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Research Article

An Adjustment Method for the Suspender Tension of CFSTTTHAB Based on Influence Matrix of Single Suspender

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Based on the funding project "a concrete-filled steel tube truss type half-through arch bridge (CFSTTTHAB) with the span of 220 m," in view of the difference of tension between one pair of suspenders, this paper proposed an improved influence matrix method for the tension of a single suspender, which was developed from a conventional influence matrix. A method for adjusting suspender tension at the completed state of construction by using numerical simulation and iterative algorithm was also presented. Finite element numerical model was used to calculate the influence matrix of a single suspender. Moreover, an iterative algorithm was used to solve the adjustment value of suspender tension. Based on the proposed method, by processing several iterations, the difference between the measured and designed suspender tension would be controlled within 6% in the projects of suspender tension adjustment. Finally, the comparison between the measured and designed suspender tension at the completed state of construction proved the feasibility and accuracy satisfaction of the proposed method for engineering requirement.

1. Introduction

Installation of grid-beam is one of the key construction processes of CFSTTTHAB [1, 2]. A popular installation method is assembling of prefabricated segments. Within each installation period, a pair of suspenders is equipped and other related suspenders are tensioned simultaneously, until closure of grid beam is accomplished [3, 4]. In practical projects, after closure, the measured suspender tension is usually different to the designed value at completed state of construction [5]. Difference also exists between upstream and downstream suspenders from one single pair. For cable bridges, one of the most vital and expensive elements are cables. In addition, prestressing force is very important in achieving the performance expected from the cable bridges [6]. Therefore, adjustment of suspender tension is essential to ensure measured suspender tension satisfying designed necessity [7, 8]. Moreover, the core mission for suspender stretching is to establish an adjustment scheme during construction process based on designed suspender tension at completed state of construction [9–11].

Since grid-beam of CFSTTTHAB is flexible, during stretching process for each group of suspenders, interaction between different group is inevitable, which generates deformation and internal force redistribution [12–15]. Because the grid-beam is a high order statically indeterminate structure, when making tension adjustment for a single suspender, it is quite complicated to evaluate the amount of interaction for the rest of suspenders. The adjustment scheme for all suspenders is also difficult to establish as well [16]. Commonly, numerical simulation with influence matrix is adopted to determine adjustment scheme based on relationship between adjusting tension and influence matrix in terms of current suspender tension, designed tension, and construction order [17–19]. However, conventional influence matrix considers a pair of suspenders as an integrity. For a pair of suspenders, the difference of tension occurs between upstream and downstream suspenders. Consequently, conventional influence matrix adjustment plan is not the ideal solution [20].

This paper aims at proposing an adjustment method for suspender tension of CFSTTTHAB by improving algorithm based on conventional influence matrix. The proposed method is then verified by data collecting from a supporting project of a CFSTTTHAB with the span of 220 m. The adjustment plan for suspender tension of CFSTTTHAB is determined after taking into consideration the difference of upstream and downstream in one pair of suspenders. The research also provides further reference for suspender tensioning construction for similar type of bridges.

2. Adjustment Method for the Suspender Tension of CFSTTTHAB Based on Influence Matrix for Single Suspender

2.1. Theory of Solving Suspender Tension Adjustment at the Completed State of Construction Based on Conventional Influence Matrix. The designed suspender tension of bridge at the completed state of construction $\{T_L\}$ is different to the practical value $\{T_S\}$ at state of grid-beam closure, which means the design requirement has not been satisfied. Consequently, it needs to make a second step to adjust.

Because the grid beam is a high order statically indeterminate structure, when making a single suspender tension adjustment, it is quite complicated to evaluate the number of interaction for the rest of suspenders. Therefore, the conventional method is insufficiently effective to establish a suspender tension adjustment plan. In order to solve adjustment value, an influence matrix is introduced.

