# Analysis for Initial Equilibrium Condition and Erection Stages of Sorok (Self-Anchored Suspension) Bridge

**Yunki SON**
Project Manager
ENVICO Consultants
Seoul, Korea
*yunki@envico.biz*

**Dongho YOO**
President
ENVICO Consultants
Seoul, Korea
*dyoo@envico.biz*

**Seungwook JEONG**
Chief Engineer
Dealim Industrial
Seoul, Korea
*swjeong@daelim.co.kr*

**Taeseop YOON**
Project Manager
Dealim Industrial
Seoul, Korea
*stepano@ daelim.co.kr*

## Summary

This paper presents analysis and construction method of the Sorok (self-anchored suspension) bridge. To find the optimum initial equilibrium condition of self-anchored suspension bridge, the forces of main cable and hanger are developed together with minimizing vertical camber of stiffening girder. Erection stage analyses are carried out for both hanger-pulling method and girder jack-down method to find out the more effective one which ensure the erection stability and cost efficiency. Hanger-pulling method is adopted as the erection scheme of suspension system. Various measurement results at site show that analysis results are well matched up with bridge deformation and girder profile during construction and at its final stage and have a good correspondence with the original design profile.

**Keywords:** self-anchored suspension bridge; initial equilibrium condition; erection stage analysis; hanger-pulling method.

## 1. Determination of initial equilibrium condition

Initial force method (IFM) is useful for an anchored suspension bridge since there is no axial force of stiffening girder due to cable force. However, the secondary moment due to excessive internal axial force in case of self-anchored suspension system require vertical camber of stiffening girder to set target profile of bridge at final construction stage. Optimum analysis method is meditated to find the solution that minimizes this camber. As a result, we find that there is no need to divide dead load into pre and post dead load in case of self-anchored suspension bridge because the stiffening girder is erected before the cable installation. In the self-anchored suspension bridge, this improved initial force method (IIFM) to find optimum initial equilibrium condition makes one-time calculation possible for all dead load of the suspension system. The target values of this analysis are the internal bending moment and vertical camber of stiffening girder which are to be minimized as possible with controlling of cable forces. Therefore, steel manufacture could easily produce stiffening girder with no vertical camber, and also internal forces of hanger cables are well balanced.

To prove the effectiveness of improved initial force method, the comparison of vertical camber by each analysis method is shown in figure 1.

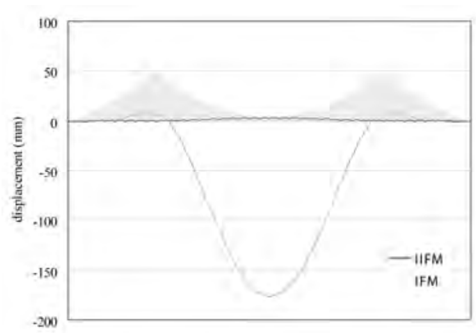


*Figure 1. Camber diagram of initial equilibrium condition*

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## 2. Hanger pulling method for erection of superstructure

In construction schedule of self-anchored suspension bridge, connecting sequence of cable and girder is one of the most important procedures. This connection method can be classified into hanger-pulling method and girder jack-down method generally. To find a convenient and safety construction method of superstructure, we carried out stage analysis for both hanger pulling method and girder jack down method.

The hanger pulling method is adopted for construction method of the Sorok Bridge finally. Even though both construction methods have no problem for structural stability, girder jack down method require elaborate controlling skill for jack down value, and huge scale facilities and supports under the stiffening girder need to be installed, compared with hanger pulling method. All works for installing of hangers in the hanger pulling method, however, is to be done on the stiffening girder, the connecting hanger to girder can be easily completed therefore,. In addition, adjustment of hanger erection sequence secures stability of main cable and minimizes the bending moment of stiffening girder.

## 3. Verification of analysis with site measurement

The final profile of stiffening girder of the Sorok Bridge is changed a little after girder and main cable are constructed. If 2$^{nd}$ dead load is larger than expected value and/or excessive creep of pylon appear, the resulting deflection of stiffening girder damages an aesthetic features of the bridge, since the only 1% final slope are planned, and make rain drainage problem. To prevent such situation, the axial force of hanger cable i.e. unstrained cable length is changed to move girder profile upward.

The original profile proposed in design stage, is changed according to the improved initial force method application. And results of site measurement after hanger erection and pavement completion are shown in Figure 2. The gap between original profile and target profile is intentionally made to satisfy above needs. And also the reason of the other gap between target profile and measurement value is that applied unit density is bigger than the actual, because the specification says that the unit density of pavement should be applied which is 10~15% larger than the actual density of 20~22kN/m$^3$. If we consider this factor, the results of analysis are very precise.

In conclusion, the analysis results are well matched up with actual bridge deformation and profile of girder during construction stages and at final stage. And it shows that the assumption and the method of analysis used in the Sorok Bridge are very reliable for self-anchored suspension bridge.

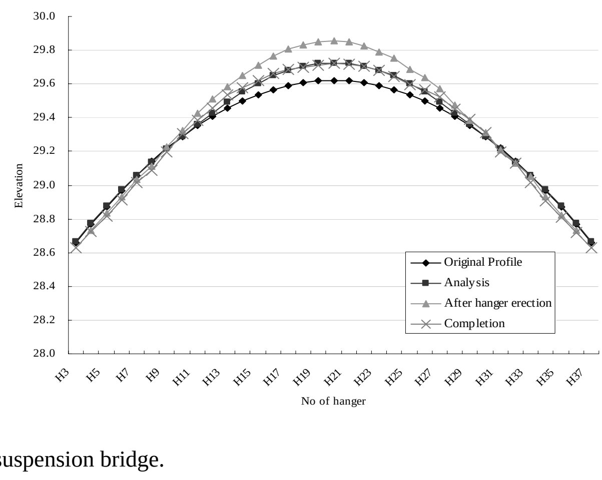


*Figure 2. Comparison of girder profile of the Sorok Bridge for each construction stages*

The Sorok Bridge construction is successfully completed with exact girder profile that is expected by analysis and it is verified by measurement results at site. Improved analysis method for initial equilibrium condition and hanger pulling method used in the Sorok Bridge are confirmed as proper and effective analysis method and construction skill for erection of self-anchored suspension bridge