INFORMATION OF DOCTORAL DISSERTATION

Thesis Title: **Studying the changes on environmental geology at Quan Chanh Bo and Bypass channel under the operation of Hau entrance navigation route**

Major: **Geology Engineering**

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1. Dissertation Summary

This doctorate dissertation studies the changes on the geo-environment at Quan Chanh Bo and Bypass (Tat Canal) during the operation of the entrance navigation route to Hau River. The objectives of this study are to determine the role of natural and artificial factor including geological structures along the shore, flow regime changes and ship-induced waves… which effect on the erosion and deposition processes to propose the sustainable mitigating solutions.

As study basis, geological structure is one of the most important physical soil natures influenced on permeability and hydraulic conductivity. Soil structure referred to the grain size and distribution ratio of cohesive soil including sand, silk, and clay are soil-classified. River morphology that affected on the hydraulic force is governed by velocity, gradient and shear stress on river-bed and river banks. The vessel's movement along the channel creates waves and the suspension of sediment through a series of processes, including lower water levels, vessel-generated flow, and the vessel's propulsion device. The wave energy can exceed the shoreline resistance and the swept material to a movable location by the lower energy wind waves or by channel flows.

The geology structure of river banks compounded with sand, silk and clay is categorized on the “ROM” scale with five erosion levels such as “Critical”, “Very High”, “High”, “Medium” and “Low” in depths varying and critical shear stress of the shoreline material based on clay-silk content. The pre-operated and post-operated channel flow mode was

simulated by the integrated MIKE 21/3 coupled to evaluate the change in hydrodynamics, sediment transport and erosion process. Waves caused by vessels are an important factor in the operation process, which is measured to the stress affecting on the stable shoreline. It is proposing sustainable development solutions, planning for maintenance and dredging activities during the operation. The study has also introduced and presented the implementation methods and study results of the three above factors influenced on the operation of the channel for 5 years since 2016.

Results show that, the inherent geological structure of the QCB is fall into the "low" region benchmarked the ROM scale. Meanwhile, the Tat canal is assessed to be non-stable state. Maximum severity is fallen into "Critical" level as per ROM scale in various depths in respective. Due to artificial canal, simulated current velocity is increased 0.5 – 0.7 m/s, maximum of 1.3 – 1.5 m/s. Moreover, measured ship-generated wave height varies in 0.3 – 1.4m. The height of ship wave depends on loading condition, vessel speed and tidal condition. River banks of QCB channel withstands the critical shearstress of 19.6 – 22.4 N/m2, in respect of shearstress generated by ship wave height of 0.68 – 0.74m. In addition, natural bank structure of Tat canal withstands the shearstress of 5.9 – 18.2 N/m2 which is equal the impact by ship wave height of 0.45 – 0.69.

The geo-environment at study area is impacted by the natural and human factors. During the normal operating, it is necessary to propose the preventive and mitigating measures to ensure the effectiveness operation. The mitigation measures are based on geological structure, hydrodynamic condition, and ship-generated wave impacts. As results, there are total six (06) measures including two (02) non-structure measures (vegetation planting) and four (04) structures have been proposed to apply for every section of the channel.

The slope stable analysis applied for two non-structured measures which has the estimated cost at 5,095,000VNĐ/m to 28,173,000VND/m has provided the stable factor varying on the range of 1.01 – 1.06. For eroded bank segments, it is recommended to provide the combined measures which not only reduces the slippery force but also increases the resistance force. Besides, stable analysis results of four structured measures (estimation cost of 34,182,000VNĐ/m to 67,932,000VND/m) is in range of 1.19 – 1.74. However, it

is necessary to carry out additional site survey and monitoring to provide the basis on selecting of mitigation measure with purpose of ensure the sustainable developing and effectiveness operation of the channel both technically and financially.

Last but not least, the sedimentation rate plays an important role in the overall maintenance program of the navigation channel. Simulation model was established for 03 scenarios: Low, Medium and High cases of sedimentation rates. It is shown that, the annual volume of dredging material of 20.7km navigation channel in 03 scenarios are 872,342.48; ,204,065.68 and 1,535,788.88 m^3 in respectively. As result, there were suggestions on yearly, bi-yearly and every five year dredging to ensure the smoothly operating of the channel.