The tension force variation of suspender no. j due to the tension adjustment of suspender no. i is defined as ΔS_{ji}. Commonly, the suspender tension is adjusted by restretching cable. Thus, the final tension for a single suspender is only related to its own adjustment amount and influenced by the following adjustment applied to other suspenders. Define the suspender number as 1#, 2#, … k# according to the stretching process. The tension variation due to stretching is represented as $\{T_a\}$. The tension adjustment value in terms of original tension for each suspender number is written as $P_i (i = 1, 2, \ldots, k)$. Here, it is assumed that the relationship of single suspender tension adjustment to the other suspenders is linear. Then, the variation of suspender tension of bridge at the completed state of construction can be written as

$$\Delta T_i = \sum_{j=i}^{k} \Delta S_{ij} \cdot P_j, \quad i = 1, 2, \ldots, k, \tag{1}$$

where ΔS_{ji} represents the tension variation of suspender j# due to adjustment of suspender i#; $\{T_a\}$ is tension variation due to restretching; P_i denotes tension variation compared to original state for suspender i#. Equation (1) can also be described in matrix form as

$$\{\Delta T\} = [A]\{P\}, \tag{2}$$

where $\{\Delta T\} = \begin{Bmatrix} \Delta T_1 \\ \Delta T_2 \\ \vdots \\ \Delta T_k \end{Bmatrix}$ is final suspender tension; $\{P\} = \begin{Bmatrix} P_1 \\ P_2 \\ \vdots \\ P_k \end{Bmatrix}$ is adjustment of suspender tension; $[A] = \begin{bmatrix} \Delta S_{11} & \Delta S_{12} & \cdots & \Delta S_{1k} \\ 0 & \Delta S_{22} & \cdots & \Delta S_{2k} \\ \vdots & \ddots & \ddots & \vdots \\ 0 & \cdots & 0 & \Delta S_{kk} \end{bmatrix}$ is influence matrix, which represents tension variation of all suspenders due to adjustment of a single suspender [1].

Since $\{\Delta T\}$ can be solved by using designed and original values of suspender tension,

$$\{\Delta T\} = \{T_L\} - \{T_S\}, \tag{3}$$

where $\{T_L\}$ is the designed suspender tension of bridge at the completed state of construction, and $\{T_S\}$ is the original suspender tension before adjustment. By substituting (3) into (2) and left-multiplying by $[A]^{-1}$ in both sides of (3), the tension adjustment for all suspenders can be written as

$$\{P\} = [A]^{-1} (\{T_L\} - \{T_S\}). \tag{4}$$

Then, the final suspender tension after adjustment is obtained as follows:

$$\{T_a\} = \{P\} + \{T_S\}. \tag{5}$$

The influence matrix $[A]$ can be solved by finite element numerical simulation. Based on suspender tension at closure state in finite element bridge mode, the tension for each suspender can be evaluated by applying the unit force to suspender #i. Then, the difference between calculated and original tensions ΔS_{ji} of suspender #j is the influencing amount of suspender #j when the unit amount of adjustment is applied to suspender #i.

2.2. Adjustment Method for the Suspender Tension of CFSTTTHAB Based on Influence Matrix for Single Suspender. As mentioned in the previous section, a pair of suspenders located at upstream and downstream side, respectively, is treated as an integrity in terms of influence matrix. Difference of tension between upstream and downstream suspenders is not considered. Hence, in practical bridge projects, this method fails to provide an ideal adjustment scheme. An improvement for the adjustment scheme is necessary.

First, the influence matrix is replaced by the impact of single suspender tension on all other suspenders. Since a pair of suspenders is stretched simultaneously, the tension variation for a pair of suspenders will not affect each other. Consequently, elements of ΔS_{ii} in influence matrix can be represented as

$$\Delta S_{ii} = \begin{bmatrix} \Delta S_{i_s i_s} & 0 \\ 0 & \Delta S_{i_x i_x} \end{bmatrix}. \tag{6}$$

