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Abutment Failure and Rehabilitation of Multi-span Simply-supported Bridges: Baghipol Bridge Case Study

Khawja Daud Kawkabi*, Khaja Wahaajuddin Kawkabi**

*(Transportation Engineering Department, Kabul Polytechnic University, Afghanistan
Email: daud.kawkabi@kpu.edu.af)

** (Department of Mechanics, Civil Engineering and Architecture, Northwestern Polytechnical University, China
Email: wahaaj.kawkabi@mail.nwpu.edu.cn)

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Abstract:

Baghipol Bridge is located is west part of Afghanistan in Farah Province. Due to high traffic and seasonal floods, one of its abutments was failed by the active earth pressure. The abutment structure was made by sheet piles. This type of abutment can be very cost efficient and time saving for the construction; however, in the case of high traffic flow and heavy axle loading considerable bending and deflection in sheet piles can be observed, which can cause significant damage in superstructure. This paper studies the causes for this failure in the bridge abutment by analysis of the Finite element models, and describes the rehabilitation strategy to maintain the traffic flow during the construction of new abutment.

Keywords **—**Bridges; Rehabilitation; Sheet pile Abutment; Lateral earth pressure Abutment Failure; Simply-supported Bridges

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I. INTRODUCTION

Baghipolbridge was built by the United states of America about 60 years ago on Farahrod river in Farah province of Afghanistan. This bridge is one of the most important transportation structures in west of Afghanistan. It is a gateway for major parts of west areas to Afghanistan ring road.

Fig. 1 Baghipol Bridge

One of the bridge abutments was failed and rehabilitated in 2005 and by USAID. There are three causes which are expected to be the reason for the abutment failure: Raise of daily traffic and axle load; seasonal flooding; local gravel extraction from riverbed near abutment;

A. *Raise of daily traffic and axle load*

Afghanistan experienced a high raise in trade and transportation after 2000, which this can be inferred from GDP data of Afghanistan as illustrated in figure 3, so it is estimated that the damage in this structure is caused by high traffic and truck axle load, and expected to be the main reason for abutment failure.

B. *Seasonal Floods*

Fast-flowing water undermines the foundation of piers and abutments (Åkesson 2008). Baghipol Bridge is located on the one of the most unpredictable flows in Afghanistan. Farahrod is a part of Helmand basin and one of the major flows in southwest areas (Sether2008) . Helmand basin had its highest flow stream and many floods in 1996-2000 in 60 years between 2012 and 1952.(Goesa. et al. 2015) It is expected that this cause speedup thedamage in the abutment.

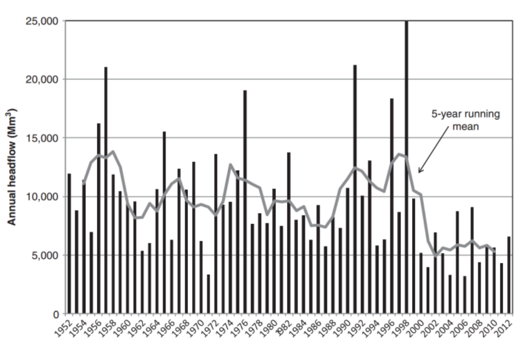

Fig. 2Annual flow Helmand Basin (1952 -2012) (Goesa. et al. 2015)

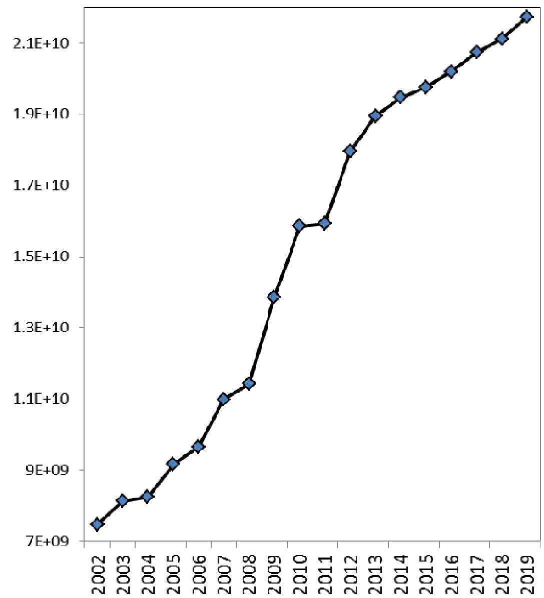

Fig. 3Afghanistan GDP from 2002 to 2019 (world bank data 2019)

C. *Local gravel extractions near abutment*

Site observations show that there was an excavation done by local contractors along the damaged abutment, which may provide access of water to the bridge abutment.

Fig. 4Baghipol Bridge during Seasonal Floods.

