000	-0.000022	0.000000	0.000000
11	CB	-0.000062	0.000000	0.000000	0.000000	0.000050	0.000000	0.000000
12	CB	0.000017	0.000000	0.000000	0.000000	-0.000022	0.000000	0.000000
13	CB	-0.000058	0.000000	0.000000	0.000000	0.000050	0.000000	0.000000
14	CB	0.000015	0.000000	0.000000	0.000000	-0.000022	0.000000	0.000000
15	CB	-0.000016	0.000000	0.000000	0.000000	0.000010	0.000000	0.000000
16	CB	0.000013	0.000000	0.000000	0.000000	-0.000021	0.000000	0.000000
17	CB	-0.000058	0.000000	0.000000	0.000000	0.000050	0.000000	0.000000
18	CB	0.000015	0.000000	0.000000	0.000000	-0.000022	0.000000	0.000000
19	CB	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
20	CB	0.000023	-0.000000	0.000020	0.000000	0.000050	0.000000	0.000003
21	CB	0.000023	0.000000	0.000000	0.000000	0.000050	0.000000	0.000009
22	CB	0.000018	0.000018	-0.000186	-0.000030	0.000041	0.000000	0.000007
23	CB	0.000003	0.000030	-0.000313	-0.000050	0.000017	0.000000	0.000003
24	CB	-0.000013	0.000033	-0.000322	-0.000057	-0.000011	0.000000	0.000000
25	CB	-0.000024	0.000029	-0.000225	-0.000050	-0.000029	0.000000	-0.000003
26	CB	-0.000022	0.000018	-0.000081	-0.000030	-0.000026	0.000000	-0.000005
27	CB	-0.000001	0.000000	0.000000	0.000000	0.000010	0.000000	0.000001
28	CB	0.000019	0.000022	-0.000146	-0.000038	0.000045	0.000000	0.000008
29	CB	0.000022	0.000040	-0.000353	-0.000067	0.000048	0.000000	0.000006
30	CB	0.000011	0.000050	-0.000521	-0.000085	0.000031	0.000000	0.000003
31	CB	-0.000006	0.000054	-0.000591	-0.000091	0.000002	0.000000	0.000000
32	CB	-0.000023	0.000050	-0.000540	-0.000085	-0.000027	0.000000	-0.000003
33	CB	-0.000036	0.000040	-0.000383	-0.000067	-0.000047	0.000000	-0.000006
34	CB	-0.000036	0.000022	-0.000173	-0.000038	-0.000049	0.000000	-0.000008
35	CB	-0.000020	0.000000	0.000000	0.000000	-0.000021	0.000000	-0.000002
36	CB	-0.000002	0.000014	-0.000017	-0.000024	0.000009	0.000000	0.000003
37	CB	-0.000001	0.000022	-0.000085	-0.000037	0.000012	0.000000	0.000001
38	CB	-0.000008	0.000022	-0.000120	-0.000037	-0.000000	0.000000	-0.000002
39	CB	-0.000017	0.000014	-0.000084	-0.000023	-0.000016	0.000000	-0.000005
40	CB	-0.000021	0.000000	0.000000	0.000000	-0.000022	0.000000	-0.000007

41	CB	-0.000021	-0.000000	0.000009	0.000000	-0.000022	0.000000	-0.000003
42	CB	-0.000018	0.000000	0.000000	0.000000	0.000010	0.000000	0.000000
43	CB	-0.000016	0.000000	0.000000	0.000000	0.000010	0.000000	0.000000
44	CB	-0.000018	0.000000	0.000000	0.000000	0.000010	0.000000	0.000000
45	CB	-0.000016	0.000000	0.000000	0.000000	0.000010	0.000000	0.000000
46	CB	0.000017	0.000000	0.000000	0.000000	-0.000021	0.000000	0.000000
47	CB	0.000013	0.000000	0.000000	0.000000	-0.000021	0.000000	0.000000
48	CB	0.000017	0.000000	0.000000	0.000000	-0.000021	0.000000	0.000000
49	CB	0.000013	0.000000	0.000000	0.000000	-0.000021	0.000000	0.000000
1	MVC(最大)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	MVC(最大)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	MVC(最大)	0.000001	0.000000	0.000000	0.000000	0.000005	0.000000	0.000000
4	MVC(最大)	0.000001	0.000000	0.000000	0.000000	0.000008	0.000000	0.000000
5	MVC(最大)	0.000049	0.000000	0.000000	0.000000	0.000047	0.000000	0.000000
6	MVC(最大)	0.000072	0.000000	0.000000	0.000000	0.000067	0.000000	0.000000
7	MVC(最大)	0.000466	0.000000	0.000000	0.000000	0.000303	0.000000	0.000000
8	MVC(最大)	0.000334	0.000000	0.000000	0.000000	0.000458	0.000000	0.000000
9	MVC(最大)	0.000343	0.000000	0.000000	0.000000	0.000612	0.000000	0.000000
10	MVC(最大)	0.000576	0.000000	0.000000	0.000000	0.000196	0.000000	0.000000
11	MVC(最大)	0.000343	0.000000	0.000000	0.000000	0.000612	0.000000	0.000000
12	MVC(最大)	0.000576	0.000000	0.000000	0.000000	0.000196	0.000000	0.000000
13	MVC(最大)	0.000324	0.000000	0.000000	0.000000	0.000612	0.000000	0.000000
14	MVC(最大)	0.000538	0.000000	0.000000	0.000000	0.000196	0.000000	0.000000
15	MVC(最大)	0.000267	0.000000	0.000000	0.000000	0.000458	0.000000	0.000000
16	MVC(最大)	0.000398	0.000000	0.000000	0.000000	0.000303	0.000000	0.000000
17	MVC(最大)	0.000324	0.000000	0.000000	0.000000	0.000612	0.000000	0.000000
18	MVC(最大)	0.000538	0.000000	0.000000	0.000000	0.000196	0.000000	0.000000
19	MVC(最大)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
20	MVC(最大)	0.000245	0.000001	0.000245	0.000012	0.000612	0.000000	0.000043
21	MVC(最大)	0.000245	0.000000	0.000000	0.000000	0.000612	0.000000	0.000017
22	MVC(最大)	0.000197	0.000001	0.000792	0.000125	0.000536	0.000000	0.000001
23	MVC(最大)	0.000147	0.000002	0.001533	0.000215	0.000310	0.000000	0.000005
24	MVC(最大)	0.000149	0.000002	0.001980	0.000247	0.000059	0.000000	0.000011
25	MVC(最大)	0.000177	0.000003	0.001977	0.000219	0.000078	0.000000	0.000019
26	MVC(最大)	0.000261	0.000003	0.001368	0.000133	0.000249	0.000000	0.000025
27	MVC(最大)	0.000372	0.000000	0.000000	0.000000	0.000458	0.000000	0.000015

28	MVC(最大)	0.000427	0.000003	0.001224	0.000141	0.000577	0.000000	0.000002
29	MVC(最大)	0.000367	0.000003	0.001932	0.000251	0.000511	0.000000	0.000002
30	MVC(最大)	0.000224	0.000003	0.002208	0.000318	0.000321	0.000000	0.000006
31	MVC(最大)	0.000112	0.000002	0.002133	0.000340	0.000131	0.000000	0.000012
32	MVC(最大)	0.000139	0.000003	0.001834	0.000318	0.000114	0.000000	0.000018
33	MVC(最大)	0.000181	0.000003	0.001542	0.000251	0.000152	0.000000	0.000025
34	MVC(最大)	0.000236	0.000003	0.000943	0.000141	0.000206	0.000000	0.000029
35	MVC(最大)	0.000305	0.000000	0.000000	0.000000	0.000303	0.000000	0.000017
36	MVC(最大)	0.000322	0.000003	0.001181	0.000121	0.000312	0.000000	0.000004
37	MVC(最大)	0.000240	0.000003	0.001557	0.000186	0.000156	0.000000	0.000008
38	MVC(最大)	0.000133	0.000002	0.001334	0.000184	0.000102	0.000000	0.000016
39	MVC(最大)	0.000136	0.000001	0.000719	0.000114	0.000175	0.000000	0.000021
40	MVC(最大)	0.000143	0.000000	0.000000	0.000000	0.000196	0.000000	0.000024
41	MVC(最大)	0.000143	0.000001	0.000167	0.000012	0.000196	0.000000	0.000008
42	MVC(最大)	0.000334	0.000000	0.000000	0.000000	0.000458	0.000000	0.000000
43	MVC(最大)	0.000267	0.000000	0.000000	0.000000	0.000458	0.000000	0.000000
44	MVC(最大)	0.000334	0.000000	0.000000	0.000000	0.000458	0.000000	0.000000
45	MVC(最大)	0.000267	0.000000	0.000000	0.000000	0.000458	0.000000	0.000000
46	MVC(最大)	0.000466	0.000000	0.000000	0.000000	0.000303	0.000000	0.000000
47	MVC(最大)	0.000398	0.000000	0.000000	0.000000	0.000303	0.000000	0.000000
48	MVC(最大)	0.000466	0.000000	0.000000	0.000000	0.000303	0.000000	0.000000
49	MVC(最大)	0.000398	0.000000	0.000000	0.000000	0.000303	0.000000	0.000000
1	MVC(最小)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	MVC(最小)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	MVC(最小)	-0.000001	0.000000	0.000000	0.000000	-0.000008	0.000000	0.000000
4	MVC(最小)	-0.000001	0.000000	0.000000	0.000000	-0.000005	0.000000	0.000000
5	MVC(最小)	-0.000073	0.000000	0.000000	0.000000	-0.000069	0.000000	0.000000
6	MVC(最小)	-0.000048	0.000000	0.000000	0.000000	-0.000046	0.000000	0.000000
7	MVC(最小)	-0.000315	0.000000	0.000000	0.000000	-0.000424	0.000000	0.000000
8	MVC(最小)	-0.000494	0.000000	0.000000	0.000000	-0.000408	0.000000	0.000000
9	MVC(最小)	-0.000837	0.000000	0.000000	0.000000	-0.000217	0.000000	0.000000
10	MVC(最小)	-0.000329	0.000000	0.000000	0.000000	-0.000418	0.000000	0.000000
11	MVC(最小)	-0.000837	0.000000	0.000000	0.000000	-0.000217	0.000000	0.000000
12	MVC(最小)	-0.000329	0.000000	0.000000	0.000000	-0.000418	0.000000	0.000000
13	MVC(最小)	-0.000781	0.000000	0.000000	0.000000	-0.000217	0.000000	0.000000
14	MVC(最小)	-0.000312	0.000000	0.000000	0.000000	-0.000418	0.000000	0.000000