When stretching of previous pair of suspenders is finished, both upstream and downstream suspenders are affected by the following stretching of other suspenders. Therefore, elements ΔS_{ii} in influence matrix can be written as

$$\Delta S_{ij} = \begin{bmatrix} \Delta S_{i_s j_s} & \Delta S_{i_s j_x} \\ \Delta S_{i_x j_s} & \Delta S_{i_x j_x} \end{bmatrix}, \tag{7}$$

where i_s and i_x represent both upstream and downstream suspenders of pair #i and $\Delta S_{i_s j_s}$ is how stretching of upstream suspender of pair #j influence upstream suspender tension of pair #j. Then, the influence matrix becomes

$$[A] = \begin{bmatrix} \Delta S_{1_s 1_s} & 0 & \Delta S_{1_s 2_s} & \Delta S_{1_s 2_x} & \cdots & \Delta S_{1_s k_s} & \Delta S_{1_s k_x} \\ 0 & \Delta S_{1_x 1_x} & \Delta S_{1_x 2_s} & \Delta S_{1_x 2_x} & \cdots & \Delta S_{1_x k_s} & \Delta S_{1_x k_x} \\ 0 & 0 & \Delta S_{2_s 2_s} & 0 & \cdots & \Delta S_{2_s k_s} & \Delta S_{2_s k_x} \\ 0 & 0 & 0 & \Delta S_{2_x 2_x} & \cdots & \Delta S_{2_x k_s} & \Delta S_{2_x k_x} \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & 0 & 0 & 0 & \Delta S_{k_s k_s} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \Delta S_{k_x k_x} \end{bmatrix}. \tag{8}$$

The final variation and adjustment of suspender tension is as follows:

$$\{\Delta T\} = \begin{Bmatrix} \Delta T_{1_s} \\ \Delta T_{1_x} \\ \Delta T_{2_s} \\ \Delta T_{2_x} \\ \vdots \\ \Delta T_{k_s} \\ \Delta T_{k_x} \end{Bmatrix}, \quad \{P\} = \begin{Bmatrix} P_{1_s} \\ P_{1_x} \\ P_{2_s} \\ P_{2_x} \\ \vdots \\ P_{k_s} \\ P_{k_x} \end{Bmatrix}. \tag{9}$$

In (8), the updated influence matrix is an influence matrix for single suspender, which takes into account difference between upstream and downstream suspenders from one pair.

2.3. Iterative Algorithm of Suspender Tension Adjustment. In the previous scetion, the relationship between suspender tension adjustment and its influence on other suspenders is assumed to be linear. However, nonlinearity exists in practical projects. Consequently, difference between designed and final suspender tensions may be beyond expectation if (4) is used to calculate tension adjustment in one step. Therefore, iterative algorithm of suspender tension adjustment is necessary to evaluate the adjustment amount by the following procedure.

(1) Calculate suspender tension adjustment $\{P\}_1$ by solving (4).
(2) Substitute adjustment $\{P\}_1$ into finite element model to generate suspender tension at completion state of construction $\{T_L\}_1$, and calculate the difference $\{\Delta T\}_1$ between $\{T_L\}$ and $\{T_L\}_1$.
(3) Replace $\{T_S\}$ with $\{T_L\}_1$ in (4), and new adjustment $\{P\}_2$ is obtained.
(4) Substitute $\{P\}_1 + \{P\}_2$ as a new set of suspender tension adjustment, and repeat the steps (2)–(4) by n times until the difference $\{\Delta T\}_n$ of between $\{T_L\}$ and $\{T_L\}_n$ satisfies the precision requirement.
(5) The final suspender tension adjustment is $\{P\} = \{P\}_1 + \{P\}_2 + \cdots \{P\}_n$.

Iterative algorithm of suspender tension adjustment can also be illustrated in Figure 1.

3. Project Application

3.1. Project Information and Numerical Simulation Model. An application example is exhibited by the rehabilitation and suspender tension adjustment project of Liujing-Yujiang bridge (shown in Figure 2) which was constructed in 1998. This bridge is typical CFSTTTHAB with 220 m span length, and the arch axis coefficient f is 4400. The width of the integral bridge deck is 25.1 m, on both sides where there is 1 m wide sidewalk as shown in Figure 3. Deck of the bridge is supported with 70 steel suspenders which is a link to arch ribs. Each arch rib is uniformly cross-sectional concrete-filled steel tube truss. The height and width of each arch rib are 4.3 m and 2 m, respectively. Five steel tube trusses and four reinforced concrete T-beams are arranged between the two arch ribs. The steel pipe of the main arch rib is made of 16-Mn-typed steel and filled with C50 concrete.

