วารสารวิชาการโรงเรียนนายเรือ ด้านวิทยาศาสตร์และเทคโนโลยี ปีที่ 1 ฉบับที่ 1 สิงหาคม 2557

The Study of Maekhong River Bank Protection due to the Construction of The North-South Economic Corridor Bridge Project

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บทคัดย่อ: โครงการสะพานมิตรภาพไทย-ลาว เป็นโครงการเชื่อมต่อทางเศรษฐกิจ โดยมีการสร้างเส้นทางคมนาคมเชื่อมต่อในสามประเทศ คือ ประเทศจีน ประเทศลาว และประเทศไทย โดยโครงการดังกล่าวอยู่ในพื้นที่อำเภอเชียงของ จังหวัดเชียงราย ในการศึกษาผลกระทบจากโครงการจำเป็นต้องมีการศึกษาทางชลศาสตร์ โดยคำนึงถึง ข้อมูลอุทกวิทยาในพื้นที่ก่อสร้าง เพื่อที่จะทำให้เข้าใจถึงผลกระทบตอม่อสะพานที่ถูกสร้างขึ้นและหามาตรการในการสร้างโครงสร้างป้องกันฝั่งที่ได้รับผลกระทบต่อไป งานวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาถึงการเปลี่ยนแปลงความเร็วและทิศทางกระแสน้ำสาเหตุจากผลกระทบจากการก่อสร้างตอม่อสะพานในการศึกษาใช้แบบจำลองคณิตศาสตร์สองมิติ ชื่อ MIKE21 ผลลัพธ์ที่ได้จะถูกนำไปใช้ในการการป้องกันการกัดเซาะบริเวณตลิ่งของพื้นที่โครงการ นอกจากนี้ การประเมินผลกระทบสิ่งแวดล้อมในด้านการกัดเซาะท้องน้ำของพื้นที่โครงการมีการใช้แบบจำลองชลศาสตร์ดังกล่าวเพื่อศึกษาผลกระทบทางดิ่งที่เกิดจากการก่อสร้าง โดยใช้สมการของ Blench ในการคำนวณหาความลึกการกัดเซาะพื้นท้องน้ำ ผลที่ได้จากความหนาแน่นการไหลของน้ำก่อนและหลังมีโครงการและแสดงให้เห็นถึงพื้นที่ที่เกิดการกัดเซาะและความลึกพื้นท้องน้ำที่กัดเซาะ จากการประเมินผลกระทบจะช่วยให้สามารถป้องกันความเสียหายที่จะเกิดจากโครงการได้ โดยจะมีมาตรการป้องกันซึ่งจะนำมาใช้ในการป้องกันการกัดเซาะตลิ่งต่อไป

คำสำคัญ: แบบจำลองชลศาสตร์ อุทกวิทยา การกัดเซาะตลิ่ง การกัดเซาะพื้นท้องน้ำ

Abstract: The project named "The North-South Economic Corridor Bridge Project" is one of the economic corridor programs aimed to construct a transportation network connecting three countries – e.g. the People's Republic of China (PRC), Lao PDR and Thailand. In fact, the project construction has its site in Chiengkhong, Chiengrai, Thailand. To complete this project, hydraulic study based on hydrological data within the construction site is included in order to understand the impact of the bridge pillar construction, and to find out the solution for the bank protection. In this study, 2D mathematical model, MIKE21 was used for modeling and simulating the conditions and situations of the project. To illustrate, the result data in the erosion assessment is further considered for riverbank protection. In fact, the result of flux calculation of the water flow both before and after the project is to be presented the river bank erosion area. In addition, the environmental impact evaluation from the bridge construction has been presented by using the mathematical model for calculating the scour depth of the water bed. From these results, it is recommended that to prevent the damage caused by the project, the construction of the 600 meter gabions along both Thai and Laos river banks should be constructed.

Keywords: hydrodynamic model, hydrology, bank erosion, scour depth

1. Introduction

The project named "The North-South Economic Corridor Bridge Project" is one of the economic corridor programs aimed to construct a transportation network connecting three countries – e.g. the People's Republic of China (PRC), Lao PDR and Thailand.

To complete this project, hydraulic study based on hydrological data within the constructed site is included. In addition, the hydraulic model is needed in order to understand the bridge pillar construction impact, and to find out the solution for the bank erosion from such impact. Therefore, hydrological information such as rainfall intensity, catchment areas and characteristics – e.g. topography, stream flow, soil type, and etc. of constructed site and discharge of Mekong River (Figure 1.) are required and provided to support engineers according to design criteria.

