Research on the Comprehensive Improvement and Planning of River Courses in Mountainous Areas

Juan Dai, Wentao Lei, Miao He and Yinjun Zhou*
Changjiang River Scientific Research Institute, Wuhan, 430010, PR China.
Email: zhouyinjun1114@126.com.

Keywords: Comprehensive improvement, planning, mountains areas, flood control, ecological management

Abstract: River is not only an important water conservancy facility, but also an important part of the ecological environment. In this study, the comprehensive treatment plan of the Baoshi River in the mountain river is taken as an example. According to the principle and layout of the comprehensive management of the river basin, combined with the analysis of the current situation of the river, flood control, bank slope protection, drinking water and irrigation water safety of the middle and lower reaches of the Baoshi River are comprehensively controlled. Construction of related projects to ensure flood control and water safety for residents. Through the comprehensive regulation of the river, the flood control standards of the cities and towns and their infrastructure are further improved, the problems of flood control security for the people's lives and property in the region and the economic development have been further solved.

1 INTRODUCTION

In recent years, the concept of 'returning to nature' (Mei and Chen, 2015) has been put forward for river regulation, and the concept of traditional river management to modern river ecological management has been formed. The river ecological management pattern is divided into three types: natural ecological river treatment, engineering ecological river treatment and landscape ecological river treatment (Ma and Wang, 2008). According to the control mode, the ecological river control is more suitable for the river channel in the plain area; the ecological river management of the landscape is more suitable for the urban river course, and the ecological river management of the engineering is the treatment, it is more suitable for the river course in the mountain area.

Mountain rivers have the characteristics of large river slope, large flow rate, large sediment concentration, strong scouring power, sudden rise and fall of floods. Therefore, the key point of mountain river regulation is flood safety, followed by maintaining the stability of the embankment (Laiet al., 2011). Using engineering measures to protect the structural stability and safety of the river, give full play to the natural advantages of the mountain area, and maintain the ecological environment of the river with appropriate section type and ecological measures (Huang and Fang, 2012).

Scholars have also carried out a great deal of research on the ecological management of river course in mountainous areas, especially the study of river ecological restoration (Nilsson et al.,1991), based on various restoration techniques of various targets (Thyssen, 2000), and the study of river ecological base flow (Li, 2006). This study takes Baoshi River as the research object, and carries out comprehensive research on river channel in mountainous area based on ecological management.

Baoshi River locates in Chuangwang Town, Tongshan County of Xianning City, and it is the third level tributary of Yangtze River Basin, the drainage area is about 214km^2. Baoshi River drain into Hengshi River in N29°31′20″ and E114°38′08″ ,runs into the Yangtze River after draining into Fushui through Daban Town, and going through Fuchi Town in Yangxin County in the east. The River has two origins, which are Taiyan Mountain in the west and Jiugong Mountain in the east. Jiugong Mountain locates in Tongshan County in Hubei Province, which is in the middle of Mufu Mountain on the border of Hubei and Jiangxi province, its

Dai, J., Lei, W., He, M. and Zhou, Y.
Research on the Comprehensive Improvement and Planning of River Courses in Mountainous Areas.
In *Proceedings of the International Workshop on Environment and Geoscience (IWEG 2018)*, pages 522-528
ISBN: 978-989-758-342-1
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altitude is 1657m and is the highest peak of Mufu Mountain. Taiyang Mountain locates in the middle part of Mufu Mountain and is 45km from Tongshan County. The altitude of Huanghejian is 1386m, and is the second highest peak in the south of Hubei province.

From the river system length and the area of the basin, JitanRiver is the major water origin of Baoshi River on the left,which joined Xialiang RiverGaochao River and Dayuan River on the right bank from the east side. The length of Baoshi River is about 35km from southwest side to northeast side along the drainage line, and its average gradient is 4.2‰. Chuangwang Town has rich water resources,by the end of 2002, it has established 16 hydropower stations, and its total installed capacity is 1.176×10^4KW, and its annualgenerated energy is 2469.42×10^4 KW·h. Regional map of Baoshi River see Figure 1 as follows.

Figure 1: Regional map of Baoshi River.

2 CURRENT SITUATION OF WATERCOURSE

Accordingto the geomorphic features of the watercourse and the boundary conditions of the riverbed, the main streams of Baoshi River can be divided into the upper, middle and down streams, while the secondary power station of Baoshi River and Baoshi River Power Station are taken as boundaries.

The watercourse above the secondary power station of Baoshi River is the upper stream, its full length is 18.5km, and average gradient is 6.1‰. The watercourse of the upper stream traverses in the mountains along the watercourses on the upper stream, and goes through Jitan village, Gaochao village and Dayuan village. High Mountain is the major landform on the upper stream, Natural landscape area of Jiugong Mountain locates in the right and its highest peak reaches to 1657m. Taiyang Mountain is on the left and its highest peak is 1386m. The riverbed of the upper stream is undercut valley, and its elevation is 587m~120m, the water of the river flows rapidly, and has numerous sharp turns. There are big stones in the river and the riverbed has good anti-scourability. Meanwhile, the upper stream has luxuriant plants and good facilities for soil and water conservation. The sediment accumulation of riverbed is not obvious, so it has relatively stable riverbed and limited deformation magnitude in general.

The middle stream is from the secondary power station of Baoshi Power Station, its full length is 13.1km, and its gradient is 3.4‰. Low mountains and hills are main landforms in the middle stream. Generally, the plant area on the left and the elevation of the ridge is about 150m. Hills are the major landforms in the plant area on the right, and the elevation is between 110m to 120m. The branch of Jiepai River joins the stream on the left, and there is a level sevenpower station. The plane modality of the riverway in the middle stream is curve, and it consists of a series of continuous curves. The average width of the river channel is 60m, but partial flood plain is as wide as 330m.