In 2018, the bridge was repaired and strengthened by removing the original bridge deck, as well as longitudinal and transversal beams, and replacing them with steel-concrete composite grid-beam. The traffic lanes are carried by grid-beam, pavement, and deck. Before rehabilitation, each original suspender is made using 61 lateral galvanized wires, whose diameter is 7 mm, and each new suspender is made using 55 lateral galvanized wires, whose diameter is also 7 mm, and covered with double layers HDPE protection. The strength of wires is 1670 MPa. There are 35 pairs of suspenders in total spacing 5 m, which are numbered 1 to 35 from Nanning to Liuzhou (as shown in Figure 2).

Because this bridge is a longitudinally symmetric structure, suspender tension adjustment may start from each side of springers to mid-span, stretching two pairs, four suspenders at once. The finite element model should be established based on each single suspender, to calculate and form the adjustment scheme. The three-dimensional finite element model is formed in Midas Civil as shown in Figure 4

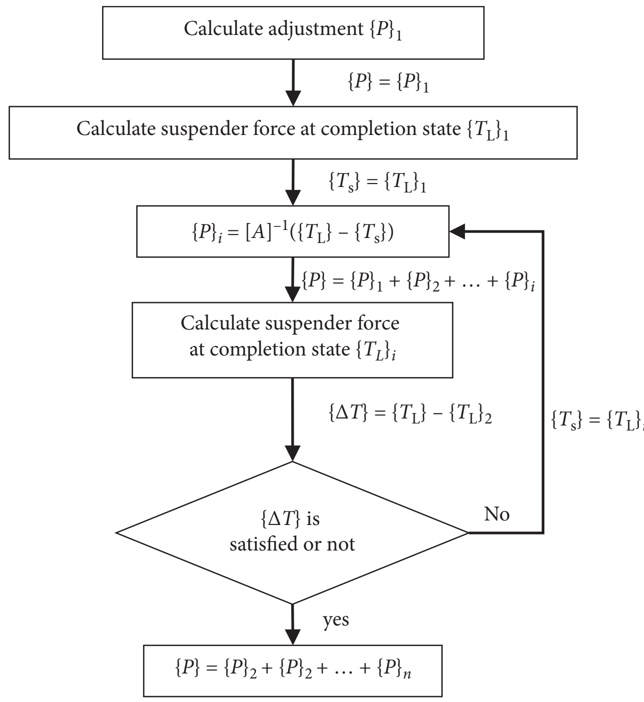

Figure 1: Flowchart of iterative algorithm of suspender tension adjustment.

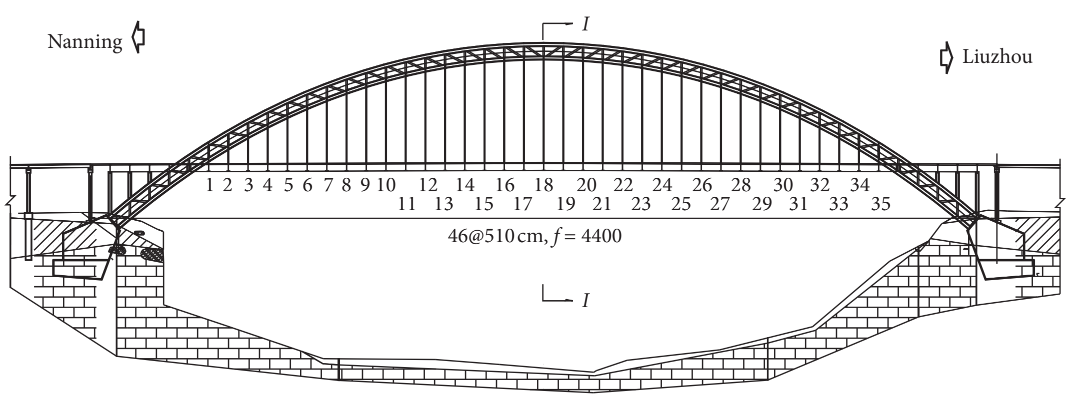

Figure 2: Liujing-Yujiang bridge.

and the whole model consisted of 1751 nodal points, 70 truss elements, 2678 beam elements, and 360 plate elements. The suspenders are represented with truss elements and the deck is described by plate elements while others are represented with beam elements. The materials of the modal are listed in Table 1.