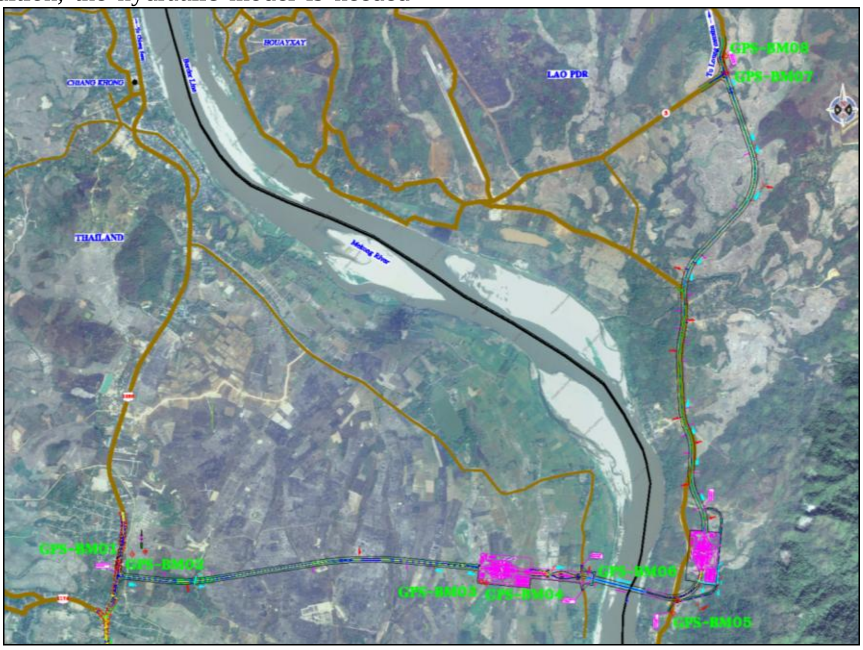

Fig. 1: Study area

2. Objective

It is to study the current shift due to the pillar construction using the mathematical model. The erosion assessment is evaluated and the data then is further used for determining the riverbank protection. The model using in this current study is 2D-Hydrodynamic Model, which is capable of simulating according to the hydrological conditions of the area before and after the project. It's reliability can be verified by field data corrections and confirmation. The details of method and scope of study are mentioned as follows:

3. Scope of the study

The scope of study can be divided in 4 sections:

3.1 To procure the model and data appropriate to the study, according to the objective.

3.2 To correct and confirm the result of the model.

3.3 To define the appropriate case study as the sample of assessment and simulate as defined.

3.4 To assess the impact of the current to the river bank; and to recommend its protection plan due to the erosion shifted.

The study of the impact due to the foundation post on circulation flow of water at the construction site of Mekong Bridge, Chiangkhong, Chiangrai has 2 main parts as follows:

A) Study of present hydrological conditions at the repeating periods of 2 years, 10 years, 50 years, and 100 years.

B) Study of hydrological conditions after the foundation post construction at the repeating periods of 2 years, 10 years, 50 years, and 100 years.

4. Methodology

In this study, there are two main present parts which are hydraulic study and erosion evaluation in the studied area. In fact, the study focuses on the current condition and after the project condition. As a result, the data will be used in the erosion assessment which is further used for riverbank protection. The details are as follows:

4.1 Hydrodynamic Simulation

The model MIKE21 from DHI Water and Environment is a mathematical model used for 2-D water flow characteristic calculation. The model assumes only 2 directions of water flow, i.e. north-south, and east-west, excluding the earth-surface perpendicular direction.

Elementary data for the model MIKE21 HD

1. Bathymetry Data
   - Topography map, ratio 1:250,000 and 1:50,000
   - Bathymetric map, sounding survey in January 2008
2. Hydrographic data used in this study are water level and flow velocity. The data can be divided into 2 main groups, i.e. the water level and velocity current used for the model calibration and verification, and the water level used in the hydrological study before and after the project. The data detail is as followed:

- Data used in the model calibration and verification the data used in this study are from the field observation. The data composes of water level of every 3 hours (daytime: 06.00- 18.00) from 3 stations. The data from 2 stations, i.e. upstream and downstream, is used as the boundary condition position for hydrological simulation. And the data from the station in vicinity of the construction site is used as the model calibration and verification. For the flow velocity calibration, the flow velocity observation data from 3 stations are used.

- The flow data used in hydrological study before and after the project are the water levels which are analyzed at the boundary condition position both upstream and downstream. The summary is shown in tables 1 and 2.

Table 1: Upstream boundary condition (U/S BC)

Tr	Q (cms)	WL (m.MSL)	Flow Area (sq.m)
2	11,620	351.43	6,109.16
5	13,664	353.48	7,284.44
10	15,018	354.84	8,074.48
20	16,314	356.13	8,839.49
50	17,995	357.82	9,821.52
100	19,254	359.08	10,552.30

Table 2: Downstream boundary condition (D/S BC)

Tr	Q (cms)	WL (m.MSL)	Flow Area (sq.m)
2	11,941	349.96	4,578.09
5	14,035	351.85	5,274.42
10	15,422	353.04	5,726.14
20	16,750	354.07	6,118.82
50	18,471	355.59	6,717.56
100	19,761	356.78	7,179.69

2-D Bathymetry Setting-up

The bathymetric data used in this study are from the sounding survey in the project area. The study of hydrological condition in the project area at present time and after the project construction is conducted using grid of size 10 x 10 square meters. The study area has its length for approximately 2500 meters both in the upstream and downstream directions from the construction site which can be expressed in the area of 3.04 square kilometers. From such boundary of study, the mesh of 194 grids x 400 grids is used (grid size 10 x 10 meters), as shown in figure 2-1 and figure 2-2