II. ABOUT THE BRIDGE STRUCTURE AND DAMAGE

Baghipol Bridge is a multi-span simply supported bridge with reinforced concrete superstructure and steel pillar system. Bridge abutment system is made by sheet piles and stone wing walls. The dimensions of the bridge are presented in figure 6.

Fig. 5Bridge pillar and support system.

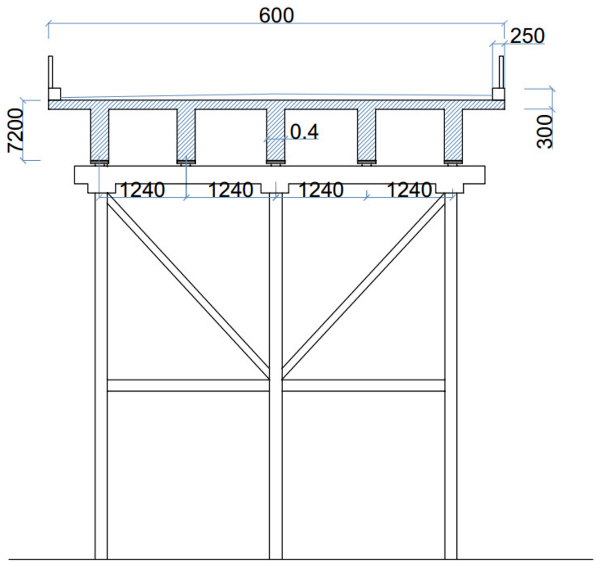

Fig. 6Bridge pillar and support system dimensions.

Following damages were noted in the structures during the site observation:

- Damages occurred in the downstream side of the abutment.
- Abutment sheet pile was bent with the maximum displacements in the higher parts of the sheet pile.
- Pier cap near the abutment was fractured with exposing the reinforcements.
- Piers near abutment had lateral displacement caused by bending of the shell plates.

Fig.7Shows the damages in the abutment

III. METHODOLOGY

Modeling procedure for the problem is divided in two parts which are: finding the lateral pressure on the pile sheet; modeling the geometrical shape of the abutment and finding the displacements in the sheet pile;

To do so, first a geotechnical model is needed to developed for plastic analysis in PLAXIS 2D and after receiving earth pressure from embankment to the sheet pile a 3D model based to the geometric and elasticity parameters of the abutment is built in

ABAQUS and the results for the displacement is printed out.

IV. MODEL

First as shown in the figure.8 the geotechnical model is made in PLAXIS 2D 8.6. In this model we find the pressure on the shell plate. The abutment model is made as a retaining wall with constrained in the top side of the shell as the bridge super structure. The load is applied to the embankment through the approach slab located 10m before the bridge structure.

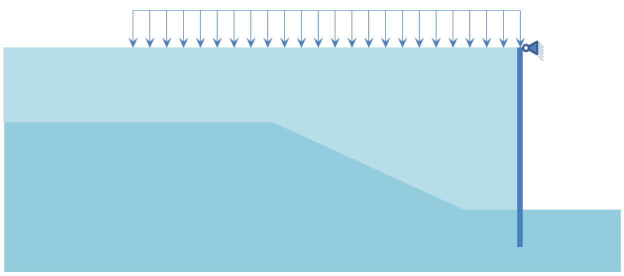

Fig.8.2D model scheme for geotechnical model in PLAXIS

After defining the geometrical dimensions for soil layers, sheet pile, constraint and load on the model, mesh and control points for stress and displacement were defined for the model.

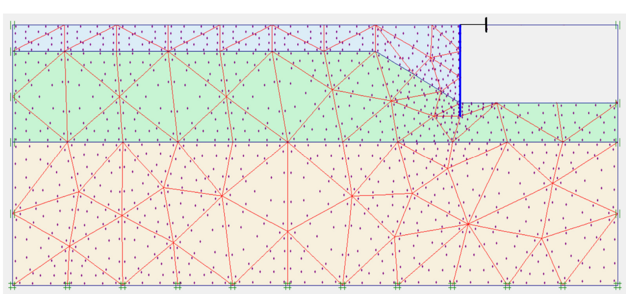

Fig.9.2D model scheme for geotechnical model in PLAXIS

The results were received from PLAXIS output for the analysis. In this model the shading graph for effective stresses, total stresses and displacement is printed out.