3.2. Influence Matrix and Solution of Adjustment Scheme. This paper proposed a designing process for suspender tension adjustment scheme in terms of influence matrix of single suspender. After the closure of grid-beam, the original suspender tension was measured to compare with the designed values. Table 2 lists the comparison results at the completion state of construction. Figure 5 illustrates the comparison results.

As shown in Table 2, differences between measured and designed suspender tensions at the completion state of construction is quite large. Moreover, difference also exists in one pair of suspenders, located at upstream and downstream sides, respectively. Therefore, the adjustment is in essential. The adjustment order is 1# $\longrightarrow$ 35# $\longrightarrow$ 2# $\longrightarrow$ 34# $\longrightarrow \ldots \longrightarrow$ 18#. Based on the suspender tension at closure state, influence matrix for single suspender can be calculated:

$$[A] = \begin{bmatrix} 1 & 0 & 0.000653 & 0.000573 & \cdots & -0.00023 & -0.00030 \\ 0 & 1 & 0.000573 & 0.000653 & \cdots & -0.00030 & -0.00023 \\ 0 & 0 & 1 & 0 & \cdots & -0.00024 & -0.00029 \\ 0 & 0 & 0 & 1 & \cdots & -0.00029 & -0.00024 \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}. \tag{10}$$

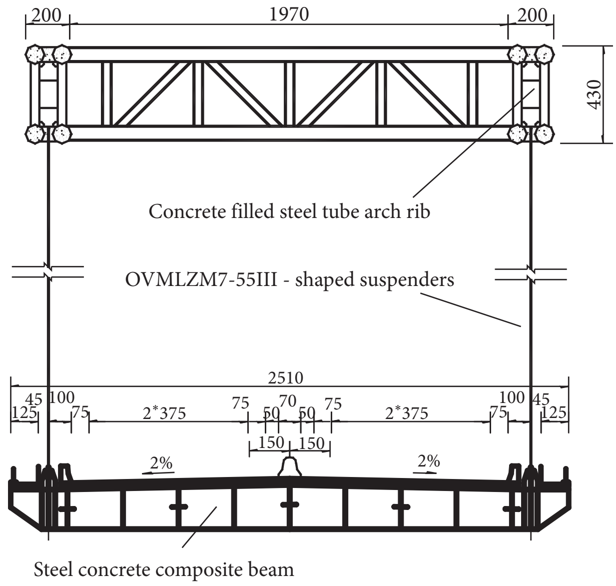

Figure 3: The I-I cross-section (unit: cm).

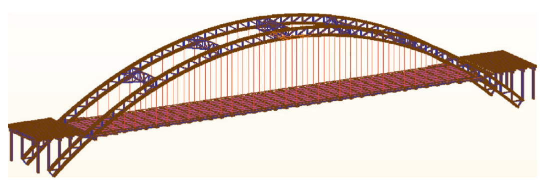

Figure 4: Finite element model of Liujing-Yujiang Bridge.

Table 1: Materials of the modal.

Material type	Applicable parts	Modulus of elasticity (kN/m^2)	Bulk density (kN/m^3)
16Mn	Arch rib	2.10*e*8	76.98
OVMLZM7-55III	Suspenders	2.05*e*8	78.5
C50	Deck	3.45*e*7	26
Q345	Main girders and cross-beams	2.06*e*8	100.7

Suspender tension adjustment value is solved by iterative algorithm. After three iterations, the adjustment value and final suspender tension at completion state are shown in Table 3 and Figure 6.

As shown in Table 3, based on the proposed method, it only takes a few steps of iterative algorithm to solve the adjustment. As a result, the difference between final measured suspender tensions at completion state of construction and design suspender tension is smaller than 5%.

3.3. Evaluation on Application Effect of Suspender Tension Adjustment Scheme. The tension for each suspender is adjusted based on the computed results. The practical tension is measured by the vibration approach. The measured and designed suspender tensions at completion state of construction are shown in Table 4 and Figure 7.