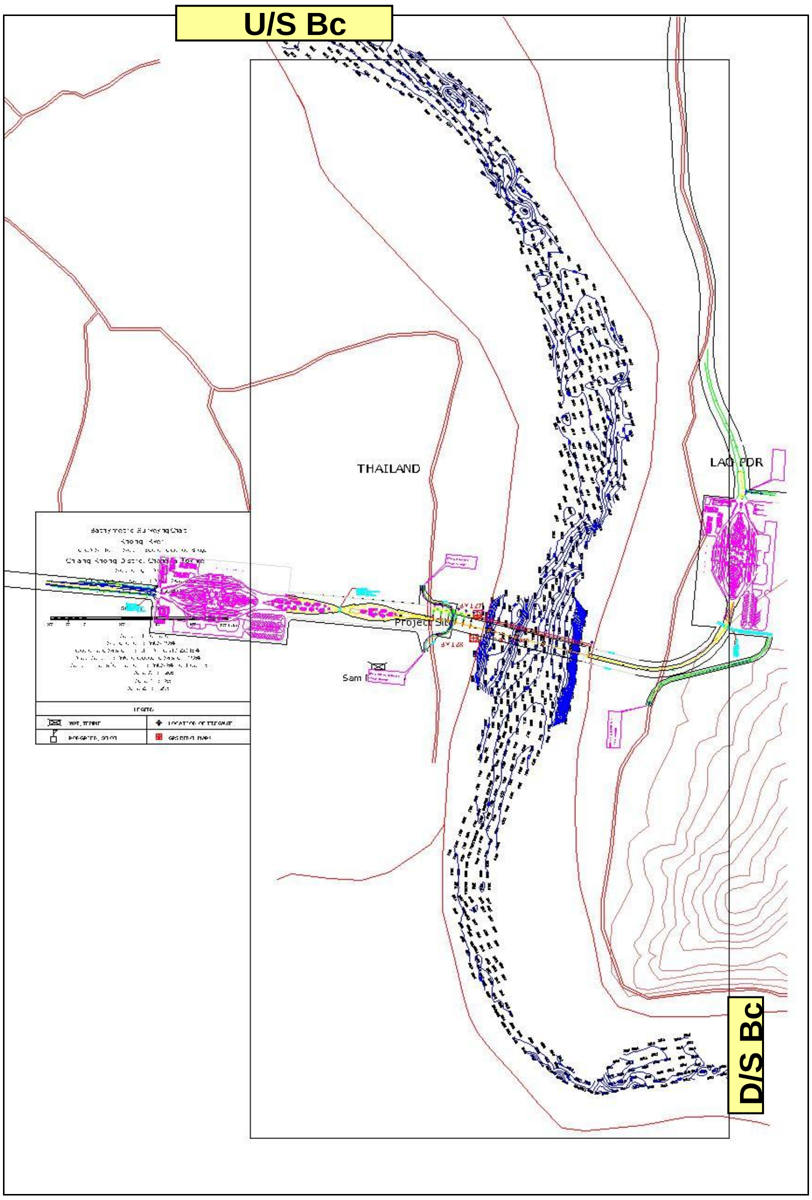

Fig. 2-1: Boundary of study for 2-D Bathymetry Setting-up and the grid setting.

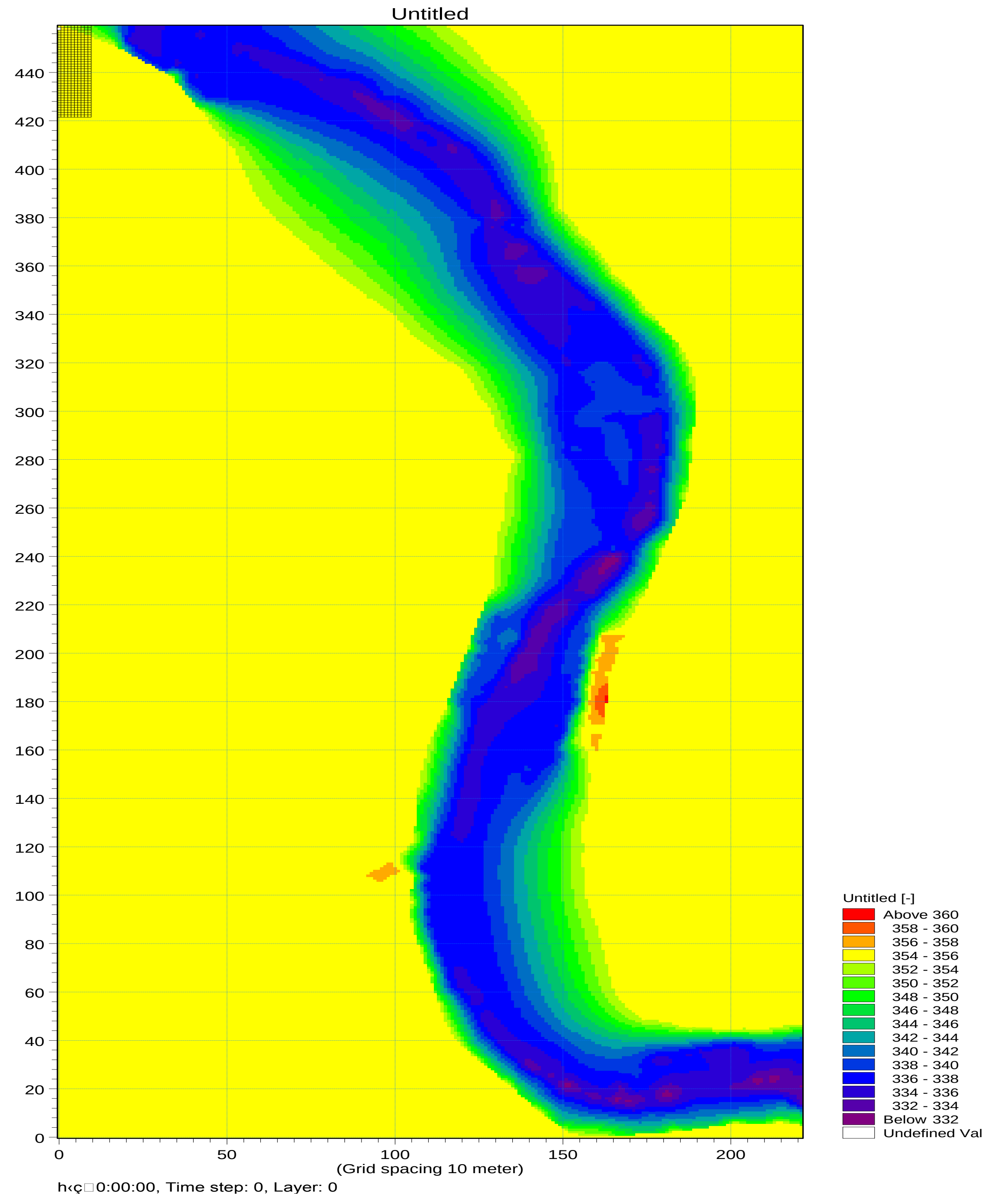

Fig. 2-2: Boundary of study for 2-D Bathymetry Setting-up and the grid setting.