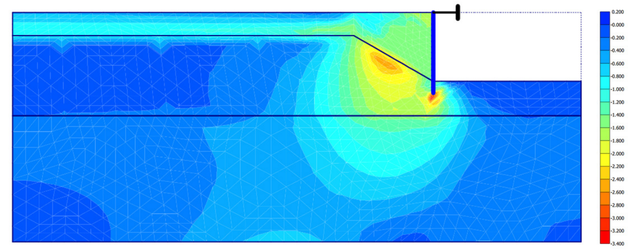

Fig.10.effective stresses plotted in PLAXIS model

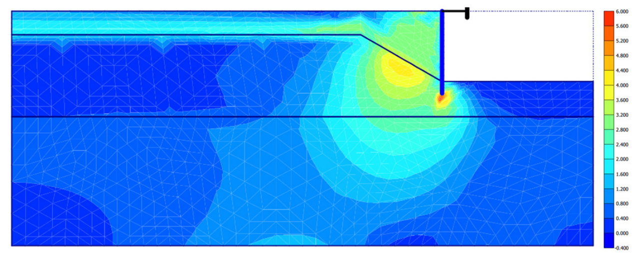

Fig.11total stresses plotted in PLAXIS model

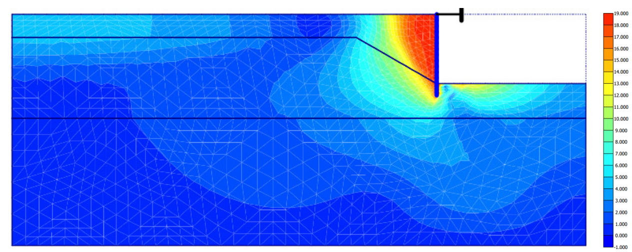

Fig.12 displacement plotted in PLAXIS model

The results for the earth pressure received from PLAXIS, so ;further after, the 3D model is build in ABAQUS 2018.

The model in ABAQUS was made by solid parts. And the analysis for this model was done using the static general steps.

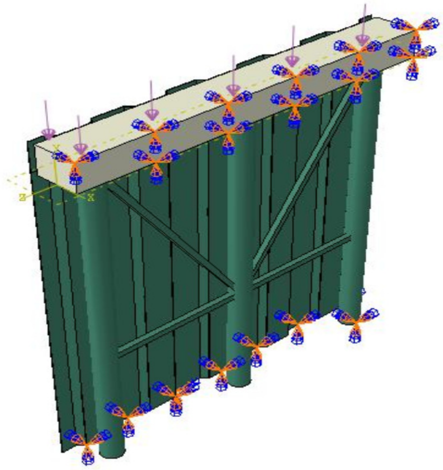

Fig.13 Boundary condition and loading in ABAQUS

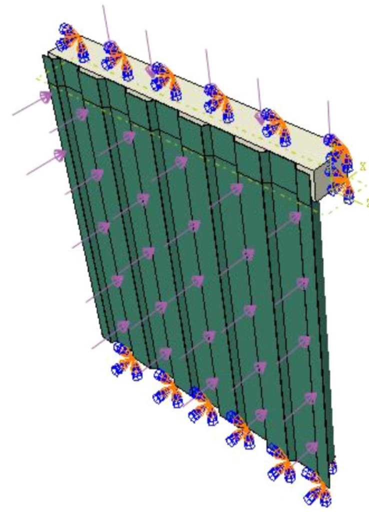

Fig.14 Boundary condition and loading in ABAQUS

After the load was applied from to the sheet pile, the load from the super structure was applied to the pile cap. The final results for the displacement of the sheet pile was printed out which is illustrated in figure 12 because in the boundary condition for the bottom side of the sheet pile was assumed to be rigid so the displacements are zero for the bottom side.

The displacement analyzed for the top side of the sheet plate is considered with the effect of the superstructure along its axial axis. As a conclusion we can see that the maxim displacement occurs in the top side of the sheet pile about 10 cm.

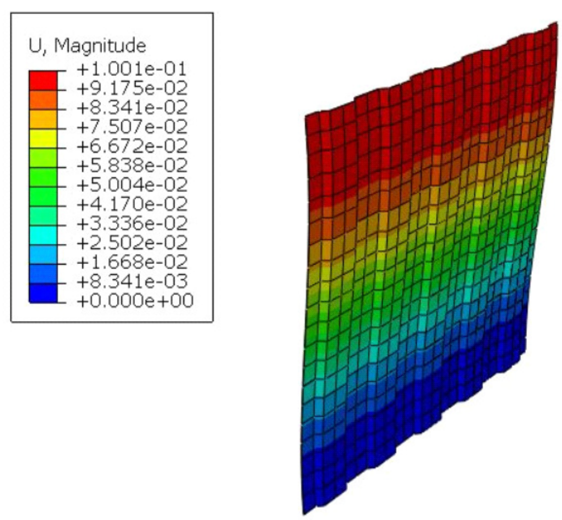

Fig.15 Displacement results in ABAQUS

V. REHABILITATION STRATEGY

In this project one of the main concerns was that at least one lane should be available for daily traffic passage. So the rehabilitation was suggested to be done in the two phases. In each phase the half side of the abutment was installed and the other side was available for daily traffic.

