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Infinite element fashioning of incremental bridge launching and study on behavior of the bridge during construction stages

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ABSTRACT: Incremental launching is a widespread bridge erection technique which may offer many advantages for bridge designers. Since internal forces of deck vary perpetually during construction stages, simulation and modeling of the bridge behavior, for each step of launching, are tedious and time consuming tasks. The problem becomes much more complicated in construction progression. Considering other load cases such as support settlements or temperature effects makes the problem more intricate. Therefore, modeling of construction stages entails a reliable, simple, economical and fast algorithmic solution. In this paper, a new Finite Element (FE) model for study on static behavior of bridges during launching is presented. Also a simple method is introduced to normalize all quantities in the problem. The new FE model eliminates many limitations of some previous models. To exemplify, the present model is capable to simulate all the stages of launching, yet some conventional models of launching are insufficient for them. The problem roots from the main assumptions considered to develop these models. Nevertheless, by using the results of the present FE model, some solutions are presented to improve accuracy of the conventional models for the initial stages. It is shown that first span of the bridge plays a very important role for initial stages; it was eliminated in most researches. Also a new simple model is developed named as "semi infinite beam" model. By using the developed model with a simple optimization approach, some optimal values for launching nose specifications are obtained. The study may be suitable for practical usages and also useful for optimizing the nose-deck system of incrementally launched bridges.

KEYWORDS: Incremental bridge launching, Finite element method, Nose – deck system, Optimization, Semi infinite beam model.

I INTRODUCTION

Bridge piers are constructed first in incremental bridge launching method and after that, deck segments are pushed forward above them until they reach their final positions (Fig. 1). Constructing, curing, pre-stressing and pushing the segments are done on a construction platform close to bridge abutments [2, 3]. These segments may be over a half- length of the bridge spans; therefore, number of structural weak points in junctions is reduced considerably. Some other advantages such as high speed working due to eliminating casting molds, reducing manpower and constructional costs, proper and accurate supervisions, no needing to block obstacles under the bridge during launching and minimizing the destruction of the environment in construction location, make incremental launching more competitive in comparison to other erection techniques [4-6]. Temporary tensions occurred during construction stages may be different and much more critical than those in service life.

Fig. 1 Incremental bridge launching [1]

Therefore, an appropriate method should be used to reduce these forces and thus avoid wasting the advantages of the method by using overdesigned structural members. Different methods have so far been introduced by engineers and researchers for this purpose. Among them, using a nose-deck system, owing to its simplicity and efficiency, has been known as the standard method. In this sense, a light nose girder, attached in front of the deck, is used to reduce the cantilever moment of deck at its end [2]. Nose specifications have significant effects on the nose-deck interaction.

II Assumptions and Definitions of the Parameters

In this study some assumptions are considered for generating the finite element model. This section gives some explanations about assumptions and definitions used here.

2. 1. Arrangement scheme of piers

Various schemes of pier arrangement can be considered in the model. But it is more reasonable to set the arrangement of piers based on optimum static performance of the bridge in service time. Constructional stresses can be controlled by other practices such as using a light nose girder attached in front of deck, pre-stressing or using some temporary piers. In the present study, the bridge structure consists of some identical mid spans and shorter end

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ones. Most bridges with continuous system were constructed according to this pattern around the world due to its structural and architectural benefits.

2. 2. Definition of stage, station and phase

The nose tip passes through all spans during launching and the number of launching spans equals the launching stage. The number of piers behind the launching stage is defined as the station. For each stage of launching two different phases can be considered. Phase one refers to the position that nose tip has not reached the next pier and the nose-deck system has a cantilever scheme. This phase lasts till nose tip reaches the next pier. Phase two starts after that and lasts till nose girder passes the pier completely.

2. 3. Specifications of launching nose

Although majority of noses are constructed with tapered sections, in this study it is assumed that the nose girder is prismatic. Using mean values of the tapered nose specifications for an equivalent prismatic nose will introduce a very small error (less than 2%) [13, 14]; therefore, this assumption is accurate enough. Flexural stiffness, dead load, length and height of nose are defined by , , and , respectively.

