A NOVEL CONCEPT FOR A CABLE-STAYED MOVABLE FOOTBRIDGE

Tianhao ZHANG
PhD Candidate
Tongji University
Shanghai, China
The University of Tokyo
Tokyo, Japan
zhtenkou@hotmail.com

Ken’ichi KAWAGUCHI
Professor
The University of Tokyo
Tokyo, Japan
kawaken@iis.u-tokyo.ac.jp

Minger WU
Professor
Tongji University
Shanghai, China
wuminger@tongji.edu.cn

Summary
Movable footbridges can be interesting and feasible solutions to cross waterways when the traffic on the
waterways to be crossed is not heavy. They can lower the height in elevation in use, which considerably
reduce the effort of the passengers, and also can be spectacular landmarks. In this paper, a novel concept
for a cable-stayed movable footbridge is proposed. The concept of geometric design is firstly introduced. The
moving mechanism is then shown by means of tracing the opening process. As an essential part of the
footbridge concept, the flexible deck which makes use of torsional deformation is introduced. Both static and
dynamic analysis of the flexible deck are conducted. The insufficiency in dynamic performance is then
discussed. Pre-twisted deck is considered as a possible solution by rising natural frequencies, and with
which the performance is shown to be improved according to the result of numerical analysis. Investigation
of this innovative concept of movable footbridge highlights new design possibilities for unique lightweight
structures with curved configurations.

Keywords: structural concepts; movable structure; prestressed structure; kinematical analysis; generalized
inverse; natural frequency

1. Introduction
Movable bridges usually take at least two different phases in their configurations at a crossover point at
transportations. The geometry of those movable bridges is able to modify back and forth with time goes,
beside they seem to be a sort of four-dimensional structures. Though the recent decades have seen the
developments of hydraulic machinery and programmable controllers, maintenance difficulties and expenses
are still substantial problems for movable bridges, especially for those using complicated joints. Nevertheless,
the story of movable footbridges is far from ending and many still trust their vast potential and varied
possibilities. They do not necessarily give the economic solutions but provide fascinating landscapes and
bold challenge of engineering. Needless to say, the more interesting configuration and movement the
bridges have, the more tourists would be captivated and gather around these new landmarks. In this paper,
a novel concept for a cable-stayed movable footbridge is proposed.

2. Design Concepts
The starting structural concept consists in a three-dimensional S-shaped twisting configuration driven by
cables. In order to absorb the torsional deformation, the middle part of the deck is showing a remarkable and
mysterious curve attracting pedestrians. The moving mechanism is introduced applying the generalized
inverse method [1].
3. Analysis of the flexible deck

The utilizing of the elastic torsional deformation of the deck is aimed to design the footbridge without complicated joints or locking device. So that the maintenance reduction appears for the new footbridge. However this leads to a significant contradiction in stiffness of flexible deck of the novel footbridge. In order to clarify the stiffness for external load, the mechanical performance of flexible deck is investigated [2]. The static behavior is satisfied with external loads. Based on the research on vertical bending and twisting. Unfortunately, the special flexible deck seems to be unreasonable according to the natural frequency.

4. Pre-twisted flexible deck

In order to bring improvements in dynamic performance, a story of pre-twisted flexible deck is introduced instead of setting dampers. A new concept comes from setting an appropriate configuration as stress-free state 0. The key idea is to redefine a stress-free configuration. As a consequence, the pre-twisted deck seems to show an improved behavior in dynamic analysis. At the same time, the strain and stress of the deck is decreased comparing with the original flexible deck.

5. Discussion and Conclusions

The research has proposed a novel concept for a movable footbridge supported by cables. Though there are several topics remaining to be solved, according to the information illustrated in this paper, investigation on the innovative concept of movable footbridge has highlighted new design possibilities for unique lightweight structures with curved configurations. Also, one solution for the dynamic performance was proposed with a pre-twisted flexible deck, showing a feasibility for the concept.

6. References