15	MVC(最小)	-0.000422	0.000000	0.000000	0.000000	-0.000408	0.000000	0.000000
16	MVC(最小)	-0.000288	0.000000	0.000000	0.000000	-0.000424	0.000000	0.000000
17	MVC(最小)	-0.000781	0.000000	0.000000	0.000000	-0.000217	0.000000	0.000000
18	MVC(最小)	-0.000312	0.000000	0.000000	0.000000	-0.000418	0.000000	0.000000
19	MVC(最小)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
20	MVC(最小)	-0.000144	-0.000007	-0.000087	-0.000001	-0.000217	0.000000	-0.000009
21	MVC(最小)	-0.000144	0.000000	0.000000	0.000000	-0.000217	0.000000	-0.000027
22	MVC(最小)	-0.000139	-0.000074	-0.002253	-0.000001	-0.000201	0.000000	-0.000025
23	MVC(最小)	-0.000129	-0.000127	-0.004093	-0.000003	-0.000147	0.000000	-0.000020
24	MVC(最小)	-0.000230	-0.000146	-0.004698	-0.000004	-0.000113	0.000000	-0.000012
25	MVC(最小)	-0.000385	-0.000129	-0.003829	-0.000005	-0.000330	0.000000	-0.000005
26	MVC(最小)	-0.000459	-0.000078	-0.002034	-0.000005	-0.000468	0.000000	-0.000003
27	MVC(最小)	-0.000415	0.000000	0.000000	0.000000	-0.000408	0.000000	-0.000017
28	MVC(最小)	-0.000319	-0.000083	-0.002205	-0.000005	-0.000259	0.000000	-0.000029
29	MVC(最小)	-0.000241	-0.000148	-0.004445	-0.000005	-0.000133	0.000000	-0.000025
30	MVC(最小)	-0.000181	-0.000188	-0.006103	-0.000005	-0.000081	0.000000	-0.000018
31	MVC(最小)	-0.000142	-0.000201	-0.006716	-0.000004	-0.000132	0.000000	-0.000012
32	MVC(最小)	-0.000234	-0.000188	-0.006036	-0.000004	-0.000333	0.000000	-0.000006
33	MVC(最小)	-0.000370	-0.000148	-0.004340	-0.000005	-0.000513	0.000000	-0.000002
34	MVC(最小)	-0.000422	-0.000083	-0.002121	-0.000004	-0.000562	0.000000	-0.000002
35	MVC(最小)	-0.000359	0.000000	0.000000	0.000000	-0.000424	0.000000	-0.000014
36	MVC(最小)	-0.000245	-0.000071	-0.001485	-0.000005	-0.000197	0.000000	-0.000022
37	MVC(最小)	-0.000191	-0.000110	-0.002564	-0.000004	-0.000022	0.000000	-0.000016
38	MVC(最小)	-0.000189	-0.000108	-0.002631	-0.000003	-0.000145	0.000000	-0.000008
39	MVC(最小)	-0.000207	-0.000067	-0.001554	-0.000001	-0.000344	0.000000	-0.000003
40	MVC(最小)	-0.000220	0.000000	0.000000	0.000000	-0.000418	0.000000	-0.000017
41	MVC(最小)	-0.000220	-0.000007	-0.000078	-0.000001	-0.000418	0.000000	-0.000043
42	MVC(最小)	-0.000494	0.000000	0.000000	0.000000	-0.000408	0.000000	0.000000
43	MVC(最小)	-0.000422	0.000000	0.000000	0.000000	-0.000408	0.000000	0.000000
44	MVC(最小)	-0.000494	0.000000	0.000000	0.000000	-0.000408	0.000000	0.000000
45	MVC(最小)	-0.000422	0.000000	-0.000000	0.000000	-0.000408	0.000000	0.000000
46	MVC(最小)	-0.000315	0.000000	0.000000	0.000000	-0.000424	0.000000	0.000000
47	MVC(最小)	-0.000288	0.000000	-0.000000	0.000000	-0.000424	0.000000	0.000000
48	MVC(最小)	-0.000315	0.000000	0.000000	0.000000	-0.000424	0.000000	0.000000
49	MVC(最小)	-0.000288	0.000000	0.000000	0.000000	-0.000424	0.000000	0.000000
1	MVC(全部)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

2	MVC(全部)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	MVC(全部)	-0.000001	0.000000	0.000000	0.000000	-0.000008	0.000000	0.000000
4	MVC(全部)	0.000001	0.000000	0.000000	0.000000	0.000008	0.000000	0.000000
5	MVC(全部)	-0.000073	0.000000	0.000000	0.000000	-0.000069	0.000000	0.000000
6	MVC(全部)	0.000072	0.000000	0.000000	0.000000	0.000067	0.000000	0.000000
7	MVC(全部)	0.000466	0.000000	0.000000	0.000000	-0.000424	0.000000	0.000000
8	MVC(全部)	-0.000494	0.000000	0.000000	0.000000	0.000458	0.000000	0.000000
9	MVC(全部)	-0.000837	0.000000	0.000000	0.000000	0.000612	0.000000	0.000000
10	MVC(全部)	0.000576	0.000000	0.000000	0.000000	-0.000418	0.000000	0.000000
11	MVC(全部)	-0.000837	0.000000	0.000000	0.000000	0.000612	0.000000	0.000000
12	MVC(全部)	0.000576	0.000000	0.000000	0.000000	-0.000418	0.000000	0.000000
13	MVC(全部)	-0.000781	0.000000	0.000000	0.000000	0.000612	0.000000	0.000000
14	MVC(全部)	0.000538	0.000000	0.000000	0.000000	-0.000418	0.000000	0.000000
15	MVC(全部)	-0.000422	0.000000	0.000000	0.000000	0.000458	0.000000	0.000000
16	MVC(全部)	0.000398	0.000000	0.000000	0.000000	-0.000424	0.000000	0.000000
17	MVC(全部)	-0.000781	0.000000	0.000000	0.000000	0.000612	0.000000	0.000000
18	MVC(全部)	0.000538	0.000000	0.000000	0.000000	-0.000418	0.000000	0.000000
19	MVC(全部)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
20	MVC(全部)	0.000245	-0.000007	0.000245	0.000012	0.000612	0.000000	0.000043
21	MVC(全部)	0.000245	0.000000	0.000000	0.000000	0.000612	0.000000	-0.000027
22	MVC(全部)	0.000197	-0.000074	-0.002253	0.000125	0.000536	0.000000	-0.000025
23	MVC(全部)	0.000147	-0.000127	-0.004093	0.000215	0.000310	0.000000	-0.000020
24	MVC(全部)	-0.000230	-0.000146	-0.004698	0.000247	-0.000113	0.000000	-0.000012
25	MVC(全部)	-0.000385	-0.000129	-0.003829	0.000219	-0.000330	0.000000	0.000019
26	MVC(全部)	-0.000459	-0.000078	-0.002034	0.000133	-0.000468	0.000000	0.000025
27	MVC(全部)	-0.000415	0.000000	0.000000	0.000000	0.000458	0.000000	-0.000017
28	MVC(全部)	0.000427	-0.000083	-0.002205	0.000141	0.000577	0.000000	-0.000029
29	MVC(全部)	0.000367	-0.000148	-0.004445	0.000251	0.000511	0.000000	-0.000025
30	MVC(全部)	0.000224	-0.000188	-0.006103	0.000318	0.000321	0.000000	-0.000018
31	MVC(全部)	-0.000142	-0.000201	-0.006716	0.000340	-0.000132	0.000000	-0.000012
32	MVC(全部)	-0.000234	-0.000188	-0.006036	0.000318	-0.000333	0.000000	0.000018
33	MVC(全部)	-0.000370	-0.000148	-0.004340	0.000251	-0.000513	0.000000	0.000025
34	MVC(全部)	-0.000422	-0.000083	-0.002121	0.000141	-0.000562	0.000000	0.000029
35	MVC(全部)	-0.000359	0.000000	0.000000	0.000000	-0.000424	0.000000	0.000017
36	MVC(全部)	0.000322	-0.000071	-0.001485	0.000121	0.000312	0.000000	-0.000022
37	MVC(全部)	0.000240	-0.000110	-0.002564	0.000186	0.000156	0.000000	-0.000016