Since the grid used for the study is quite small, in order to keep calculating stability the time interval (Δt) chosen from the modeling is 1 second.

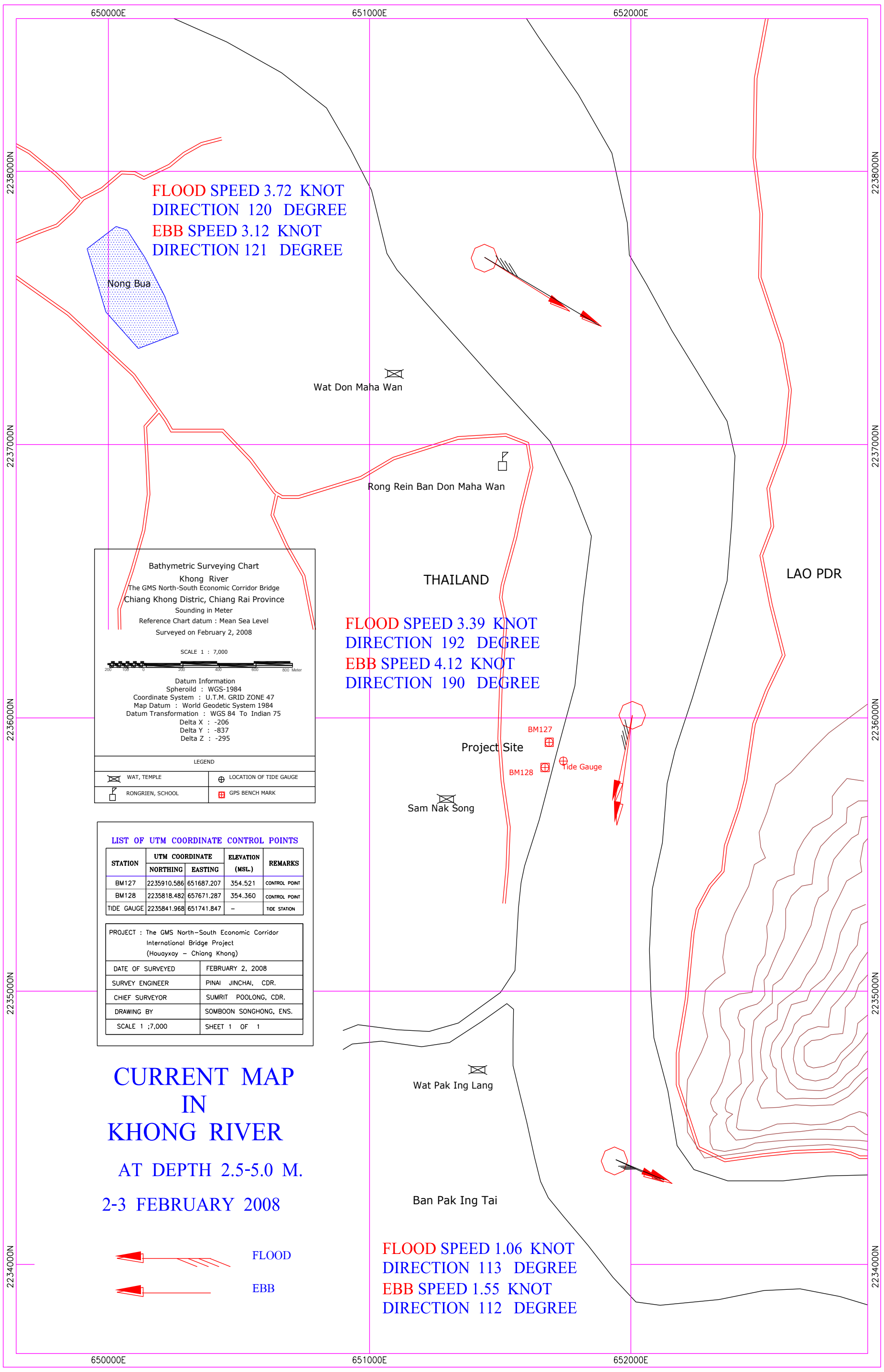

Fig. 3-1: Result of current velocity calibration at the bridge construction site from 3 points of current survey.

