Study on prediction of riverbed erosion and deposition at tail of Ganjiang River

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Abstract. The trend of a river erosion and deposition is the first construction condition for a bridge construction. In order to evaluate the construction conditions of a bridge located at the end of Ganjiang River, based on the two-dimensional flow and sediment mathematical model, the amount and distribution of sediment erosion and deposition in the river reach under various typical and series of annual flow and sediment processes were calculated and analysed in this paper. The results show that the river reach where the project is located is dominated by micro siltation under various water and sediment processes, but the unfavourable conditions caused by local scour of piers should be considered in the construction of the project.

1. Introduction
Riverbed scouring and silting has an important impact on river crossing engineering, especially on the construction of bridge engineering, and is of great significance to the long-term safe operation of bridge [1-2]. Due to the rapid development of traffic in Nanchang, the capital city of Jiangxi Province, it is necessary to build bridges at the end of Ganjiang River and master the development trend of river erosion and deposition at the bridge site [3-4]. Based on the typical hydrological year and series of annual runoff and sediment data of Ganjiang River tail reach, this paper predicts and calculates the scouring and silting trend of Ganjiang River tail reach, and the research results can provide reference for the construction of bridge engineering in this reach.

2. Study reach and method

2.1. Study reach
Ganjiang River is the largest river in Poyang Lake system, which is located in the south bank of the middle and lower reaches of the Yangtze River. The proposed bridge project is located at the downstream end of Ganjiang River and beside Jiulong Lake in Nanchang City. The bridge crosses the main stream of Ganjiang River.

The study area of this paper is located in the upper reaches of Nanchang reach of Ganjiang River, with a total length of 30km upstream and downstream of the proposed bridge. The river reach is basically in a slightly silted state, and the riverbed is relatively stable. The shape of the study river section is straight and slightly curved. The curvature is very small, and the channel is wide and narrow. In recent years, the river section near the proposed bridge project shows a general trend of siltation, and the horizontal contour and deep groove contour show a local narrowing of siltation. The river section has experienced a process of wide shallow development and then relatively stable. The results of field survey and historical investigation show that the sand mining activities near the upstream of the proposed
project line are more frequent in recent years, resulting in beach scouring and river undercutting. The location and riverbed morphology of the study reach is shown in Figure 1.

2.2. Data and method
There are two schemes for calculating hydrological year of riverbed erosion and deposition: typical year scheme and measured series year scheme. Due to the recent climate change and human activities, the water and sediment conditions of Ganjiang River have changed to some extent. Therefore, the hydrological year selected in this study is mainly based on the water and sediment conditions since the 1990s.

(1) Typical runoff and sediment year
In this typical water and sediment year, the water and sediment series of medium water and sediment, large water and large sediment and large water and small sediment are considered. Figure 2 shows the water and sediment situation of Ganjiang River since 1990s. It can be seen that the year of reclaimed water mainly includes 1993, 1999, 2001, 2005 and 2014. The ratio of annual runoff to annual average value is 0.95, 1.00, 1.05, 1.00 and 0.95 respectively. And the ratio of annual sediment discharge to annual average value is 1.38, 0.93, 0.87, 1.18 and 0.40 respectively. Therefore, 2005 is selected as the typical year of reclaimed water and sediment. The flood years mainly include 1992, 1998, 2002, 2010, 2012 and 2016. The ratio of annual runoff to multi-year average is 1.31, 1.38, 1.32, 1.32, 1.30 and 1.53 respectively, and the ratio of annual sediment discharge to multi-year average is 3.20, 1.64, 1.66, 1.29, 0.79 and 0.77 respectively. Therefore, combined with the incoming sediment situation, 1992 is selected as the typical year of large runoff and large sediment, and 2016 is selected as the typical year of large runoff and small sediment Type year.

(2) Series of water and sediment years
For series years, it is necessary to comprehensively consider the water and sediment conditions of small water and small sediment, medium water and large water and large sediment as well as the influence in recent years. Considering that this study should focus on the engineering safety, so considering the adverse water and sediment situation, 2008-2017 is selected as the typical series year. Based on the above data, the evolution trend of riverbed erosion and deposition before and after the implementation of the project and the impact of the project implementation are calculated by using a two-dimensional mathematical model of water and sediment in plane [5].

The calculated starting terrain of typical year and series year is the measured terrain in August 2020. During the calculation, the inlet discharge, sediment concentration and water level are generalized according to the measured daily mean values of corresponding typical years and series years, as shown in Figure 3. The average value of incoming sediment gradation from 2013 to 2015 and the measured value of riverbed gradation was used to give the composition of sediment.
3. Results

3.1. Amount of sediment evolution
In terms of the amount of erosion and deposition, in the case of no project, the calculated river reaches in each typical year and series year are mainly silted. The siltation amounts in 1992, 2005 and 2016 are 7.601 million m³, 2.654 million m³ and 1.634 million m³ respectively, and the siltation amounts in 2008-2017 are 12.379 million m³. After the implementation of the bridge project, due to the piers occupying part of the flow area, the flow velocity slightly increased, resulting in a slight decrease in the amount of sedimentation compared with the case without the project. The amount of sedimentation in 1992, 2005, 2016 and 2008-2017 were 7.449 million m³, 2.574 million m³, 1.569 million m³ and 12.07 million m³ respectively, which were about -2.0%, -3.0%, -4.0%, -3.0% less than the case without the project.

3.2. Distribution of the sediment evolution
Figure 4 shows the calculated distribution of the sediment evolution before and after a bridge project. According to the distribution of erosion and deposition, the channel of the calculated reach is basically U-shaped, and the sediment is deposited in the whole channel. From the scouring and silting changes of the section where the project is located, the section of the project is dominated by micro silting. After the implementation of the project, the regional deposition decreases slightly with the increase of the flow velocity, while the regional deposition increases slightly with the decrease of the flow velocity, but
the amplitude is generally small, and the overall impact of the implementation of the project on the riverbed erosion and deposition is small.

| Situation | Series                      | Amount of sediment evolution (10^4 m^3) | Rate of change |
|-----------|-----------------------------|----------------------------------------|----------------|
| 1992      | Big water and big sand     | 760.1                                  | -2.0%          |
| 2005      | Medium water and sand      | 265.4                                  | -3.0%          |
| 2016      | Big water and small sand   | 163.4                                  | -4.0%          |
| 2008–2017 | Series year                | 1237.9                                 | -3.0%          |

Figure 4: Calculated distribution of the sediment evolution before and after a bridge project.

4. Conclusions
The results of mathematical model calculation show that in all kinds of hydrological years and hydrological conditions, the studied river reaches are slightly silted, and the siltation thickness is generally less than 1m. After the implementation of the bridge process, due to the reduction of the cross-section area of the river and the increase of the flow velocity in some areas, the siltation of the river is weakened, but it is still siltation on the whole. However, it is worth noting that the turbulence effect of the local flow of the pier is strengthened, and the local anti-scour treatment of the pier needs to be strengthened.

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