38	MVC(全部)	-0.000189	-0.000108	-0.002631	0.000184	-0.000145	0.000000	0.000016
39	MVC(全部)	-0.000207	-0.000067	-0.001554	0.000114	-0.000344	0.000000	0.000021
40	MVC(全部)	-0.000220	0.000000	0.000000	0.000000	-0.000418	0.000000	0.000024
41	MVC(全部)	-0.000220	-0.000007	0.000167	0.000012	-0.000418	0.000000	-0.000043
42	MVC(全部)	-0.000494	0.000000	0.000000	0.000000	0.000458	0.000000	0.000000
43	MVC(全部)	-0.000422	0.000000	0.000000	0.000000	0.000458	0.000000	0.000000
44	MVC(全部)	-0.000494	0.000000	0.000000	0.000000	0.000458	0.000000	0.000000
45	MVC(全部)	-0.000422	0.000000	-0.000000	0.000000	0.000458	0.000000	0.000000
46	MVC(全部)	0.000466	0.000000	0.000000	0.000000	-0.000424	0.000000	0.000000
47	MVC(全部)	0.000398	0.000000	-0.000000	0.000000	-0.000424	0.000000	0.000000
48	MVC(全部)	0.000466	0.000000	0.000000	0.000000	-0.000424	0.000000	0.000000
49	MVC(全部)	0.000398	0.000000	0.000000	0.000000	-0.000424	0.000000	0.000000
1	1.4 DL+1.2 LL(全部)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	1.4 DL+1.2 LL(全部)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	1.4 DL+1.2 LL(全部)	-0.000003	0.000000	-0.000000	0.000000	-0.000015	0.000000	0.000000
4	1.4 DL+1.2 LL(全部)	0.000003	0.000000	-0.000000	0.000000	0.000015	0.000000	0.000000
5	1.4 DL+1.2 LL(全部)	-0.000141	0.000000	-0.000004	0.000000	-0.000133	0.000000	0.000000
6	1.4 DL+1.2 LL(全部)	0.000139	0.000000	-0.000004	0.000000	0.000131	0.000000	0.000000
7	1.4 DL+1.2 LL(全部)	0.000902	0.000000	-0.000000	0.000000	-0.000932	0.000000	0.000000
8	1.4 DL+1.2 LL(全部)	-0.000956	0.000000	-0.000000	0.000000	0.000744	0.000000	0.000000
9	1.4 DL+1.2 LL(全部)	-0.002257	0.000000	0.000000	0.000000	0.001746	0.000000	0.000000
10	1.4 DL+1.2 LL(全部)	0.001033	0.000000	0.000000	0.000000	-0.000952	0.000000	0.000000
11	1.4 DL+1.2 LL(全部)	-0.002257	0.000000	0.000000	0.000000	0.001746	0.000000	0.000000
12	1.4 DL+1.2 LL(全部)	0.001033	0.000000	0.000000	0.000000	-0.000952	0.000000	0.000000
13	1.4 DL+1.2 LL(全部)	-0.002093	0.000000	0.000000	0.000000	0.001746	0.000000	0.000000
14	1.4 DL+1.2 LL(全部)	0.000945	0.000000	0.000000	0.000000	-0.000952	0.000000	0.000000
15	1.4 DL+1.2 LL(全部)	-0.000838	0.000000	-0.000000	0.000000	0.000744	0.000000	0.000000
16	1.4 DL+1.2 LL(全部)	0.000748	0.000000	-0.000000	0.000000	-0.000932	0.000000	0.000000
17	1.4 DL+1.2 LL(全部)	-0.002093	0.000000	0.000000	0.000000	0.001746	0.000000	0.000000
18	1.4 DL+1.2 LL(全部)	0.000945	0.000000	0.000000	0.000000	-0.000952	0.000000	0.000000
19	1.4 DL+1.2 LL(全部)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
20	1.4 DL+1.2 LL(全部)	0.000757	-0.000008	0.000697	0.000014	0.001746	0.000000	0.000056
21	1.4 DL+1.2 LL(全部)	0.000757	0.000000	0.000000	0.000000	0.001746	0.000000	0.000033
22	1.4 DL+1.2 LL(全部)	0.000590	-0.000064	-0.006442	0.000108	0.001472	0.000000	-0.000021
23	1.4 DL+1.2 LL(全部)	0.000242	-0.000111	-0.011207	0.000188	0.000711	0.000000	-0.000019
24	1.4 DL+1.2 LL(全部)	-0.000538	-0.000128	-0.012112	0.000217	-0.000350	0.000000	-0.000014

25	1.4 DL+1.2 LL(全部)	-0.000944	-0.000114	-0.009106	0.000193	-0.000982	0.000000	0.000018
26	1.4 DL+1.2 LL(全部)	-0.001000	-0.000069	-0.004063	0.000118	-0.001093	0.000000	0.000023
27	1.4 DL+1.2 LL(全部)	-0.000518	0.000000	-0.000000	0.000000	0.000744	0.000000	0.000020
28	1.4 DL+1.2 LL(全部)	0.000903	-0.000069	-0.005584	0.000117	0.001588	0.000000	-0.000024
29	1.4 DL+1.2 LL(全部)	0.000873	-0.000122	-0.012416	0.000207	0.001584	0.000000	-0.000021
30	1.4 DL+1.2 LL(全部)	0.000492	-0.000155	-0.017788	0.000263	0.001007	0.000000	-0.000017
31	1.4 DL+1.2 LL(全部)	-0.000287	-0.000166	-0.019931	0.000281	0.000207	0.000000	0.000014
32	1.4 DL+1.2 LL(全部)	-0.000749	-0.000155	-0.018092	0.000263	-0.000941	0.000000	0.000017
33	1.4 DL+1.2 LL(全部)	-0.001158	-0.000122	-0.012906	0.000207	-0.001568	0.000000	0.000021
34	1.4 DL+1.2 LL(全部)	-0.001240	-0.000069	-0.006022	0.000116	-0.001656	0.000000	0.000024
35	1.4 DL+1.2 LL(全部)	-0.000838	0.000000	-0.000000	0.000000	-0.000932	0.000000	-0.000019
36	1.4 DL+1.2 LL(全部)	0.000341	-0.000066	-0.002115	0.000112	0.000561	0.000000	-0.000022
37	1.4 DL+1.2 LL(全部)	0.000275	-0.000101	-0.004785	0.000171	0.000431	0.000000	-0.000017
38	1.4 DL+1.2 LL(全部)	-0.000387	-0.000100	-0.005561	0.000169	-0.000180	0.000000	0.000017
39	1.4 DL+1.2 LL(全部)	-0.000593	-0.000061	-0.003548	0.000103	-0.000731	0.000000	0.000019
40	1.4 DL+1.2 LL(全部)	-0.000687	0.000000	0.000000	0.000000	-0.000952	0.000000	-0.000031
41	1.4 DL+1.2 LL(全部)	-0.000687	-0.000008	0.000380	0.000014	-0.000952	0.000000	-0.000055
42	1.4 DL+1.2 LL(全部)	-0.000956	0.000000	0.000000	0.000000	0.000744	0.000000	0.000000
43	1.4 DL+1.2 LL(全部)	-0.000838	0.000000	-0.000000	0.000000	0.000744	0.000000	0.000000
44	1.4 DL+1.2 LL(全部)	-0.000956	0.000000	0.000000	0.000000	0.000744	0.000000	0.000000
45	1.4 DL+1.2 LL(全部)	-0.000838	0.000000	-0.000000	0.000000	0.000744	0.000000	0.000000
46	1.4 DL+1.2 LL(全部)	0.000902	0.000000	0.000000	0.000000	-0.000932	0.000000	0.000000
47	1.4 DL+1.2 LL(全部)	0.000748	0.000000	-0.000000	0.000000	-0.000932	0.000000	0.000000
48	1.4 DL+1.2 LL(全部)	0.000902	0.000000	0.000000	0.000000	-0.000932	0.000000	0.000000
49	1.4 DL+1.2 LL(全部)	0.000748	0.000000	-0.000000	0.000000	-0.000932	0.000000	0.000000