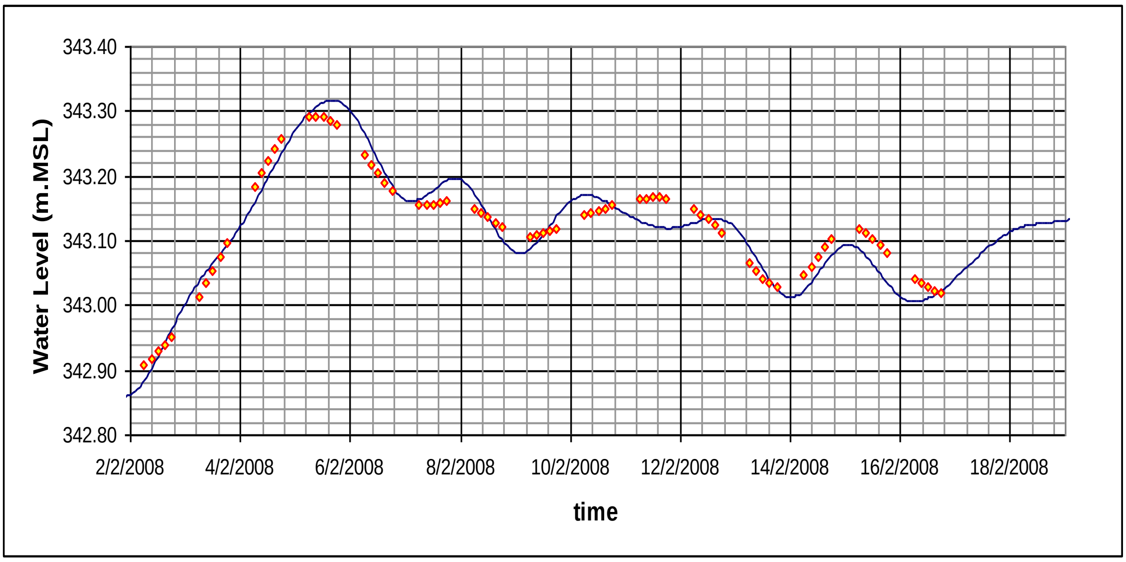

Fig. 3-2: Result of current velocity calibration at the bridge construction site from 3points of Current survey.

Hydrodynamic Model Calibration and Hydrodynamic Model Verification

From the model calibration the friction coefficient, Manning's M, is in between 18.50 - 32.25 meter1/3/second, or equal to 0.031 – 0.035 in the term of Manning's "n". The water level calibration result showed a very good match. For the flow velocity calibration the result was fair, as shown in figure 3-1 and figure 3-2. After the model calibration, the result yielded was used to study the present and after-the-project hydrological conditions.

Model Application - Hydrodynamic Computation

Eight cases were studied, four cases with return periods 2, 10, 50, and 100 years for the present condition and four cases for after the project condition.

4.2 Scour depth evaluation

In the evaluation, the highest erosion depth or scour depth is calculated by the Blench's equation (1969).

$$D_{max} = z(q^2/F_{b0}) \qquad (1)$$

where

D_{max} = maximum scour depth in meters
Z = factor accounting for the local flow pattern
q = Local discharge density (m^3/s/m width)
F_{b0} = Zero base factor (Fig.4)

The erosion of any position on any grid, the equation is calculated by following:

$$D_{(i,j)} = z(q_{(i,j)}^2/F_{b0}) \qquad (2)$$

where

$D_{(i,j)}$ = maximum scour depth in meters at grid position i,j
$q_{(i,j)}$ = Flux result at grid position i,j
i = Horizontal grid number
j = Vertical grid number

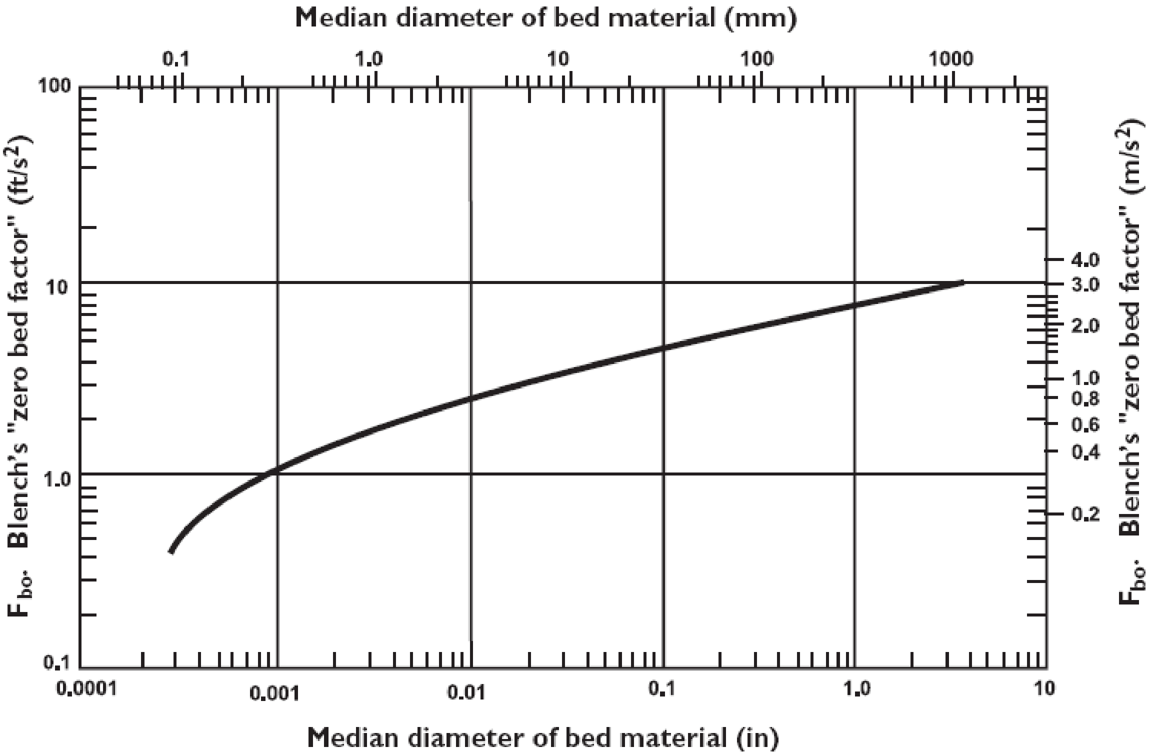

Fig. 4: Chart for estimating F_{b0}

5. Result

It was found that the flow pattern for all the return periods were identical. The flow in the vicinity of the pillar changes its direction to avoid the pillar and return to the usual flow condition. The farthest deviated distance was 350 meters from the pillar construction site. From that reason, the flow velocity in between the pillars and the river banks is increased. However, the study in normal condition (Tr100 years), the flow change due to the construction is small for before and after the project. In the case of high return period, the current may corrode both the channel and banks due to the change from the construction. The calculation results are shown from figure 5 to 7.