From the previously mentioned comparison results, the difference between the measured and designed suspender tensions at completion state is less than 7%, which satisfies the engineering requirement. Based on the proposed

Table 2: Original suspender tension after closure.

Number of suspenders	Measured suspender tension after closure (kN)		Designed suspender tension at completion state (kN)	Relative difference	
	Upstream	Downstream		Upstream (%)	Downstream (%)
1	226.9	212	442.7	−48.75	−52.11
2	883.6	818.5	453	95.06	80.68
3	556.7	631.1	580.9	−4.17	8.64
4	447.5	455.7	519.4	−13.84	−12.26
5	495.8	549.3	496.8	−0.20	10.57
6	483.3	456.9	489.6	−1.29	−6.68
7	478.7	486.6	490.3	−2.37	−0.75
8	460.3	486.9	492	−6.44	−1.04
9	456.8	428.6	492.7	−7.29	−13.01
10	511.4	492.1	492.4	3.86	−0.06
11	534.6	514.3	491.3	8.81	4.68
12	518.7	532.8	491.1	5.62	8.49
13	554.2	514.8	493.4	12.32	4.34
14	502.2	460.7	495.2	1.41	−6.97
15	448.6	398.2	495.6	−9.48	−19.65
16	491.2	476.2	492.9	−0.34	−3.39
17	408.1	452.6	485.1	−15.87	−6.70
18	620.3	654.1	478	29.77	36.84
19	442.8	423.1	485.1	−8.72	−12.78
20	463.3	414.2	492.9	−6.01	−15.97
21	458.6	445.9	495.6	−7.47	−10.03
22	493.1	508.2	495.2	−0.42	2.63
23	492.7	502.2	493.4	−0.14	1.78
24	481	481	491.1	−2.06	−2.06
25	470.8	464.2	491.3	−4.17	−5.52
26	486.2	506.1	492.4	−1.26	2.78
27	596.7	548.1	492.7	21.11	11.24
28	468.1	532	492	−4.86	8.13
29	402.5	382.4	490.3	−17.91	−22.01
30	486	555.9	489.6	−0.74	13.54
31	374.1	368.3	496.8	−24.70	−25.87
32	528.5	543.1	519.4	1.75	4.56
33	667	693	580.9	14.82	19.30
34	502.3	451.5	453	10.88	−0.33
35	410.4	422.8	442.7	−7.30	−4.50

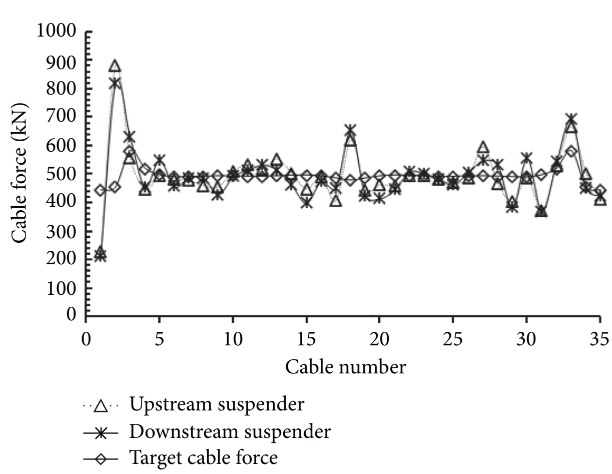

Figure 5: Comparison between measured and designed suspender tension at completion state.

Table 3: Adjustment value and final suspender tension at completion state.