Table 38 Beam Forces After Strengthening

单元	荷载	位置	轴向 (kN)	剪力-y (kN)	剪力-z (kN)	扭矩 (kN*m)	弯矩-y (kN*m)	弯矩-z (kN*m)	双力矩 (kN*m^2)	自由扭矩 (kN*m)	翘曲扭矩 (kN*m)
1	SW	I[3]	-164.46	0.00	67.08	0.00	-357.85	-0.00	0.00	0.00	0.00
1	SW	J[1]	-174.95	0.00	67.08	0.00	-368.91	-0.00	0.00	0.00	0.00
2	SW	I[4]	-160.64	-0.00	-67.08	0.00	350.13	0.00	0.00	0.00	0.00
2	SW	J[2]	-171.45	-0.00	-67.08	0.00	361.54	0.00	0.00	0.00	0.00
3	SW	I[5]	-62.67	0.00	67.08	0.00	-250.53	-0.00	0.00	0.00	0.00
3	SW	J[3]	-164.46	0.00	67.08	0.00	-357.85	-0.00	0.00	0.00	0.00
4	SW	I[6]	-58.85	-0.00	-67.08	0.00	242.81	0.00	0.00	0.00	0.00

4	SW	J[4]	-160.64	-0.00	-67.08	0.00	350.13	0.00	0.00	0.00	0.00
5	SW	I[8]	174.94	0.00	67.08	0.00	0.00	0.00	0.00	0.00	0.00
5	SW	J[5]	-62.67	0.00	67.08	0.00	-250.53	-0.00	0.00	0.00	0.00
6	SW	I[7]	171.44	-0.00	-67.08	0.00	0.00	0.00	0.00	0.00	0.00
6	SW	J[6]	-58.85	-0.00	-67.08	0.00	242.81	0.00	0.00	0.00	0.00
7	SW	I[20]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	SW	J[21]	0.00	0.00	45.38	0.00	-9.07	0.00	0.00	0.00	0.00
8	SW	I[21]	0.00	0.00	-980.14	0.00	-9.07	0.00	0.00	0.00	0.00
8	SW	J[22]	0.00	0.00	-571.76	0.00	2784.35	0.00	0.00	0.00	0.00
9	SW	I[22]	0.00	0.00	-571.76	0.00	2784.35	0.00	0.00	0.00	0.00
9	SW	J[23]	0.00	0.00	-118.01	0.00	4163.90	0.00	0.00	0.00	0.00
10	SW	I[23]	0.00	0.00	-118.01	0.00	4163.90	0.00	0.00	0.00	0.00
10	SW	J[24]	0.00	0.00	335.74	0.00	3728.45	0.00	0.00	0.00	0.00
11	SW	I[24]	0.00	0.00	335.74	0.00	3728.45	0.00	0.00	0.00	0.00
11	SW	J[25]	0.00	0.00	789.49	0.00	1478.00	0.00	0.00	0.00	0.00
12	SW	I[25]	0.00	0.00	789.49	0.00	1478.00	0.00	0.00	0.00	0.00
12	SW	J[26]	0.00	0.00	1243.24	0.00	-2587.45	0.00	0.00	0.00	0.00
13	SW	I[26]	0.00	0.00	1243.24	0.00	-2587.45	0.00	0.00	0.00	0.00
13	SW	J[27]	0.00	0.00	1696.99	0.00	-8467.90	0.00	0.00	0.00	0.00
14	SW	I[27]	-67.08	-0.00	-1744.82	0.00	-8546.67	-0.00	0.00	0.00	0.00
14	SW	J[28]	-67.08	-0.00	-1319.43	0.00	-2801.22	-0.00	0.00	0.00	0.00
15	SW	I[28]	-67.08	-0.00	-1319.43	0.00	-2801.22	-0.00	0.00	0.00	0.00
15	SW	J[29]	-67.08	-0.00	-894.03	0.00	1349.02	-0.00	0.00	0.00	0.00
16	SW	I[29]	-67.08	-0.00	-894.03	0.00	1349.02	-0.00	0.00	0.00	0.00
16	SW	J[30]	-67.08	-0.00	-468.64	0.00	3904.04	-0.00	0.00	0.00	0.00
17	SW	I[30]	-67.08	-0.00	-468.64	0.00	3904.04	-0.00	0.00	0.00	0.00
17	SW	J[31]	-67.08	-0.00	-43.25	0.00	4863.85	-0.00	0.00	0.00	0.00
18	SW	I[31]	-67.08	-0.00	-43.25	0.00	4863.85	-0.00	0.00	0.00	0.00
18	SW	J[32]	-67.08	-0.00	382.14	0.00	4228.44	-0.00	0.00	0.00	0.00
19	SW	I[32]	-67.08	-0.00	382.14	0.00	4228.44	-0.00	0.00	0.00	0.00
19	SW	J[33]	-67.08	-0.00	807.53	0.00	1997.82	-0.00	0.00	0.00	0.00
20	SW	I[33]	-67.08	-0.00	807.53	0.00	1997.82	-0.00	0.00	0.00	0.00
20	SW	J[34]	-67.08	-0.00	1232.92	0.00	-1828.02	-0.00	0.00	0.00	0.00
21	SW	I[34]	-67.08	-0.00	1232.92	0.00	-1828.02	-0.00	0.00	0.00	0.00
21	SW	J[35]	-67.08	-0.00	1658.31	0.00	-7249.07	-0.00	0.00	0.00	0.00
22	SW	I[35]	0.00	0.00	-1477.04	0.00	-7169.96	-0.00	0.00	0.00	0.00

22	SW	J[36]	0.00	0.00	-1023.29	0.00	-2169.31	-0.00	0.00	0.00	0.00
23	SW	I[36]	0.00	0.00	-1023.29	0.00	-2169.31	-0.00	0.00	0.00	0.00
23	SW	J[37]	0.00	0.00	-569.54	0.00	1016.35	-0.00	0.00	0.00	0.00
24	SW	I[37]	0.00	0.00	-569.54	0.00	1016.35	-0.00	0.00	0.00	0.00
24	SW	J[38]	0.00	0.00	-115.79	0.00	2387.00	-0.00	0.00	0.00	0.00
25	SW	I[38]	0.00	0.00	-115.79	0.00	2387.00	-0.00	0.00	0.00	0.00
25	SW	J[39]	0.00	0.00	337.96	0.00	1942.66	-0.00	0.00	0.00	0.00
26	SW	I[39]	0.00	0.00	337.96	0.00	1942.66	-0.00	0.00	0.00	0.00
26	SW	J[40]	0.00	0.00	746.34	0.00	-9.07	-0.00	0.00	0.00	0.00
27	SW	I[40]	0.00	0.00	-45.37	0.00	-9.08	0.00	0.00	0.00	0.00
27	SW	J[41]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	SW	I[8]	-1.39	0.00	-0.00	0.00	-0.00	0.00	0.00	0.00	0.00
28	SW	J[15]	1.39	0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	SW	I[7]	-2.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	SW	J[16]	2.05	0.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00
1	CB	I[3]	-0.00	0.00	5.03	-0.00	-26.81	-0.00	0.00	0.00	0.00
1	CB	J[1]	-0.00	0.00	5.03	-0.00	-27.64	-0.00	0.00	0.00	0.00
2	CB	I[4]	-0.00	-0.00	-5.03	-0.00	26.24	0.00	0.00	0.00	0.00
2	CB	J[2]	-0.00	-0.00	-5.03	-0.00	27.09	0.00	0.00	0.00	0.00
3	CB	I[5]	-0.00	0.00	5.03	-0.00	-18.77	-0.00	0.00	0.00	0.00
3	CB	J[3]	-0.00	0.00	5.03	-0.00	-26.81	-0.00	0.00	0.00	0.00
4	CB	I[6]	-0.00	-0.00	-5.03	-0.00	18.19	0.00	0.00	0.00	0.00
4	CB	J[4]	-0.00	-0.00	-5.03	-0.00	26.24	0.00	0.00	0.00	0.00
5	CB	I[8]	-0.00	0.00	5.03	-0.00	0.00	0.00	0.00	0.00	0.00
5	CB	J[5]	-0.00	0.00	5.03	-0.00	-18.77	-0.00	0.00	0.00	0.00
6	CB	I[7]	-0.00	-0.00	-5.03	-0.00	0.00	0.00	0.00	0.00	0.00
6	CB	J[6]	-0.00	-0.00	-5.03	-0.00	18.19	0.00	0.00	0.00	0.00
7	CB	I[20]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-124.87	-124.87
7	CB	J[21]	0.00	0.00	3.40	13.84	-0.68	0.00	16.65	-360.78	-374.62
8	CB	I[21]	0.00	0.00	-73.44	-399.88	-0.68	0.00	16.65	-360.78	39.10
8	CB	J[22]	0.00	0.00	-42.84	-275.34	208.63	0.00	3.03	-269.04	6.30
9	CB	I[22]	0.00	0.00	-42.84	-275.34	208.63	0.00	3.03	-269.04	6.30
9	CB	J[23]	0.00	0.00	-8.84	-136.96	312.01	0.00	0.70	-136.26	0.70
10	CB	I[23]	0.00	0.00	-8.84	-136.96	312.01	0.00	0.70	-136.26	0.70
10	CB	J[24]	0.00	0.00	25.16	1.42	279.38	0.00	1.17	-0.68	-2.10
11	CB	I[24]	0.00	0.00	25.16	1.42	279.38	0.00	1.17	-0.68	-2.10