From the change affected from the construction, the vertical eroded depth can be evaluated as shown in figure 5 to 7. It is found that the highest erosion depth affected from the project are 11, 26, 30 and 48 cm., for the return period 2, 10, 50, and 100 years, respectively. To prevent the damage caused by the project construction, the protection measure is applied to prevent the erosion of the banks by considering the protection area as:

1) Since the Mekong River is the river boundary between two countries, Thailand and Laos, the protected areas have to be equal to each bank by considering the bigger area first.
2) The velocity for the flood flow of the Mekong River is very high and the project is in the narrow part of the river. As a result, the flow current is higher than normal. Therefore, the protection should start from the narrow part from the upstream part of the project.

For the return period of two years, the protection is not needed, for 5, 50, and 100 years return periods, the protection should be 300, 400, and 600 meters respectively. The relationship between the return periods and the protection areas is as shown in figure 8. In addition, the protection area positions are as shown in figure 9.

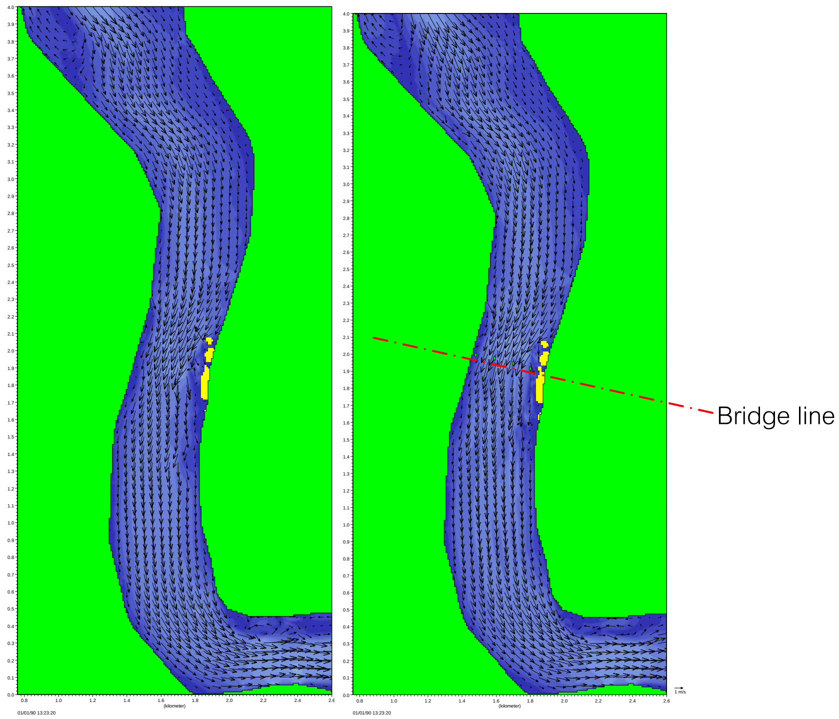

Fig. 5: Hydrological condition during flooding period, 100 years return period, before and after foundation pillar construction.

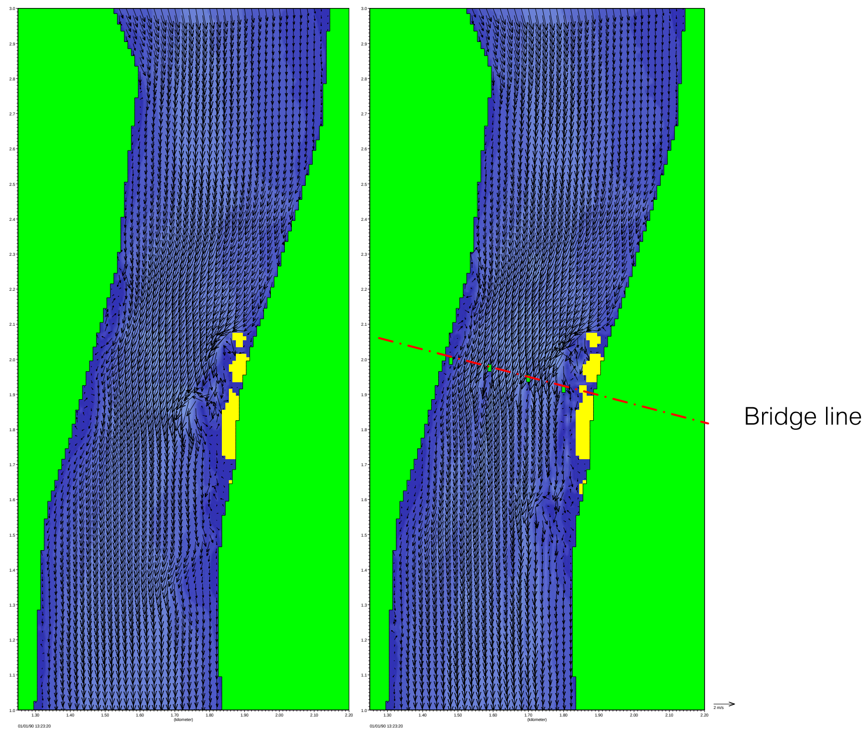

Fig. 6: Hydrological condition in the foundation post area during the flooding period, 100 years return period, before and after foundation pillar construction.