Following steps were proposed for rehabilitation:

1. Preparing the temporary pier foundation;
2. Traffic management in one lane;
3. Installation of temporary pier and beam;
4. Temporary sheet pile driving in the middle line of approach along the road;
5. Remove the one side of the back filling soil and construction of the sheet pile sheet strengthening structure (Bars and concrete Blocks)
6. Demolition the damaged pier cap;
7. Construction of the new pier cap;
8. Construction of the approach slab;
9. Change the traffic to the other side and continue the above procedure for the second half abutment.

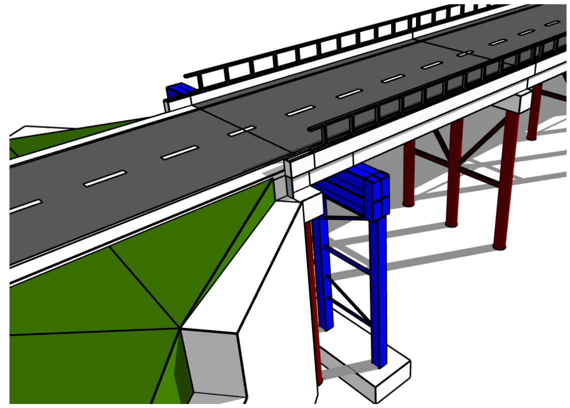

Fig.16Construction of temporary pier

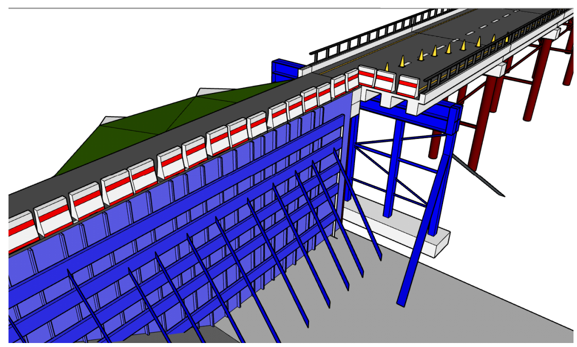

Fig.17excavation of the previous abutment back filling

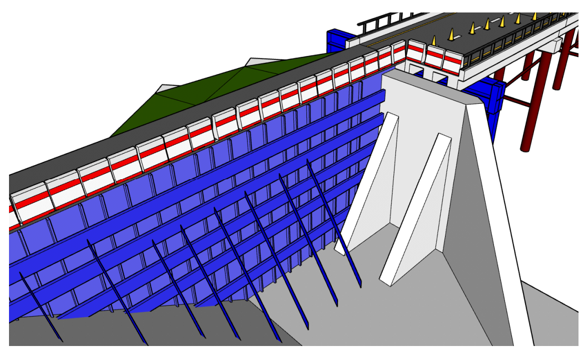

Fig.18construction of the new abutment

VI. CONCLUSIONS

Sheet pile abutments are mostly used in the low traffic volume roads, and are good, fast and cost efficient for short span bridges. Sheet pile abutments are not recommended to be used in structures with high traffic, and should not be used without reinforcement and anchors. In places which required material for RC abutments construction is available, RC abutments are recommended to be used instead of steel sheet pile abutments.

Bending and deflections in sheet piles causesconsiderable fracture and displacement in superstructure and settlement of approach slab. In the case of using steel sheet piles abutment, sheet piles with embedded piles in embankment is recommended to be used.

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REFERENCES

[1] *SIMULIA Abaqus FEA,*ABAQUS Inc,2018

[2] *PLAXIS 2D 8.6,*Bentley Systems, 2007

[3] World Bank national accounts data, and OECD National Accounts data files, Afghanistan GDP data, 2019 https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=AF

[4] B.J.M Goesa, S.E. Howartha, R.B. Wardlawb, I.R. Hancockc, &U.N.,"Integrated water resources management in an insecure river basin: a case study of Helmand River Basin, Afghanistan" *International Journal of Water Resources Development,* 2005 p.10

http://dx.doi.org/10.1080/07900627.2015.1012661

[5] Tara Williams Sether, 2008 "Streamflow Characteristics of Streams in the Helmand Basin, Afghanistan" U.S. Geological Survey, Reston, Virginia p.308-3014

[6] David J. White,"Modified Sheet Pile Abutments for Low-Volume

[7] Road Bridges",Center for Earthworks Engineering Research, Iowa State University, 2012 Ames, Iowa, United States

[8] F. W. Klaiber, D. J. White, T. J. Wipf, B. M. Phares, V. W. Robbins, 2004,"Development of Abutment Design Standards for Local Bridge DesignsVolume 1 of 3: Development of Design Methodology" Iowa Department of Transportation" Ames, Iowa, United States

[9] E. Yandzio, 1998 "Design Guide for steel Sheet Pile Bridge Abutments", *SCI publication, UK*

[10] BjörnÅkesson,2008 "Understanding Bridge Collapses", *Taylor & Francis Group,* London, UK

