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STRUCTURAL ANALYSIS OF THE EMERGENCY TO LONG-TERM BRIDGE

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Abstract: In view of the present bridge suddenly destroyed in man-made and natural disasters,causing traffic disruption, to meet the need to set up emergency bridge quickly when sudden traffic blowout ,at the same time after the completion of the relief without disrupting traffic, a small amount of work is done by the conversion of Long-term bridge, which is the general idea of an emergency bridge transfer to Long-term bridge. This paper put forward two kinds solution of an emergency bridge transfer to Long-term bridge:1) emergency bridge transfer to Long-term bridge base on the Bailey beam;2)emergency bridge transfer to Long-term bridge base on the steel-concrete composite bridge. And these two kind of schemes in the overall structure of the emergency stages and long-term stages are analyzed by finite element analysis, and introduces the construction process of two schemes.

Keywords: Emergency Bridge; Long-term Bridge; Finite Element Analysis; Construction Process

1. Introduction

Bridges as choke points in its service period, due to human factors such as overloading, and natural disasters as earthquake factors results in the decrease of bridge structure durability, even happen collapse malignant events, such as impact bridge operation safety and traffic flow, seriously affect the post-disaster reconstruction work. Bridge after the accident, the domestic usually USES is "321" assembled highway bridge steel, It can better apply to disaster relief, but due to her as a temporary bridge, and Bridges in the original recovery after opening, generally shall be removed and reused or abandoned, still need to Original bridge for repair or reconstruction, caused great waste of resources.

Therefore, we need to turn an emergency permanent bridge structure to change this situation, After the accident can be quick to build, guarantee in a relatively short period of time to restore the traffic on the road, to ensure the supply of post-disaster supplement lifeline, returned to normal transport in a timely manner. After the temporary bridge opened to traffic, under the condition of without causing obvious influence of the passage, by a small amount of work, able to bridge into a permanent This technique can shorten the road to the normal cycle of traffic accident, saving manpower and cost . This paper put forward two kinds solution of an emergency bridge transfer to Long-term bridge:1) emergency bridge transfer to Long-term bridge base on the Bailey beam;2)emergency bridge transfer to Long-term bridge base on the steel-concrete composite bridge.

2. Structural Analysis of Emergency Bridge transfer to Long-term Bridge base on the Bailey Beam

2.1. The Construction of Emergency Bridge

Sheme 1 is evolved on the basis of the beam Bailey. Using standard Bailey assembly on site in the event of the bridge damaged. The elevation drawing of sheme 1 as shown in Figure 1,the cross-section of sheme 1 as shown in Figure 2.The 3 meters standard Bailey connected through the dowel. Crossbeam using I25a-beams and connected with Bailey beam by U-bolt, longitudinal beam adopts I12.6-beams.5mm thick steel deck is use for carriageway slab. The steel desk and longitudinal beam connected by U-bolt.

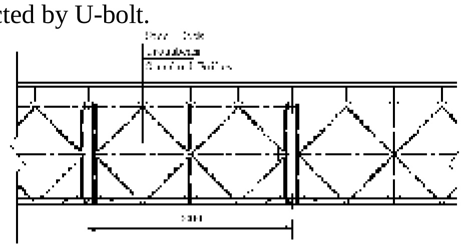

Figure 1. The elevation drawing of sheme 1(unit mm)

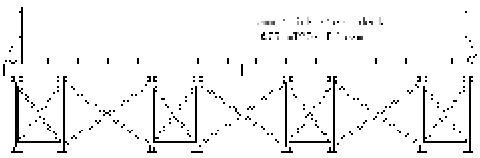

Figure 2. Cross-section of sheme 1

2.2. Analysis of Emergency Bridge

Simulations are carried out by the special bridge finite element software MIDAS/Civil, half of the bridge is used to simulation. Bailey are connected by dowels, so it can occur due to free rotation. Therefore, in the simulation we release rotational restraint between Baileys. Use the only compression elastic connection to simulate the connection between main beam and crossbeam. In the same way the only compression elastic connection is use to simulate the connection between longitudinal beam and crossbeam. Steel deck plate use plate unit and have the common node of crossbeam. Vehicle select 30 tons load. Finite element model shown in Figure 3.The deformation under 1.0 dead load and1.0 lane load shown in Figure 4. The results that emergency bridge under 1.0 dead load and1.0 lane load are shown in table 1.