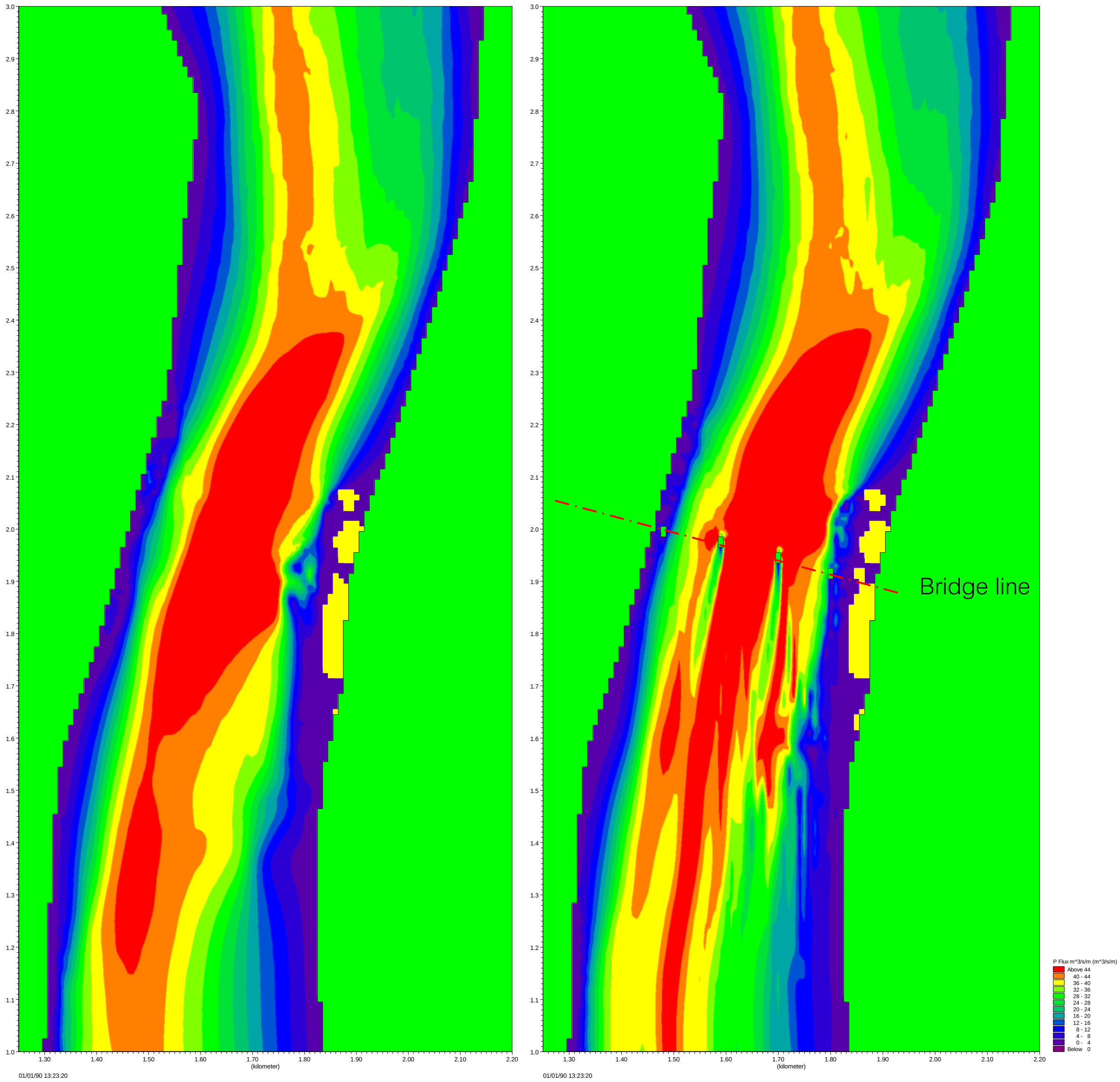

Fig. 7: Flow density condition in the pillar area during the flooding period, 100 years repeating period, before and after foundation post construction.