2. Results of the dissertation

As result, study outcomes are given as below:

1) The geo-environment at the study area is the estuarine area which has the riverine system is dominant and simple geological structure. The weak Holocene formation is usually affected by the high current velocity which leads the erosion-deposition phenomenon at different rates varying the navigation channel. The QCB is compounded by the 2m mud-clay layer on the top surface, followed by the clay layer of 10 – 15m with contribution of clay material of 25.9 – 72.2%. Tat canal is primary low-land area, weak cohesion and thick mud layer (>5m) on the surface. Secondly, the sand layer of 2 – 4m compounded by clay (0.2 – 61.1%) and sand percentage >40% in respectively.

2) The rate of erosion-deposition is significant affected by natural and artificial factors during the normal operation of the navigation channel through QCB and Tat canal. It was found that, there were 03 main factor contribute on the erosion-deposition mechanism, including: geological bank structure, change on current flow and vessel wave generated by the movement of the cargoships.

3) The aims of alternative navigation route to Hau river through the existing QCB channel and Bypass canal (new artificial canal) are to avoid the grounding risks of Dinh An

estuary. Study results shown that, the geological structure of the existing QCB channel has been categorized as "Low" as per the "ROM scale". The critical shearstress τc(SC) is 22.4 N/m^2. On the contrast, the digging of new artificial canal, bypass canal broke down the natural stability condition leading the unstable conditions on the new canal banks. Regarding ROM scale, the bank stability of Bypass canal is fallen into "HIGH" to "CRITICAL". The high risk of unstable condition is found at the second layer (-1.5 to -7.5m in depth) with the critical shearstress τc(SC) is 18.2 N/m^2.

4) The simulation results show that, with effect of new canal, the current velocity at Dai An, Long Toan T-cross and new estuary increased significantly. Simulated current speed at Long Toan reached 1m/s while current velocity of 0.5 – 0.7 m/s was added at Dai An and reached the maximum of 1.3 – 1.5m/s. Increasement of current puts and pressure on the stability of bank structures and movement of the vessel.

5) The movement of vessel shall increase the naval flow through existing QCB channel, increase the risk of bank erosion. Wave generated by cargo ships through the channel was measured. It was shown that, vessel wave-generated height is in range of 0.3 – 1.4m, wave height is depended upon load condition, vessel speed and tidal condition. In addition, full-loaded vessel moves at high speed shall generate the current of 0.57 – 6.42 m/s and high wave to attack the river bank. The shear rate is proportional with wave height generated by vessel. As results, the existing bank of QCB channel can resist the critical shearstress of 19.6 – 22.4 N/m^2, in accordance of stress generated by the vessel wave of 0.68 – 0.74m. Meanwhile, Bypass canal banks resist the critical stress of 5.9 – 18.2 N/m^2 generated by wave height of 0.45 – 0.69m in respectively.

6) To ensure the sustainable development of the navigation route, there were Six (06) mitigation measures (02 non-structured and 04 structured measures) were recommended. Simulated results shown that, total dredging volume in various scenarios are 1,535,788.88; 1,204,065.68 and 872,342.48 per year. Depend on the deposition rate, suggested dredging period for each segments are yearly, bi-yearly and every five year.

3. Further research of the dissertation

Nowadays, the erosion-deposition is the most important issue in Mekong delta, especially on the navigation routes. It is a complex natural phenomenon, a result of the interaction of various factors. Factors affect on the erosion mechanism are categorizes two main group: natural and human factor. In fact, deposition on estuarine areas increase continuously, reaching the limit and move forward to inland gradually to re-generate the new balance condition of the hydro-morphology system. Moreover, in the climate change decade, the adaptive measures are required to fight against the erosion-deposition issues on the navigation channel. Therefore, it is necessary to provide adequate consideration on the navigation routes, especially artificial channel to have an overall view of points regarding the changes on geo-environment under global climate change as well as their impacts on:

1) Consider provision of mangrove forest along the navigation routes to protect the river banks; well-manage the natural ecosystem on the channels as well as the building of hypo-dams on the upstream of Mekong River…which derives on the geo-environment changes;

2) It is necessary to provide the study on the building of breakwater groins at the estuary of Bypass canal to detailly assess the adverse impacts of these structures to the local erosion-deposition problems;

3) Calculate the salinity area due to the operating of bypass canal, determine the increasement of Holocene groundwater in according to sea level rise scenarios to provide the master management plan on the sustainability development.

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