11	CB	J[25]	0.00	0.00	59.16	139.80	110.75	0.00	6.30	126.50	-13.30
12	CB	I[25]	0.00	0.00	59.16	139.80	110.75	0.00	6.30	126.50	-13.30
12	CB	J[26]	0.00	0.00	93.16	278.18	-193.88	0.00	36.63	200.48	-77.70
13	CB	I[26]	0.00	0.00	93.16	278.18	-193.88	0.00	36.63	200.48	-77.70
13	CB	J[27]	0.00	0.00	127.16	416.56	-634.51	0.00	213.50	-36.35	-452.91
14	CB	I[27]	-5.03	-0.00	-130.74	-519.45	-640.41	-0.00	213.50	-36.35	483.10
14	CB	J[28]	-5.03	-0.00	-98.87	-389.72	-209.90	-0.00	36.63	-306.83	82.89
15	CB	I[28]	-5.03	-0.00	-98.87	-389.72	-209.90	-0.00	36.63	-306.83	82.89
15	CB	J[29]	-5.03	-0.00	-66.99	-259.99	101.08	0.00	6.29	-245.78	14.21
16	CB	I[29]	-5.03	-0.00	-66.99	-259.99	101.08	0.00	6.29	-245.78	14.21
16	CB	J[30]	-5.03	-0.00	-35.12	-130.26	292.53	0.00	1.11	-127.88	2.37
17	CB	I[30]	-5.03	-0.00	-35.12	-130.26	292.53	0.00	1.11	-127.88	2.37
17	CB	J[31]	-5.03	-0.00	-3.24	-0.53	364.45	0.00	0.36	-0.50	0.03
18	CB	I[31]	-5.03	-0.00	-3.24	-0.53	364.45	0.00	0.36	-0.50	0.03
18	CB	J[32]	-5.03	-0.00	28.63	129.21	316.84	0.00	1.03	127.02	-2.19
19	CB	I[32]	-5.03	-0.00	28.63	129.21	316.84	0.00	1.03	127.02	-2.19
19	CB	J[33]	-5.03	-0.00	60.51	258.94	149.70	0.00	5.83	245.78	-13.16
20	CB	I[33]	-5.03	-0.00	60.51	258.94	149.70	0.00	5.83	245.78	-13.16
20	CB	J[34]	-5.03	-0.00	92.38	388.67	-136.98	0.00	33.92	311.91	-76.76
21	CB	I[34]	-5.03	-0.00	92.38	388.67	-136.98	0.00	33.92	311.91	-76.76
21	CB	J[35]	-5.03	-0.00	124.26	518.40	-543.18	0.00	197.72	71.01	-447.39
22	CB	I[35]	0.00	0.00	-110.68	-348.41	-537.25	0.00	197.72	71.01	419.42
22	CB	J[36]	0.00	0.00	-76.68	-210.03	-162.55	0.00	33.94	-138.10	71.94
23	CB	I[36]	0.00	0.00	-76.68	-210.03	-162.55	0.00	33.94	-138.10	71.94
23	CB	J[37]	0.00	0.00	-42.68	-71.65	76.16	0.00	5.89	-59.46	12.19
24	CB	I[37]	0.00	0.00	-42.68	-71.65	76.16	0.00	5.89	-59.46	12.19
24	CB	J[38]	0.00	0.00	-8.68	66.73	178.86	0.00	1.42	67.94	1.22
25	CB	I[38]	0.00	0.00	-8.68	66.73	178.86	0.00	1.42	67.94	1.22
25	CB	J[39]	0.00	0.00	25.32	205.11	145.57	0.00	2.65	200.21	-4.90
26	CB	I[39]	0.00	0.00	25.32	205.11	145.57	0.00	2.65	200.21	-4.90
26	CB	J[40]	0.00	0.00	55.92	329.65	-0.68	0.00	13.83	297.29	-32.36
27	CB	I[40]	0.00	0.00	-3.40	-13.84	-0.68	0.00	13.83	297.29	311.13
27	CB	J[41]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	103.71	103.71
28	CB	I[8]	-0.00	0.00	-0.00	0.00	-0.00	0.00	0.00	0.00	0.00
28	CB	J[15]	-0.00	0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	CB	I[7]	-0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

29	CB	J[16]	-0.00	0.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00
1	MVC(最大)	I[3]	0.00	0.00	153.91	0.00	495.36	0.00	0.00	0.00	0.00
1	MVC(最大)	J[1]	0.00	0.00	153.91	0.00	510.68	0.00	0.00	0.00	0.00
2	MVC(最大)	I[4]	0.00	0.00	103.07	0.00	716.75	0.00	0.00	0.00	0.00
2	MVC(最大)	J[2]	0.00	0.00	103.07	0.00	740.09	0.00	0.00	0.00	0.00
3	MVC(最大)	I[5]	0.00	0.00	153.91	0.00	346.80	0.00	0.00	0.00	0.00
3	MVC(最大)	J[3]	0.00	0.00	153.91	0.00	495.36	0.00	0.00	0.00	0.00
4	MVC(最大)	I[6]	0.00	0.00	103.07	0.00	497.05	0.00	0.00	0.00	0.00
4	MVC(最大)	J[4]	0.00	0.00	103.07	0.00	716.75	0.00	0.00	0.00	0.00
5	MVC(最大)	I[8]	0.00	0.00	153.91	0.00	0.00	0.00	0.00	0.00	0.00
5	MVC(最大)	J[5]	0.00	0.00	153.91	0.00	346.80	0.00	0.00	0.00	0.00
6	MVC(最大)	I[7]	0.00	0.00	103.07	0.00	0.00	0.00	0.00	0.00	0.00
6	MVC(最大)	J[6]	0.00	0.00	103.07	0.00	497.05	0.00	0.00	0.00	0.00
7	MVC(最大)	I[20]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	359.09	359.09
7	MVC(最大)	J[21]	0.00	0.00	776.40	0.00	0.00	0.00	30.11	1077.40	1633.63
8	MVC(最大)	I[21]	0.00	0.00	121.57	1782.47	0.00	0.00	30.11	1077.40	31.03
8	MVC(最大)	J[22]	0.00	0.00	192.61	1445.57	2533.74	0.00	475.01	1025.20	810.50
9	MVC(最大)	I[22]	0.00	0.00	192.61	1445.57	2533.74	0.00	475.01	1025.20	810.50
9	MVC(最大)	J[23]	0.00	0.00	373.17	1096.80	4041.03	0.00	535.76	792.89	1022.96
10	MVC(最大)	I[23]	0.00	0.00	373.17	1096.80	4041.03	0.00	535.76	792.89	1022.96
10	MVC(最大)	J[24]	0.00	0.00	559.96	776.69	4271.23	0.00	540.00	481.88	1046.85
11	MVC(最大)	I[24]	0.00	0.00	559.96	776.69	4271.23	0.00	540.00	481.88	1046.85
11	MVC(最大)	J[25]	0.00	0.00	746.12	485.70	3398.08	0.00	532.65	216.61	1066.70
12	MVC(最大)	I[25]	0.00	0.00	746.12	485.70	3398.08	0.00	532.65	216.61	1066.70
12	MVC(最大)	J[26]	0.00	0.00	924.22	224.89	1681.51	0.00	480.48	104.06	1196.01
13	MVC(最大)	I[26]	0.00	0.00	924.22	224.89	1681.51	0.00	480.48	104.06	1196.01
13	MVC(最大)	J[27]	0.00	0.00	1086.20	7.00	346.09	0.00	179.23	687.46	2115.42
14	MVC(最大)	I[27]	92.85	0.00	69.57	1922.33	411.11	0.00	179.23	687.46	389.88
14	MVC(最大)	J[28]	92.85	0.00	95.22	1619.12	1408.87	0.00	439.95	1177.78	913.16
15	MVC(最大)	I[28]	92.85	0.00	95.22	1619.12	1408.87	0.00	439.95	1177.78	913.16
15	MVC(最大)	J[29]	92.85	0.00	201.94	1328.08	2951.14	0.00	491.96	994.94	1017.53
16	MVC(最大)	I[29]	92.85	0.00	201.94	1328.08	2951.14	0.00	491.96	994.94	1017.53
16	MVC(最大)	J[30]	92.85	0.00	332.60	1055.76	4080.69	0.00	501.05	730.35	1036.21
17	MVC(最大)	I[30]	92.85	0.00	332.60	1055.76	4080.69	0.00	501.05	730.35	1036.21
17	MVC(最大)	J[31]	92.85	0.00	481.06	803.32	4443.33	0.00	502.28	477.77	1039.71
18	MVC(最大)	I[31]	92.85	0.00	481.06	803.32	4443.33	0.00	502.28	477.77	1039.71