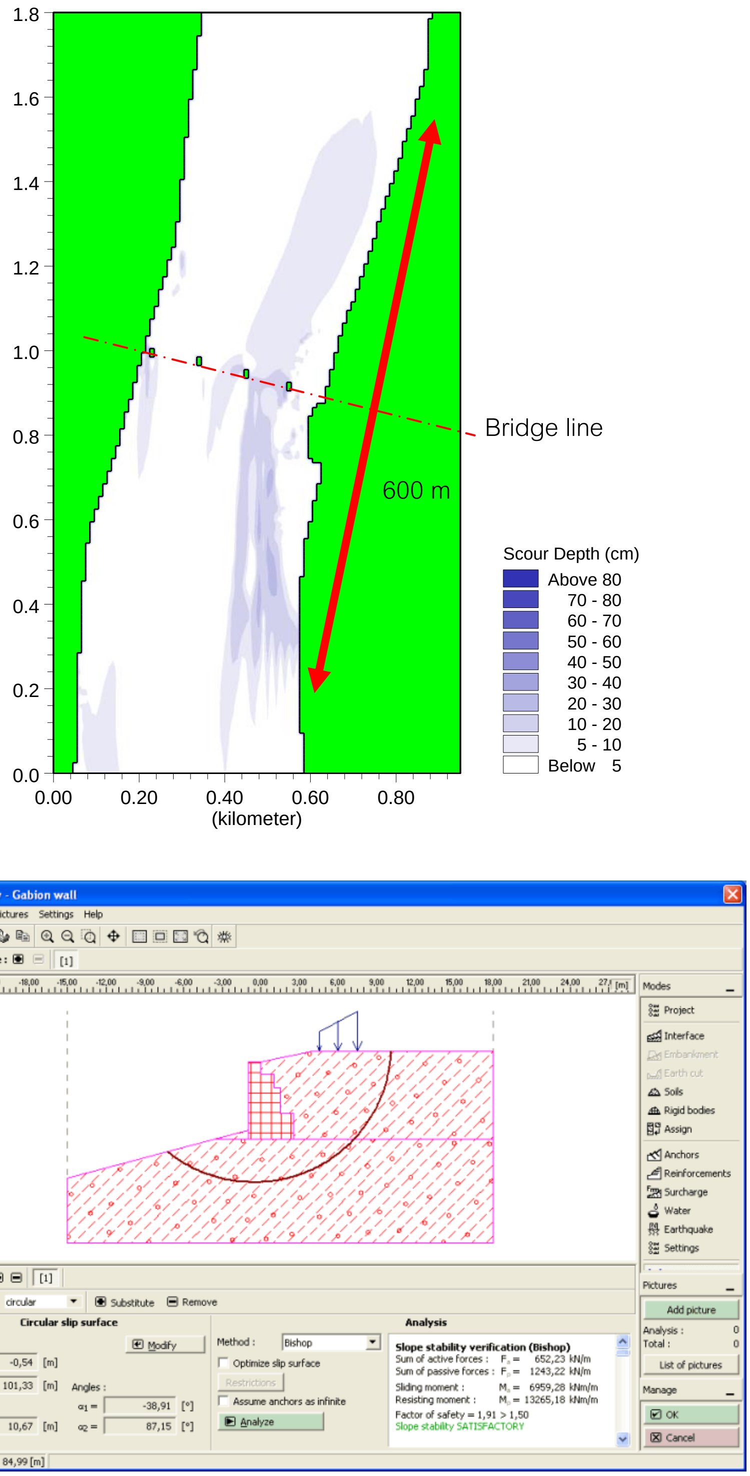

Fig. 8: Scour depth area that occurred after the project at 100 years repeating period

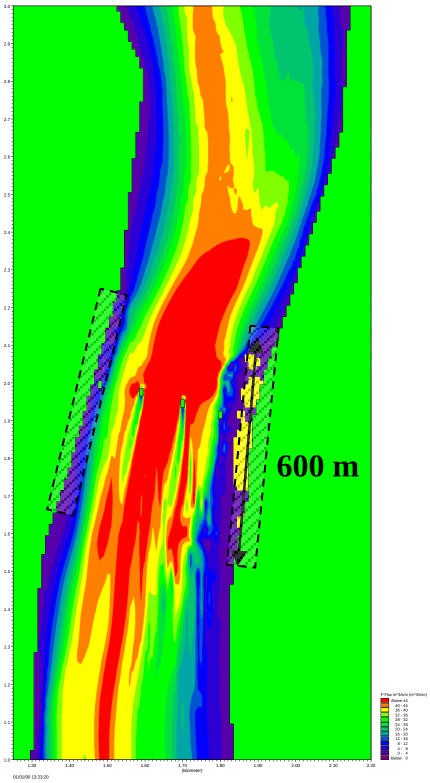

Fig. 9: Corrosion-protection-structure-shall-be location.

The model result has shown the differences between before and after the project concerning the idea that the changes of the current cause the erosion. In fact, the worst case erosion affected from the magnitude and direction changes of the current before and after the project which can evaluate by Blench's equation. Therefore, this can lead to the protection measure to be used later. In this project, the bank protection is to use 600 meter gabions for both sides.

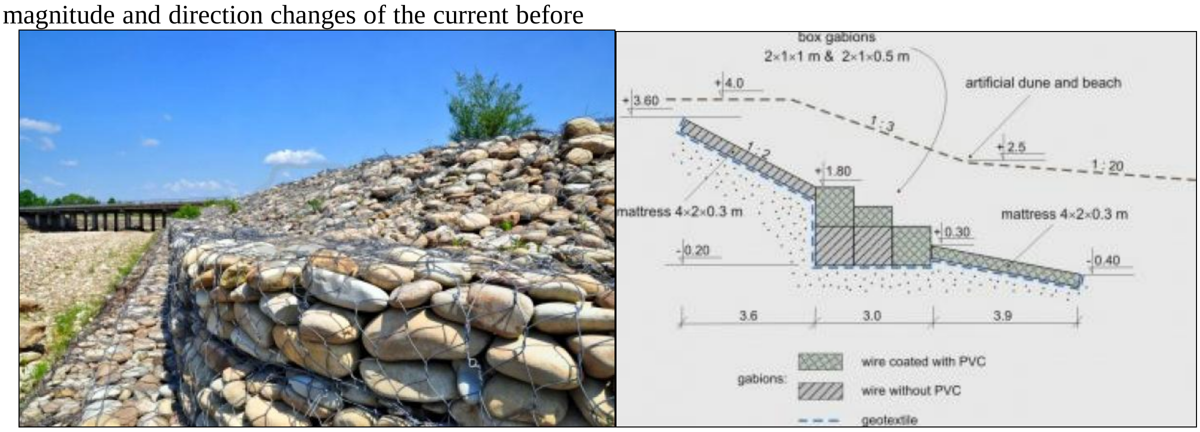

Fig. 10: Corrosion-protection for the construction of the 600 meter gabions is recommended along both Thai and Laos river banks

6. Conclusions

In conclusion, the environmental impact evaluation of the water bed scour depth from the bridge construction has been presented by using mathematical model. In fact, 2D mathematical model, MIKE21 was used for modeling and simulating the conditions and situations of the project. To illustrate, the result data in the erosion assessment is further considered for riverbank protection. The result of flux calculation of the water flow both before and after the project is to be presented the river bank erosion area. In addition, the environmental impact evaluation from the bridge construction has been presented by using the mathematical model for calculating the scour depth of the water bed. Since the Mekong River is the river boundary between two countries, Thailand and Laos, the protected areas have to be equal to each bank by considering the bigger area, and the velocity for the flood flow of the Mekong River is very high and the project is in the narrow part of the river. As a result, the flow current is higher than normal. Therefore, the protection should start from the narrow part from the north of the project. From these results, it is recommended that to prevent the damage caused by the project, the construction of the 600 meter gabions along both Thai and Laos river banks should be constructed as shown in figure 10.

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