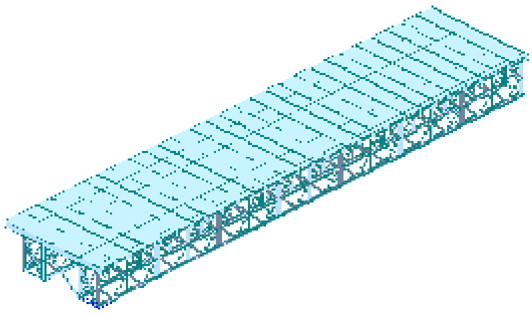

Figure 3. Finite element mode of emergency bridge

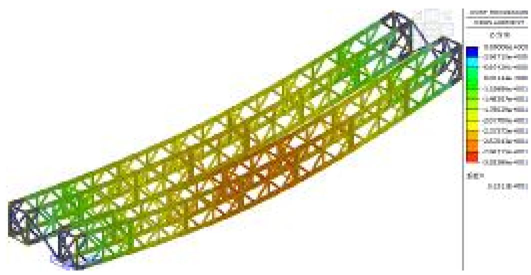

Figure 4. The deformation under 1.0 dead load and1.0 lane load

Table 1. The results of emergency bridge‘s main beam

Location	Displacement (mm)	The stress of Top flange(MPa)	The stress of lower flange (MPa)
1/2L	32.64	-146.3	23.2
1/4L	22.75	-118.5	15.6

Seen from table 1 results, the maximal displacement under 1.0 dead load and1.0 lane load is 32.64mm,less than the code requirement: L/600 = 21000/600 = 35mm,so the stiffness of the structure meets the code requirements. The maximum stress under 1.0 dead load and1.0 lane load is 146.3MPa, less than the code requirement: 560×1000/(25.48×100)=219.78MPa,so the strength of the structure meets the code requirements.

2.3. The Construction of Long-term Bridge

Under long-term load the strength, stiffness and stability of emergency bridge can not meet regulatory requirements. Without prejudice to the prevailing, a small amount of renovation work is completed to the long-term bridge renovation. Use the following guidelines for emergency bridge conversion: Using cold pressing forming technology to reinforcement the connection between Baileys, makes it to rigid connection.

We use concrete deck to improve the driving comfort. Concrete deck welding with Bailey beam thought the reserved steel plate. Considering the lifting capacity, the length of a prefabricated concrete is 3m.Concrete deck Longitudinal connected via infusion epoxy mortar. The elevation drawing of long-term shown in Figure 5, the cross-section of long-term shown in Figure 6.The reserved Steel in Prefabricated concrete deck shown in Figure 7,the reserved Steel in Bailey shown in Figure 8.

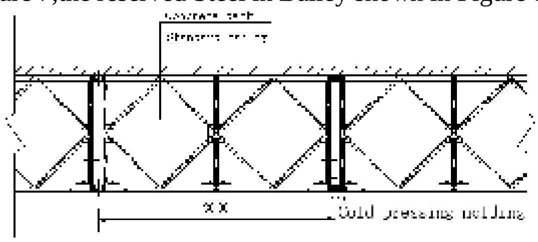

Figure 5. The elevation drawing of long-term bridge(unit mm)

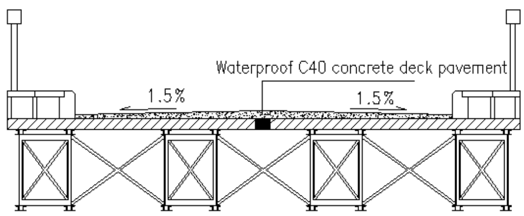

Figure 6. The cross section of long-term bridge

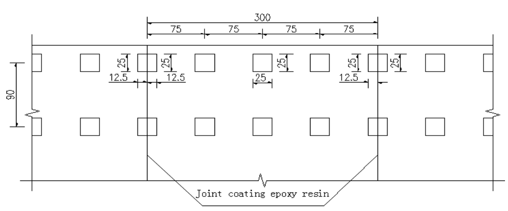

Figure 7. The reserved Steel in Prefabricated concrete deck(unit cm)

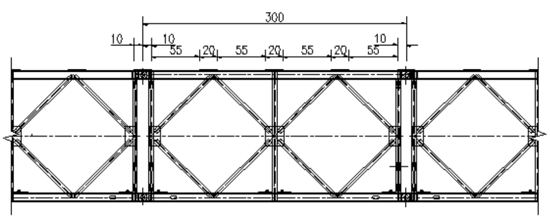

Figure 8. The reserved Steel in Bailey(unit cm)

2.4. Construction Process

Emergency bridge transform to Long-term bridge using demi construction. After the half bridge complete conversion, Vehicles move to long-term bridge, and then finish the other half bridge. Specific construction process as shown in Figure 9 to Figure 14.