2. 4. Normalizing the formulations

In this study, three main specifications of deck including flexural stiffness ( ), dead load ( ) and mid spans length ( ) have been considered as the measurement scales i.e. their values are assumed to be unit. Any other quantity in the problem can be stated normalized to these values. Therefore, , , and , in normalized dimensionless formats, are presented by four dimensionless parameters as (ratio of nose length to mid span length), (ratio of nose load to deck load), (ratio of nose flexural stiffness to deck flexural stiffness) and (ratio of nose section height to mid span length). Such an approach leads to expressing the unknown forces in a dimensionless format as a coefficient of deck characteristics. For instance, internal moment for each section of deck is obtained as a coefficient of . Length of end spans and deck height, in the normalized format, are denoted by and , respectively. This method is so beneficiary and useful for parametric studies on the nose-deck interaction

III Finite Element Formulation

It is well-understood that the axial stiffness of the bridge deck is high and its axial force is relatively small; therefore, axial displacements are negligible and thus usual beam elements are sufficient to model the continuous deck of the bridge; for these elements axial degree of freedom is not considered.
The data which does fit to their transaction through the internet region of process constrain then it will be retrieve their data according to their specification from other point to their devices. The query which does not specify through where top to bottom region of work flow of process through that various specification according through that cause it own and various specified data various suspicious data from the marginal note depend upon their process should specify the low constrains.

IV Nose-Deck Interaction

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Moreover, not any maximum moment should emerge along the deck that exceeds that of and (marked with triangles). As shown below, choosing a sufficiently large value for may control the latter criterion. It should be noted that the station moment in zone C (moment of second station before launching span) is also dependent on the nose specifications. An optimal design for nose specifications must prevent the maximum moment of zone C to be more critical than maximum moment of zones A and B. More complexities arise out of optimization of nose specifications due to interdependency of the nose characteristics. Therefore, an exact and effective optimization requires mathematical approaches along with difficult engineering assessments. Fontan et al. completely discussed this problem in a mathematical point of view [8].

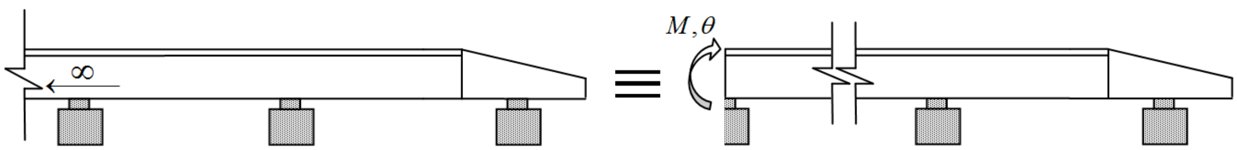

Fig. 2 Assumption of the conventional simplified model

IV Conclusion

In this paper, a new finite element model has been developed to analyze the construction stages of incrementally launched bridges. This model eliminates many limitations of some previous models and can be used for studying on behavior of the bridge considering different load cases. Effects of support settlement, shear strain, temperature gradient, construction platform and unequal spans can be considered in the presented model. By using a simple technique, all parameters involved in the problem can be normalized with respect to main specifications of deck, and all unknown variables are obtained as dimensionless normalized quantities. This method is especially advantageous for studying on the nose-deck interaction and optimizing the nose specifications.

A brief study on the nose-deck interaction and optimum specifications regarding the effect of temperature gradient and shear strain has been done. The final results indicate that the effects of these two parameters on the nose-deck interaction are not generally significant.

By using the presented FE model, an extensive study has been done to assess the accuracy of the Marchetti’s conventional model. It has been concluded that this model is only accurate when there are at least five spans behind the under study station which means that the simplified model is not useful for studying on initial stages of launching. Therefore, a comprehensive study is conducted regarding rotations of pier sections during launching. Such a study results in some modification factors through which the Marchetti’s formulation can be modified for initial stages of launching easily. Moreover, a new simple semi infinite beam model has risen out of this study. It has been demonstrated that the model can be useful for optimum design of the nose girder parameters and also efficient for parametric study of the nose-deck system.

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