Number of suspenders	Adjustment value (kN)		Suspender tension after adjustment (kN)		Demanded suspender tension (kN)	Relative difference	
	Upstream	Downstream	Upstream	Downstream		Upstream (%)	Downstream (%)
1	18.7	24.9	454.4	455.4	442.7	2.66	2.86
2	−2.7	−10.6	473.5	475.4	453.0	4.52	4.94
3	−463.7	−458.2	599.9	609.1	580.9	3.26	4.85
4	−51.1	−33.1	527.7	540.9	519.4	1.61	4.14
5	42.3	−86.9	498.2	509.1	496.8	0.28	2.47
6	−15.6	−90.7	487.0	493.8	489.6	−0.55	0.85
7	93.4	41.7	486.3	488.5	490.3	−0.81	−0.37
8	95.2	28.6	489.1	486.3	492.0	−0.58	−1.14
9	31.1	−32.5	493.0	485.3	492.7	0.06	−1.50
10	194.4	139.7	496.9	485.2	492.4	0.91	−1.47
11	35.7	58.5	499.4	484.8	491.3	1.65	−1.32
12	65.7	−38.4	501.2	485.0	491.1	2.05	−1.25
13	30.9	36.1	503.2	486.7	493.4	1.99	−1.36
14	107.5	93.7	502.3	487.0	495.2	1.42	−1.66
15	26.9	39.5	492.0	472.9	495.6	−0.72	−4.58
16	18.3	−49.9	488.5	476.5	492.9	−0.88	−3.32
17	1.4	76.2	476.5	465.9	485.1	−1.78	−3.95
18	−82.3	−46.3	478.0	478.0	478.0	0.00	0.00
19	−65.0	6.7	479.4	471.2	485.1	−1.17	−2.87
20	32.4	8.7	484.3	474.4	492.9	−1.74	−3.76
21	−85.4	−10.3	480.4	471.0	495.6	−3.07	−4.98
22	46.0	49.5	486.6	485.4	495.2	−1.74	−1.99
23	−62.6	−10.2	485.6	486.5	493.4	−1.58	−1.39
24	35.4	34.4	484.0	486.2	491.1	−1.45	−1.00
25	−71.8	25.4	484.4	487.8	491.3	−1.41	−0.71
26	26.4	22.2	484.8	490.0	492.4	−1.53	−0.48
27	−5.4	75.8	483.3	490.6	492.7	−1.91	−0.42
28	25.6	25.8	479.1	489.2	492.0	−2.62	−0.55
29	38.2	96.8	474.1	486.5	490.3	−3.31	−0.77
30	40.7	67.9	472.0	486.0	489.6	−3.60	−0.74
31	−0.2	10.5	480.5	494.2	496.8	−3.29	−0.52
32	22.7	76.2	508.0	520.1	519.4	−2.18	0.13
33	48.0	2.4	576.4	585.5	580.9	−0.79	0.78
34	8.9	23.4	454.3	457.2	453.0	0.29	0.94
35	−139.9	−173.7	445.6	445.3	442.7	0.67	0.59

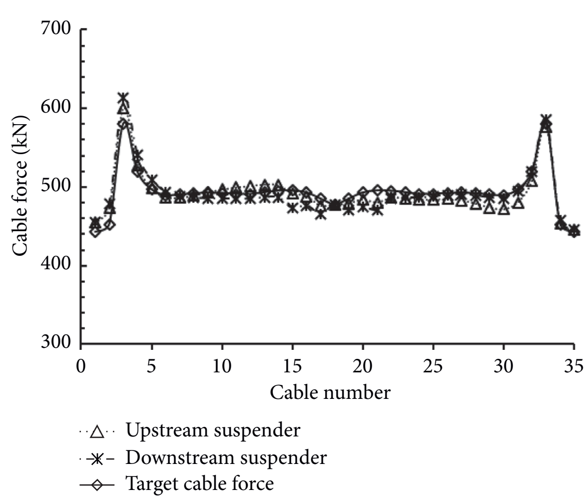

Figure 6: Theoretical and designed suspender tension after adjustment.

Table 4: Value comparison between measured and designed suspender tension at completion state.