Step one: erection of Bailey, crossbeam and steel deck, practicing two-way road traffic as emergency bridge, the cross-section of step 1 as shown in Figure 9.

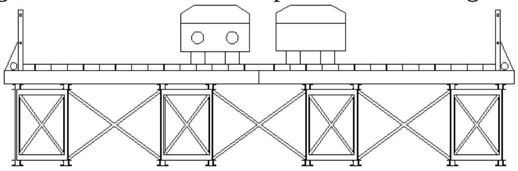

Figure 9. The cross-section of step 1

Step two: Remove the right side of the cross beam and the steel deck, the left half bridge is continue as an emergency bridge, the cross-section of step 2 as shown in Figure 10.

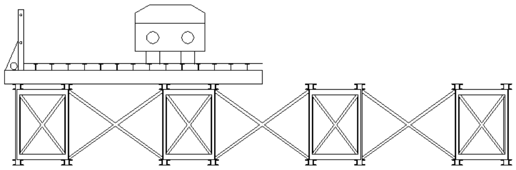

Figure 10. The cross-section of step 2

Step three: Using cold pressing forming technology to reinforcement the connection between Baileys, Install the right side concrete deck, welding with main beam, install the outside parapet, the cross-section of step 3 as shown in Figure 11.

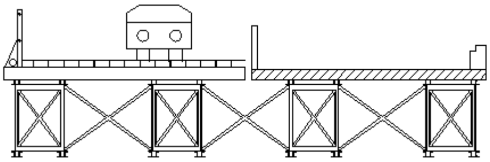

Figure 11. The cross-section of step 3

Step four: Vehicles move to the right side. As the same time, remove the left side of the cross beam and the steel deck, Install the left side concrete deck, welding with main beam, using cold pressing forming technology to reinforcement the connection between Baileys, Install the left side footwalk and bridge deck pavement.The cross-section of step 4 as shown in Figure 12.

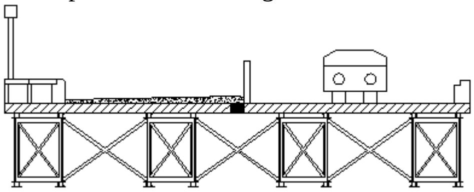

Figure 12. The cross-section of step 4

Step five: Vehicles move to the left side, Install the right side footwalk and bridge deck pavement. The cross-section of step 5 as shown in Figure 13.

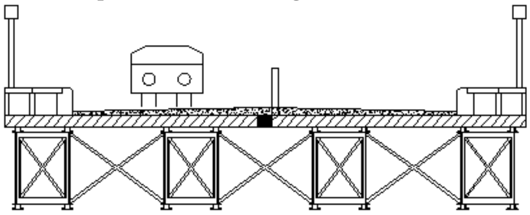

Figure 13. The cross-section of step 5

Step six: Remove the intermediate temporary railing, complete conversion to long-term bridge. The cross-section of step 6 as shown in Figure 14.

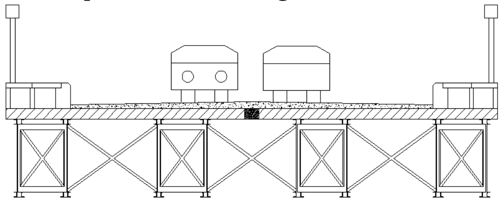

Figure 14. The cross-section of step 6

3. Structural Analysis of Emergency Bridge transfer to Long-term Bridge base on the steel-concrete Composite Bridge

Steel - concrete composite bridge (the combination of the bridge) is the steel beams and concrete deck integrally connected by shear connectors and consider joint force of bridge structure. Its steel girder section can be quickly set up to meet the emergency bridge needs of traffic. The concrete deck and steel beam integrally connected can use PCSS shear connectors to meet the need of rapidly transformation. PCSS shear connectors is a shear key that vertical steel plates and shear keys set inside the prefabricated bridge deck, latter the vertical steel and prefabricated deck is connected by welding steel girder.

3.1. The Construction of Emergency Bridge

Emergency bridge using the I-beam shown in Figure 8,considering the current requirements for lifting capacity and reserve standardization component, I-beam length is divided into 6 metres and 7 metres, the erection of the main girder is assembling on site, and the main girders connected by welding. In order to meet the requirements of emergency bridge that open to traffic rapidly, we used the steel bridge deck. Set I20 I-beam above the main beam as the crossbeam, laying 5mm steel plate as a lane on the crossbeam. The cross-section of scheme 2 as shown in Figure 15.Main beams and cross beams are connected by bolts. Use the U-bolts to connect steel deck and crossbeam.