18	MVC(最大)	J[32]	92.85	0.00	640.44	570.96	4004.34	0.00	501.05	252.91	1042.98
19	MVC(最大)	I[32]	92.85	0.00	640.44	570.96	4004.34	0.00	501.05	252.91	1042.98
19	MVC(最大)	J[33]	92.85	0.00	803.13	358.86	2818.49	0.00	491.96	73.82	1062.66
20	MVC(最大)	I[33]	92.85	0.00	803.13	358.86	2818.49	0.00	491.96	73.82	1062.66
20	MVC(最大)	J[34]	92.85	0.00	960.79	167.85	1359.34	0.00	439.97	88.26	1197.62
21	MVC(最大)	I[34]	92.85	0.00	960.79	167.85	1359.34	0.00	439.97	88.26	1197.62
21	MVC(最大)	J[35]	92.85	0.00	1104.35	9.40	622.75	0.00	185.30	555.98	2077.30
22	MVC(最大)	I[35]	0.00	0.00	30.87	1707.56	532.38	0.00	185.30	555.98	350.73
22	MVC(最大)	J[36]	0.00	0.00	122.82	1302.71	1855.16	0.00	484.07	899.91	918.31
23	MVC(最大)	I[36]	0.00	0.00	122.82	1302.71	1855.16	0.00	484.07	899.91	918.31
23	MVC(最大)	J[37]	0.00	0.00	283.40	920.61	3231.96	0.00	533.06	630.32	1027.12
24	MVC(最大)	I[37]	0.00	0.00	283.40	920.61	3231.96	0.00	533.06	630.32	1027.12
24	MVC(最大)	J[38]	0.00	0.00	485.53	571.40	3487.59	0.00	534.81	313.14	1047.99
25	MVC(最大)	I[38]	0.00	0.00	485.53	571.40	3487.59	0.00	534.81	313.14	1047.99
25	MVC(最大)	J[39]	0.00	0.00	722.93	257.05	2349.55	0.00	475.71	118.74	1144.28
26	MVC(最大)	I[39]	0.00	0.00	722.93	257.05	2349.55	0.00	475.71	118.74	1144.28
26	MVC(最大)	J[40]	0.00	0.00	960.80	16.51	0.00	0.00	31.03	697.41	2044.08
27	MVC(最大)	I[40]	0.00	0.00	0.00	1303.28	0.00	0.00	31.03	697.41	697.10
27	MVC(最大)	J[41]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1730.66	1730.66
28	MVC(最大)	I[8]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	MVC(最大)	J[15]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	MVC(最大)	I[7]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	MVC(最大)	J[16]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	MVC(最小)	I[3]	-0.00	-0.00	-103.07	-0.00	-732.54	-0.00	0.00	0.00	0.00
1	MVC(最小)	J[1]	-0.00	-0.00	-103.07	-0.00	-755.19	-0.00	0.00	0.00	0.00
2	MVC(最小)	I[4]	-0.00	-0.00	-153.91	-0.00	-484.68	-0.00	0.00	0.00	0.00
2	MVC(最小)	J[2]	-0.00	-0.00	-153.91	-0.00	-500.46	-0.00	0.00	0.00	0.00
3	MVC(最小)	I[5]	-0.00	-0.00	-103.07	-0.00	-512.84	-0.00	0.00	0.00	0.00
3	MVC(最小)	J[3]	-0.00	-0.00	-103.07	-0.00	-732.54	-0.00	0.00	0.00	0.00
4	MVC(最小)	I[6]	-0.00	-0.00	-153.91	-0.00	-336.12	-0.00	0.00	0.00	0.00
4	MVC(最小)	J[4]	-0.00	-0.00	-153.91	-0.00	-484.68	-0.00	0.00	0.00	0.00
5	MVC(最小)	I[8]	-0.00	-0.00	-103.07	-0.00	0.00	0.00	0.00	0.00	0.00
5	MVC(最小)	J[5]	-0.00	-0.00	-103.07	-0.00	-512.84	-0.00	0.00	0.00	0.00
6	MVC(最小)	I[7]	-0.00	-0.00	-153.91	-0.00	0.00	0.00	0.00	0.00	0.00
6	MVC(最小)	J[6]	-0.00	-0.00	-153.91	-0.00	-336.12	-0.00	0.00	0.00	0.00
7	MVC(最小)	I[20]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-1729.96	-1729.96

7	MVC(最小)	J[21]	0.00	0.00	0.00	-1303.28	-257.68	0.00	-65.35	-676.66	-676.34
8	MVC(最小)	I[21]	-0.00	0.00	-990.41	-13.68	-257.68	0.00	-65.35	-676.66	-2054.07
8	MVC(最小)	J[22]	-0.00	0.00	-777.11	-212.99	-390.45	0.00	-9.58	-54.48	-1146.87
9	MVC(最小)	I[22]	-0.00	0.00	-777.11	-212.99	-390.45	0.00	-9.58	-54.48	-1146.87
9	MVC(最小)	J[23]	-0.00	0.00	-561.42	-473.49	-822.42	0.00	-1.70	-197.97	-1050.88
10	MVC(最小)	I[23]	-0.00	0.00	-561.42	-473.49	-822.42	0.00	-1.70	-197.97	-1050.88
10	MVC(最小)	J[24]	-0.00	0.00	-372.59	-763.13	-1254.39	0.00	-1.63	-464.58	-1043.54
11	MVC(最小)	I[24]	-0.00	0.00	-372.59	-763.13	-1254.39	0.00	-1.63	-464.58	-1043.54
11	MVC(最小)	J[25]	-0.00	0.00	-214.63	-1081.45	-1686.36	0.00	-9.49	-768.44	-1025.75
12	MVC(最小)	I[25]	-0.00	0.00	-214.63	-1081.45	-1686.36	0.00	-9.49	-768.44	-1025.75
12	MVC(最小)	J[26]	-0.00	0.00	-90.96	-1426.99	-2132.13	0.00	-58.79	-998.05	-915.98
13	MVC(最小)	I[26]	-0.00	0.00	-90.96	-1426.99	-2132.13	0.00	-58.79	-998.05	-915.98
13	MVC(最小)	J[27]	-0.00	0.00	-20.43	-1791.38	-3253.23	0.00	-397.12	-620.52	-349.71
14	MVC(最小)	I[27]	-137.31	-0.00	-1108.85	-8.41	-3379.17	-0.00	-397.12	-620.52	-2120.75
14	MVC(最小)	J[28]	-137.31	-0.00	-959.98	-167.21	-1865.74	-0.00	-55.34	-97.99	-1204.82
15	MVC(最小)	I[28]	-137.31	-0.00	-959.98	-167.21	-1865.74	-0.00	-55.34	-97.99	-1204.82
15	MVC(最小)	J[29]	-137.31	-0.00	-799.10	-358.22	-1372.45	-0.00	-8.39	-73.81	-1063.89
16	MVC(最小)	I[29]	-137.31	-0.00	-799.10	-358.22	-1372.45	-0.00	-8.39	-73.81	-1063.89
16	MVC(最小)	J[30]	-137.31	-0.00	-635.12	-570.33	-1109.11	-0.00	-1.38	-252.29	-1043.19
17	MVC(最小)	I[30]	-137.31	-0.00	-635.12	-570.33	-1109.11	-0.00	-1.38	-252.29	-1043.19
17	MVC(最小)	J[31]	-137.31	-0.00	-476.22	-802.69	-845.77	-0.00	-0.28	-477.18	-1039.74
18	MVC(最小)	I[31]	-137.31	-0.00	-476.22	-802.69	-845.77	-0.00	-0.28	-477.18	-1039.74
18	MVC(最小)	J[32]	-137.31	-0.00	-329.85	-1055.14	-854.48	-0.00	-1.23	-729.93	-1036.22
19	MVC(最小)	I[32]	-137.31	-0.00	-329.85	-1055.14	-854.48	-0.00	-1.23	-729.93	-1036.22
19	MVC(最小)	J[33]	-137.31	-0.00	-202.72	-1327.45	-973.02	-0.00	-7.53	-994.93	-1017.54
20	MVC(最小)	I[33]	-137.31	-0.00	-202.72	-1327.45	-973.02	-0.00	-7.53	-994.93	-1017.54
20	MVC(最小)	J[34]	-137.31	-0.00	-103.15	-1618.50	-1420.83	-0.00	-50.38	-1177.69	-913.49
21	MVC(最小)	I[34]	-137.31	-0.00	-103.15	-1618.50	-1420.83	-0.00	-50.38	-1177.69	-913.49
21	MVC(最小)	J[35]	-137.31	-0.00	-99.82	-1921.69	-3389.23	-0.00	-378.69	-686.86	-403.58
22	MVC(最小)	I[35]	-0.00	0.00	-1050.20	-8.46	-3253.32	-0.00	-378.69	-686.86	-2062.79
22	MVC(最小)	J[36]	-0.00	0.00	-863.83	-271.44	-2244.05	-0.00	-56.62	-154.72	-1183.42
23	MVC(最小)	I[36]	-0.00	0.00	-863.83	-271.44	-2244.05	-0.00	-56.62	-154.72	-1183.42
23	MVC(最小)	J[37]	-0.00	0.00	-657.93	-586.20	-1669.08	-0.00	-9.50	-334.42	-1062.15
24	MVC(最小)	I[37]	-0.00	0.00	-657.93	-586.20	-1669.08	-0.00	-9.50	-334.42	-1062.15
24	MVC(最小)	J[38]	-0.00	0.00	-444.20	-937.34	-1094.12	-0.00	-2.14	-656.08	-1025.04
25	MVC(最小)	I[38]	-0.00	0.00	-444.20	-937.34	-1094.12	-0.00	-2.14	-656.08	-1025.04