Number of suspenders	Measured suspender tension after closure (kN)		Designed suspender tension at completion state (kN)	Relative difference	
	Upstream	Downstream		Upstream (%)	Downstream (%)
1	463.8	450.3	442.7	4.76	1.71
2	477.2	479.5	453.0	5.33	5.85
3	615.1	591.4	580.9	5.89	1.82
4	515.6	525.1	519.4	−0.74	1.09
5	489.7	514.7	496.8	−1.43	3.60
6	471.5	466.7	489.6	−3.70	−4.67
7	486.0	482.6	490.3	−0.88	−1.58
8	463.2	465.0	492.0	−5.86	−5.48
9	496.8	479.3	492.7	0.84	−2.72
10	506.8	501.4	492.4	2.92	1.83
11	521.7	498.6	491.3	6.19	1.49
12	462.6	484.9	491.1	−5.81	−1.26
13	495.3	493.7	493.4	0.38	0.06
14	488.8	475.7	495.2	−1.28	−3.94
15	478.1	488.6	495.6	−3.52	−1.40
16	475.6	471.4	492.9	−3.51	−4.35
17	463.3	478.1	485.1	−4.49	−1.43
18	477.5	465.4	478.0	−0.11	−2.63
19	461.8	486.9	485.1	−4.80	0.37
20	501.1	494.5	492.9	1.66	0.32
21	474.2	480.5	495.6	−4.32	−3.04
22	470.7	485.0	495.2	−4.94	−2.07
23	480.1	495.8	493.4	−2.69	0.49
24	490.0	474.1	491.1	−0.23	−3.47
25	499.4	476.5	491.3	1.65	−3.02
26	508.8	497.8	492.4	3.33	1.09
27	478.9	468.4	492.7	−2.80	−4.92
28	468.3	482.2	492.0	−4.82	−2.00
29	492.3	500.1	490.3	0.40	2.00
30	475.3	487.5	489.6	−2.92	−0.44
31	472.5	469.4	496.8	−4.88	−5.52
32	507.4	508.0	519.4	−2.31	−2.19
33	574.8	602.0	580.9	−1.05	3.62
34	469.5	478.1	453.0	3.63	5.53
35	462.3	470.6	442.7	4.42	6.31

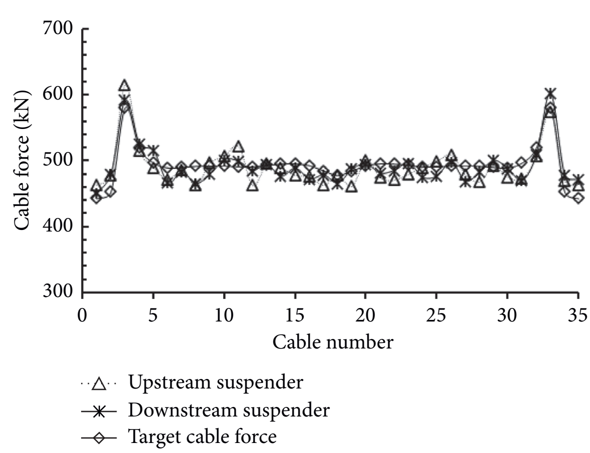

Figure 7: Plot comparison between measured and designed suspender tension at completion state.

adjustment scheme, the suspender tension at completion state of construction is sufficiently precise to meet the design requirement.

4. Conclusion

In this paper, the suspender tension adjustment for CFSTTTHAB is studied when a large difference of suspender tensions between upstream and downstream after the completion of the lattice beams exist. As an improved method of the traditional influence matrix, an adjustment method for the suspender tension of CFSTTTHAB based on influence matrix of single suspender is proposed. The proposed method is applied to practical engineering, and the results of theoretical suspender tension adjustment and actual suspender tension adjustment are compared with the design suspender tension value, respectively. From the point of view of the investigation carried out, the following conclusions are reached.

(1) There is a big difference between the measured suspender tensions of upstream and downstream after the completion of the lattice beams, among which the difference of 3# suspender is up to 13.37%. Therefore, the traditional influence matrix method which only considers the average value of the upstream and downstream suspender tensions will produces large errors.

(2) Using the proposed method in this study, only a few iterations are needed to obtain satisfactory adjustment results of suspender tensions, with an only maximum difference of −4.98% from the designed suspender tension of completed bridge.

(3) It can be seen from the actual project implementation effect that the maximum deviation between the suspender tension of final adjustment and designed completed bridge is only 6%, which meets the engineering requirements.

In conclusion, the method proposed in this paper is convenient and feasible in theoretical calculation and can be operated in engineering application as well as meeting the accuracy requirements of engineering.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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