3.2. Analysis of Emergency Bridge

Simulations are carried out by the special bridge finite element software MIDAS/Civil, using rigid connection between main beams and crossbeams, steel deck plate use plate unit and have the common node of crossbeam, half of the bridge is used to simulation. Vehicle uses the "highway bridge load in China"(JTJ001-97)QC-20, eccentric loading on the rail side. Finite element model shown in Figure 16. The results that emergency bridge under 1.0 dead load and1.0 lane load are shown in table 3.

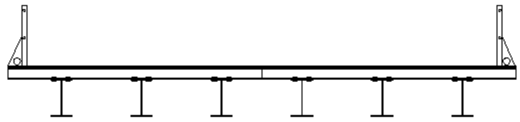

Figure 15. The cross-section of emergency bridge of scheme 2(Cross-linking is not displayed)

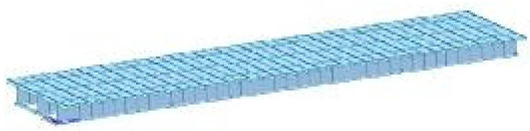

Figure 16. The finite element model of emergency bridge

Table 3. The results of emergency bridge's main beam

location	displacement (mm)	The stress of Top flange(MPa)	The stress of lower flange (MPa)
L/2	36.85	-147.84	53.15
L/4	/	-114.36	43.47

Seen from table 3 results, the maximal displacement under 1.0 dead load and1.0 lane load is 36.85mm,less than the code requirement: L/600 = 20000/600 = 33mm,so the stiffness of the structure meets the code requirements. The maximum stress under 1.0 dead load and1.0 lane load is 147.84MPa, less than the code requirement: 0.75×275=206.25 MPa, so the strength of the structure meets the code requirements.

3.3. The Construction of Long-term Bridge

In the process of transformation of Long-term bridge is full use the characteristics of the prefabricated bridge that the PCSS shear key is suitable for. The I-beam girder segment is connected by welding. And the I-beam height can withstand long-term load, Therefore, the conversion process does not need to transform the main beam. As the same as sheme1,we use concrete deck to improve the driving comfort. In the process of converting, removing the steel deck and crossbeam, lifting prefabricated concrete deck, after hoisting to right place ,we connected the concrete deck and main beam by welding, so that under load it can give full play to advantages of PCSS shear connectors. The cross-section of Long-term bridge of scheme 2 as shown in Figure 17.

3.4. Analysis of Long-term Bridge

The simulation of Long-term bridge is considering the PCSS shear key connection is good, so use rigid connection between the main beam and concrete deck, cast layer using construction phase of the joint cross-section, eccentric loading on the rail side, choosing load-II level as the highway vehicle, the crowd load is 3.0kN/m2, considering the temperature rise, the temperature drop and temperature gradient effect. Finite element model shown in Figure 18. The results that Long-term bridge are shown in table 4

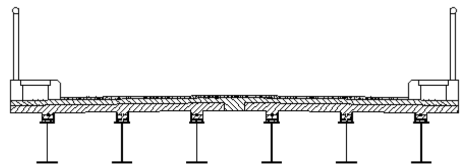

Figure 17. The cross-section of of Long-term bridge of scheme 2(Cross-linking is not displayed)

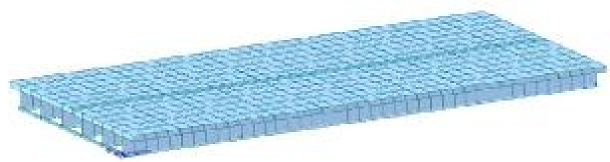

Figure 18. The finite element model of long-term bridge

Table 4. The results of long-term bridge's main beam

mid-span deflection (cm)		Permanent load	Vehicle load	crowd load	temperature rise	Combination of long-term effects
		5.55	0.75	0.06	0.19	6.29
Stress in the span(MPa)	The stress of Top flange	-121.00	-7.66	-0.73	-7.78	-133.32
	The stress of lower flange	119.00	59.63	3.73	4.43	168.02

Seen from table 4 results, the maximal displacement under 1.0 dead load +1.0 lane load+0.8 crowd load+0.8 temperature rise is 62.9mm, within the range of camber, so the stiffness of the structure meets the code requirements. The maximum stress under 1.0 dead load +1.0 lane load+0.8 crowd load+0.8 temperature rise is 168.02MPa, less than the code requirement:

0.75×275=206.25 MPa, so the strength of the structure meets the code requirements.