25	MVC(最小)	J[39]	-0.00	0.00	-233.38	-1323.30	-519.15	-0.00	-9.43	-859.19	-811.10
26	MVC(最小)	I[39]	-0.00	0.00	-233.38	-1323.30	-519.15	-0.00	-9.43	-859.19	-811.10
26	MVC(最小)	J[40]	-0.00	0.00	-161.76	-1698.47	-257.68	-0.00	-62.05	-965.77	-31.18
27	MVC(最小)	I[40]	0.00	0.00	-776.40	0.00	-257.68	0.00	-62.05	-965.77	-1558.71
27	MVC(最小)	J[41]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-321.88	-321.88
28	MVC(最小)	I[8]	-0.00	0.00	-0.00	0.00	-0.00	0.00	0.00	0.00	0.00
28	MVC(最小)	J[15]	-0.00	0.00	-0.00	0.00	-0.00	0.00	0.00	0.00	0.00
29	MVC(最小)	I[7]	-0.00	0.00	-0.00	0.00	-0.00	0.00	0.00	0.00	0.00
29	MVC(最小)	J[16]	-0.00	0.00	-0.00	0.00	-0.00	0.00	0.00	0.00	0.00
1	MVC(全部)	I[3]	-0.00	0.00	153.91	0.00	-732.54	0.00	0.00	0.00	0.00
1	MVC(全部)	J[1]	-0.00	0.00	153.91	0.00	-755.19	0.00	0.00	0.00	0.00
2	MVC(全部)	I[4]	-0.00	-0.00	-153.91	0.00	716.75	-0.00	0.00	0.00	0.00
2	MVC(全部)	J[2]	-0.00	-0.00	-153.91	0.00	740.09	-0.00	0.00	0.00	0.00
3	MVC(全部)	I[5]	-0.00	0.00	153.91	0.00	-512.84	0.00	0.00	0.00	0.00
3	MVC(全部)	J[3]	-0.00	0.00	153.91	0.00	-732.54	0.00	0.00	0.00	0.00
4	MVC(全部)	I[6]	-0.00	-0.00	-153.91	0.00	497.05	-0.00	0.00	0.00	0.00
4	MVC(全部)	J[4]	-0.00	-0.00	-153.91	0.00	716.75	-0.00	0.00	0.00	0.00
5	MVC(全部)	I[8]	-0.00	0.00	153.91	0.00	0.00	0.00	0.00	0.00	0.00
5	MVC(全部)	J[5]	-0.00	0.00	153.91	0.00	-512.84	0.00	0.00	0.00	0.00
6	MVC(全部)	I[7]	-0.00	-0.00	-153.91	0.00	0.00	0.00	0.00	0.00	0.00
6	MVC(全部)	J[6]	-0.00	-0.00	-153.91	0.00	497.05	-0.00	0.00	0.00	0.00
7	MVC(全部)	I[20]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-1729.96	-1729.96
7	MVC(全部)	J[21]	0.00	0.00	776.40	-1303.28	-257.68	0.00	-65.35	1077.40	1633.63
8	MVC(全部)	I[21]	0.00	0.00	-990.41	1782.47	-257.68	0.00	-65.35	1077.40	-2054.07
8	MVC(全部)	J[22]	0.00	0.00	-777.11	1445.57	2533.74	0.00	475.01	1025.20	-1146.87
9	MVC(全部)	I[22]	0.00	0.00	-777.11	1445.57	2533.74	0.00	475.01	1025.20	-1146.87
9	MVC(全部)	J[23]	0.00	0.00	-561.42	1096.80	4041.03	0.00	535.76	792.89	-1050.88
10	MVC(全部)	I[23]	0.00	0.00	-561.42	1096.80	4041.03	0.00	535.76	792.89	-1050.88
10	MVC(全部)	J[24]	0.00	0.00	559.96	776.69	4271.23	0.00	540.00	481.88	1046.85
11	MVC(全部)	I[24]	0.00	0.00	559.96	776.69	4271.23	0.00	540.00	481.88	1046.85
11	MVC(全部)	J[25]	0.00	0.00	746.12	-1081.45	3398.08	0.00	532.65	-768.44	1066.70
12	MVC(全部)	I[25]	0.00	0.00	746.12	-1081.45	3398.08	0.00	532.65	-768.44	1066.70
12	MVC(全部)	J[26]	0.00	0.00	924.22	-1426.99	-2132.13	0.00	480.48	-998.05	1196.01
13	MVC(全部)	I[26]	0.00	0.00	924.22	-1426.99	-2132.13	0.00	480.48	-998.05	1196.01
13	MVC(全部)	J[27]	0.00	0.00	1086.20	-1791.38	-3253.23	0.00	-397.12	687.46	2115.42
14	MVC(全部)	I[27]	-137.31	-0.00	-1108.85	1922.33	-3379.17	-0.00	-397.12	687.46	-2120.75

14	MVC(全部)	J[28]	-137.31	-0.00	-959.98	1619.12	-1865.74	-0.00	439.95	1177.78	-1204.82
15	MVC(全部)	I[28]	-137.31	-0.00	-959.98	1619.12	-1865.74	-0.00	439.95	1177.78	-1204.82
15	MVC(全部)	J[29]	-137.31	-0.00	-799.10	1328.08	2951.14	-0.00	491.96	994.94	-1063.89
16	MVC(全部)	I[29]	-137.31	-0.00	-799.10	1328.08	2951.14	-0.00	491.96	994.94	-1063.89
16	MVC(全部)	J[30]	-137.31	-0.00	-635.12	1055.76	4080.69	-0.00	501.05	730.35	-1043.19
17	MVC(全部)	I[30]	-137.31	-0.00	-635.12	1055.76	4080.69	-0.00	501.05	730.35	-1043.19
17	MVC(全部)	J[31]	-137.31	-0.00	481.06	803.32	4443.33	-0.00	502.28	477.77	-1039.74
18	MVC(全部)	I[31]	-137.31	-0.00	481.06	803.32	4443.33	-0.00	502.28	477.77	-1039.74
18	MVC(全部)	J[32]	-137.31	-0.00	640.44	-1055.14	4004.34	-0.00	501.05	-729.93	1042.98
19	MVC(全部)	I[32]	-137.31	-0.00	640.44	-1055.14	4004.34	-0.00	501.05	-729.93	1042.98
19	MVC(全部)	J[33]	-137.31	-0.00	803.13	-1327.45	2818.49	-0.00	491.96	-994.93	1062.66
20	MVC(全部)	I[33]	-137.31	-0.00	803.13	-1327.45	2818.49	-0.00	491.96	-994.93	1062.66
20	MVC(全部)	J[34]	-137.31	-0.00	960.79	-1618.50	-1420.83	-0.00	439.97	-1177.69	1197.62
21	MVC(全部)	I[34]	-137.31	-0.00	960.79	-1618.50	-1420.83	-0.00	439.97	-1177.69	1197.62
21	MVC(全部)	J[35]	-137.31	-0.00	1104.35	-1921.69	-3389.23	-0.00	-378.69	-686.86	2077.30
22	MVC(全部)	I[35]	0.00	0.00	-1050.20	1707.56	-3253.32	-0.00	-378.69	-686.86	-2062.79
22	MVC(全部)	J[36]	0.00	0.00	-863.83	1302.71	-2244.05	-0.00	484.07	899.91	-1183.42
23	MVC(全部)	I[36]	0.00	0.00	-863.83	1302.71	-2244.05	-0.00	484.07	899.91	-1183.42
23	MVC(全部)	J[37]	0.00	0.00	-657.93	920.61	3231.96	-0.00	533.06	630.32	-1062.15
24	MVC(全部)	I[37]	0.00	0.00	-657.93	920.61	3231.96	-0.00	533.06	630.32	-1062.15
24	MVC(全部)	J[38]	0.00	0.00	485.53	-937.34	3487.59	-0.00	534.81	-656.08	1047.99
25	MVC(全部)	I[38]	0.00	0.00	485.53	-937.34	3487.59	-0.00	534.81	-656.08	1047.99
25	MVC(全部)	J[39]	0.00	0.00	722.93	-1323.30	2349.55	-0.00	475.71	-859.19	1144.28
26	MVC(全部)	I[39]	0.00	0.00	722.93	-1323.30	2349.55	-0.00	475.71	-859.19	1144.28
26	MVC(全部)	J[40]	0.00	0.00	960.80	-1698.47	-257.68	-0.00	-62.05	-965.77	2044.08
27	MVC(全部)	I[40]	0.00	0.00	-776.40	1303.28	-257.68	0.00	-62.05	-965.77	-1558.71
27	MVC(全部)	J[41]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1730.66	1730.66
28	MVC(全部)	I[8]	-0.00	0.00	-0.00	0.00	-0.00	0.00	0.00	0.00	0.00
28	MVC(全部)	J[15]	-0.00	0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	MVC(全部)	I[7]	-0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	MVC(全部)	J[16]	-0.00	0.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00
1	1.4 DL+1.2 LL(全部)	I[3]	-230.24	0.00	285.63	-0.00	-1417.57	-0.00	0.00	0.00	0.00
1	1.4 DL+1.2 LL(全部)	J[1]	-244.94	0.00	285.63	-0.00	-1461.41	-0.00	0.00	0.00	0.00
2	1.4 DL+1.2 LL(全部)	I[4]	-224.90	-0.00	-285.63	-0.00	1387.01	0.00	0.00	0.00	0.00
2	1.4 DL+1.2	J[2]	-240.04	-0.00	-285.63	-0.00	1432.18	0.00	0.00	0.00	0.00