3.5. Construction Process

The construction process of sheme 2 is similar to sheme 1. using demi construction. After the half bridge complete conversion, Vehicles move to long-term bridge,and then finish the other half bridge. Specific construction process as shown in Figure 19 to Figure 24.

Step one: erection of steel I-beam, crossbeam and steel deck, practicing two-way road traffic as emergency bridge, the cross-section of step 1 as shown in Figure 19.

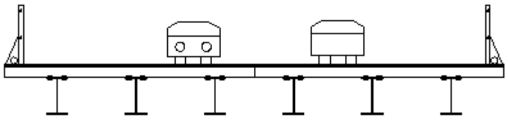

Figure 19. The cross-section of step 1

Step two: Remove the right side of the cross beam and the steel deck, the left half bridge is continue as an emergency bridge, the cross-section of step 2 as shown in Figure 20.

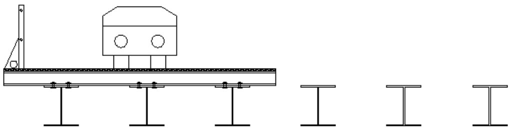

Figure 20. The cross-section of step 2

Step three: Install the right side concrete deck, welding with main beam, install the outside parapet, the cross-section of step 3 as shown in Figure 21.

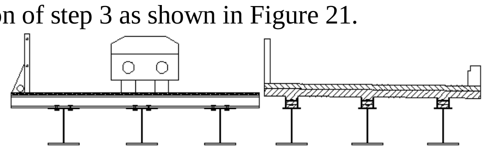

Figure 21. The cross-section of step 3

Step four: Vehicles move to the right side. As the same time, remove the left side of the cross beam and the steel deck, Install the left side concrete deck, welding with main beam, Install the left side footwalk and bridge deck pavement.The cross-section of step 4 as shown in Figure 22.

Step five: Vehicles move to the left side, Install the right side footwalk and bridge deck pavement. The cross-section of step 5 as shown in Figure 23.

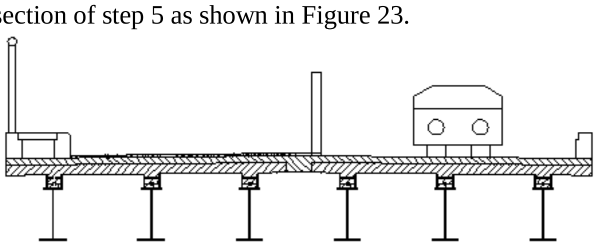

Figure 22. The cross-section of step 4

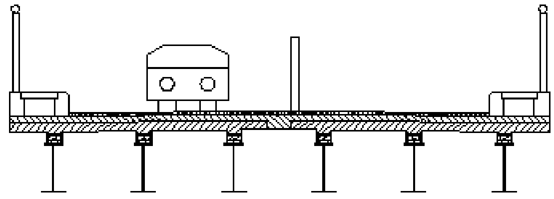

Figure 23. The cross-section of step 5

Step six: Remove the intermediate temporary railing, complete conversion to long-term bridge. The cross-section of step 6 as shown in Figure 23.

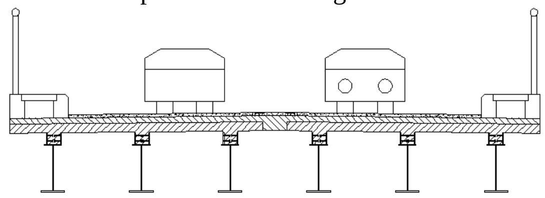

Figure 24. The cross-section of step 6

4. Conclusion

Scheme 1 based on the bailey beam emergency permanent bridge using current bailey pieces which are frequently used as a main girder bridge, bailey piece as local preparedness reserve components can rapid transport to the scene when disasters occur, a short time can finish construction meet the temporary passage,in the conversion to a permanent bridge is only need to reinforced concrete bridge panel and girder joint replacement. Through finite element simulation shows its emergency bridge phase and phase structure of the permanent bridge strength stiffness can meet the specification requirements. Scheme 2 based on emergency permanent bridge of steel concrete composite structure use the thought of combination structure , I-beam girder segment is produced in factory . In the field of welding and then install in place, it meet the temporary passage laying beam and steel bridge panel, When to permanent bridge girder is changeless, the steel bridge deck plate is replaced for pcss Shear key but concrete bridge . Through the finite element simulation shows at Emergency bridge and Permanent bridge phase its structure strength, stiffness and permanent bridge can meet the specification requirements.

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