	LL(全部)										
3	1.4 DL+1.2 LL(全部)	I[5]	-87.74	0.00	285.63	-0.00	-992.43	-0.00	0.00	0.00	0.00
3	1.4 DL+1.2 LL(全部)	J[3]	-230.24	0.00	285.63	-0.00	-1417.57	-0.00	0.00	0.00	0.00
4	1.4 DL+1.2 LL(全部)	I[6]	-82.39	-0.00	-285.63	-0.00	961.87	0.00	0.00	0.00	0.00
4	1.4 DL+1.2 LL(全部)	J[4]	-224.90	-0.00	-285.63	-0.00	1387.01	0.00	0.00	0.00	0.00
5	1.4 DL+1.2 LL(全部)	I[8]	244.92	0.00	285.63	-0.00	0.00	0.00	0.00	0.00	0.00
5	1.4 DL+1.2 LL(全部)	J[5]	-87.74	0.00	285.63	-0.00	-992.43	-0.00	0.00	0.00	0.00
6	1.4 DL+1.2 LL(全部)	I[7]	240.02	-0.00	-285.63	-0.00	0.00	0.00	0.00	0.00	0.00
6	1.4 DL+1.2 LL(全部)	J[6]	-82.39	-0.00	-285.63	-0.00	961.87	0.00	0.00	0.00	0.00
7	1.4 DL+1.2 LL(全部)	I[20]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-2250.78	-2250.78
7	1.4 DL+1.2 LL(全部)	J[21]	0.00	0.00	999.97	-1544.57	-322.87	0.00	59.44	-1317.08	1435.88
8	1.4 DL+1.2 LL(全部)	I[21]	0.00	0.00	-2663.50	1579.13	-322.87	0.00	59.44	-1317.08	-2410.14
8	1.4 DL+1.2 LL(全部)	J[22]	0.00	0.00	-1792.97	1349.21	7230.66	0.00	574.25	853.58	-1367.43
9	1.4 DL+1.2 LL(全部)	I[22]	0.00	0.00	-1792.97	1349.21	7230.66	0.00	574.25	853.58	-1367.43
9	1.4 DL+1.2 LL(全部)	J[23]	0.00	0.00	-851.30	1124.41	11115.50	0.00	643.89	760.71	-1260.08
10	1.4 DL+1.2 LL(全部)	I[23]	0.00	0.00	-851.30	1124.41	11115.50	0.00	643.89	760.71	-1260.08
10	1.4 DL+1.2 LL(全部)	J[24]	0.00	0.00	1177.20	934.02	10736.43	0.00	649.63	577.30	-1255.19
11	1.4 DL+1.2 LL(全部)	I[24]	0.00	0.00	1177.20	934.02	10736.43	0.00	649.63	577.30	-1255.19
11	1.4 DL+1.2 LL(全部)	J[25]	0.00	0.00	2083.45	-1102.02	6301.94	0.00	648.00	-745.03	1261.41
12	1.4 DL+1.2 LL(全部)	I[25]	0.00	0.00	2083.45	-1102.02	6301.94	0.00	648.00	-745.03	1261.41
12	1.4 DL+1.2 LL(全部)	J[26]	0.00	0.00	2980.01	-1322.94	-6452.42	0.00	627.86	-916.99	1326.43
13	1.4 DL+1.2 LL(全部)	I[26]	0.00	0.00	2980.01	-1322.94	-6452.42	0.00	627.86	-916.99	1326.43
13	1.4 DL+1.2 LL(全部)	J[27]	0.00	0.00	3857.24	-1566.47	-16647.25	0.00	513.98	-795.51	1904.44
14	1.4 DL+1.2 LL(全部)	I[27]	-265.71	-0.00	-3956.40	1579.57	-16916.92	-0.00	513.98	-795.51	-1868.55

14	1.4 DL+1.2 LL(全部)	J[28]	-265.71	-0.00	-3137.58	1397.34	-6454.46	-0.00	579.22	983.77	-1329.74
15	1.4 DL+1.2 LL(全部)	I[28]	-265.71	-0.00	-3137.58	1397.34	-6454.46	-0.00	579.22	983.77	-1329.74
15	1.4 DL+1.2 LL(全部)	J[29]	-265.71	-0.00	-2304.35	1229.71	5571.51	-0.00	599.16	849.83	-1256.78
16	1.4 DL+1.2 LL(全部)	I[29]	-265.71	-0.00	-2304.35	1229.71	5571.51	-0.00	599.16	849.83	-1256.78
16	1.4 DL+1.2 LL(全部)	J[30]	-265.71	-0.00	-1467.40	1084.56	10772.03	-0.00	602.81	697.38	-1248.51
17	1.4 DL+1.2 LL(全部)	I[30]	-265.71	-0.00	-1467.40	1084.56	10772.03	-0.00	602.81	697.38	-1248.51
17	1.4 DL+1.2 LL(全部)	J[31]	-265.71	-0.00	-636.56	-963.97	12651.62	0.00	603.24	-573.31	1247.69
18	1.4 DL+1.2 LL(全部)	I[31]	-265.71	-0.00	-636.56	-963.97	12651.62	0.00	603.24	-573.31	1247.69
18	1.4 DL+1.2 LL(全部)	J[32]	-265.71	-0.00	1343.60	-1085.28	11168.60	0.00	602.70	-698.10	1248.52
19	1.4 DL+1.2 LL(全部)	I[32]	-265.71	-0.00	1343.60	-1085.28	11168.60	0.00	602.70	-698.10	1248.52
19	1.4 DL+1.2 LL(全部)	J[33]	-265.71	-0.00	2179.01	-1230.43	6388.71	0.00	598.51	-849.82	1256.77
20	1.4 DL+1.2 LL(全部)	I[33]	-265.71	-0.00	2179.01	-1230.43	6388.71	0.00	598.51	-849.82	1256.77
20	1.4 DL+1.2 LL(全部)	J[34]	-265.71	-0.00	3008.37	-1398.06	-4455.99	0.00	575.46	-976.56	1329.68
21	1.4 DL+1.2 LL(全部)	I[34]	-265.71	-0.00	3008.37	-1398.06	-4455.99	0.00	575.46	-976.56	1329.68
21	1.4 DL+1.2 LL(全部)	J[35]	-265.71	-0.00	3820.81	-1580.27	-14976.22	0.00	499.16	766.59	1866.41
22	1.4 DL+1.2 LL(全部)	I[35]	0.00	0.00	-3483.04	1561.29	-14694.09	0.00	499.16	766.59	-1888.16
22	1.4 DL+1.2 LL(全部)	J[36]	0.00	0.00	-2576.54	1269.21	-5957.46	0.00	628.39	886.55	-1319.40
23	1.4 DL+1.2 LL(全部)	I[36]	0.00	0.00	-2576.54	1269.21	-5957.46	0.00	628.39	886.55	-1319.40
23	1.4 DL+1.2 LL(全部)	J[37]	0.00	0.00	-1646.62	1004.42	5407.86	0.00	647.93	673.13	-1257.51
24	1.4 DL+1.2 LL(全部)	I[37]	0.00	0.00	-1646.62	1004.42	5407.86	0.00	647.93	673.13	-1257.51
24	1.4 DL+1.2 LL(全部)	J[38]	0.00	0.00	-707.29	-1031.40	7777.32	0.00	643.76	-692.18	1259.29
25	1.4 DL+1.2 LL(全部)	I[38]	0.00	0.00	-707.29	-1031.40	7777.32	0.00	643.76	-692.18	1259.29
25	1.4 DL+1.2 LL(全部)	J[39]	0.00	0.00	1376.11	-1300.81	5742.98	0.00	574.57	-750.73	1366.28
26	1.4 DL+1.2 LL(全部)	I[39]	0.00	0.00	1376.11	-1300.81	5742.98	0.00	574.57	-750.73	1366.28

26	1.4 DL+1.2 LL(全部)	J[40]	0.00	0.00	2276.13	-1576.66	-322.87	0.00	56.60	1253.10	2407.59
27	1.4 DL+1.2 LL(全部)	I[40]	0.00	0.00	-999.97	1544.57	-322.87	0.00	56.60	1253.10	-1434.88
27	1.4 DL+1.2 LL(全部)	J[41]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2221.98	2221.98
28	1.4 DL+1.2 LL(全部)	I[8]	-1.94	0.00	-0.00	0.00	-0.00	0.00	0.00	0.00	0.00
28	1.4 DL+1.2 LL(全部)	J[15]	1.94	0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	1.4 DL+1.2 LL(全部)	I[7]	-2.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	1.4 DL+1.2 LL(全部)	J[16]	2.87	0.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00