The water head of the second grade power station of Baoshi River is 9.96M, its installed capacity is 12.3 million KW, and its annual generating capacity is 3.09 million KW.h. The powerhouse locates on the west of the mountain that is on the left bank of Baoshi River, the inlet of the power station connects with the powerhouse through channels. A part of water intaking is used for the power generation, and some part of the water is used as domestic water for residents in Chuangwang Town. The tailwater of the power station join Baoshi River at 0.5km in the downstream. According to the on-site survey, the river channel sedimentation on the upper stream of the power station dam, clayey silt is the major sedimentations. Dry weeds are floating on the water on the upper stream, and there are even white trashes that flow from the upper stream. Sedimentation is very serious in the inlet of the power station, while the decayed leaves covered the fence, and polluted the water quality of intaking water.

The middle stream of Baoshi River goes through Baoshi Village and the riverway divides the Baoshi Village into South and North parts. There is a population of ancient dwellings, residential buildings and ancestral temple are on the north bank, the street is parallel to the river bank; one abandoned commercial street is parallel to the river bank on the south, the street is 3m in width and 150m in length. The south of the commercial street is residential area, and the road network is similar with the north bank. The water surface is very broad and the water flows very stably in this area. The width of the river is about 100m, and the depth is nearly 1.5m in the dry season. Ancient dwelling are on the two sides of the river, and the residential buildings on the south is 2m above the water surface without protection of related projects. Some residential buildings on the north bank were damaged, and newly established concrete houses can be found in some places. The residents on the two sides developed embankments with cobblestones based on the natural dyke, but the embankments are scattered. Meanwhile, the embankments base is weak, so it is very easy to be damaged by flood.

Five small overflow dams were established on the middle stream of Baoshi River, which has high water level and can be used to irrigation. The dam body of the overflow dam is very low, and it is less than 0.4m in height, so it is very poor in flood protection and water storage. The dam body can be damaged seriously by flood because of low construction standard. Several dam bodies were cut off in the middle, and lost its function for flood protection and water storage, which has seriously influences onfarm irrigation in nearby areas.

The area between Baoshi River Power Station and the river mouth is the down stream, which belongs to the administrative area of Liujialing Village, and it is also the location of government building in Chuangwang Town. The river consists of a ‘U’ shape curve and straight area of the down stream. The riverway is 4.1km in length and its gradient is 2.9‰. The riverway goes through Liujialing Village and the topographic relief on two banks of the upper stream river changes slightly. The river valley on two banks is broad, and cultivated land is major form of land utilization on two sides. The river mouth links with the flood plain of Hengshi River, and a board river valley is formed. The nearby flood plain is as wide as 750m. Gravel-cobbles are the major materials of the riverbed the diameter of the gravels that cover the riverbed surface is about 5cm. Some areas of the riverbed have bed rocks exposed out of the water along the entire riverway, which forms shallow bank that cut off the channels. The banks of the downstream rivers are dominated by soil bank slopes, which are wetlands on the banks of local rivers and the vegetation grows.

3 RIVERWAY IMPROVEMENT AND PLANNING

3.1 Planning and General Layout

According to the comprehensive management principles and layout of the Baoshi River Basin, the problems of flood control in the middle and lower reaches of the Baoshi river section, the safety of drinking water and irrigation water for the protection of the bank slope, and the construction of relevant supporting projects are constructed to ensure the safety of flood control and the production and living water. The overall layout is as follows:

3.1.1 Protect and Ensure the Flood Prevention and Safe Production

The downstream of the Baoshiriver flows through Liu Jialing village, which is the residence of Chuangwang Town. Liujialing Village locates on the left bank of Baoshi River, and it has occupied about 1km of the water front. Most residential buildings are constructed along the water, and natural highland is used to avoid water or elevate the house foundation manually to avoid water influences, but no other prevention measures have been taken. Therefore, the town might be flooded once flood comes. Cultivated lands are around the two banks of the downstream riverway, and silty clay is the major component of the bank slope, the elevation of the slop is 2m higher than the river bed. During the period of serious flood, the water covers the floodplain, and large areas of farmland are flooded. Therefore, floodwall and flood control dams are major projects along the riverway of the downstream river. The flood prevention standard shall be improved to ensure the safety of production and living of residents.

3.1.2 Restore Water Conservancy and Irrigation Project and Construct Water-saving New Village

The production and domestic water in Chuangwang Town come from Baoshi River, the water supply plant for the residents and secondary power station of Baoshi River share the same water inlet. Because of high water level of the dam, and slow flow velocity, the sediment lifting of the riverbed become worse, and the inlet was blocked. In this plan, it aims to improve the water inflow capability of the inlet and ensure the domestic water supply for residents by clearing the silts of the riverway nearby the secondary power station of Baoshi River.

The overflow dam of the Baoshi River was damaged by flood seriously, and open channel was used for irrigation, so the water loss is huge, and water use efficiency is low. By restoring the overflow dam of Baoshi River to adjust the layout of open channel, strengthen anti-seepage measure, improve the capability of main stream flow, and then strengthen the recycle of tail water. Moreover, corresponding supporting buildings will be constructed, so as to improve the flood prevention and water log control of the region.

3.2 Hydrological Analysis and Hydraulic Calculation

3.2.1 Basic Hydrologic Data

There is currently no hydrological station along Baoshi River. But along its trunk Stream of Hengshi River, a hydrological station called Hengshi Hydrological Station stands in Hengshi Town of Tongshan County. The station was built in 1961 by Hubei Provincial Department of Water Resources. The drainage area is of 347km^2. In 1966, after the establishment of Fuli Reservoir, Hengshi hydrological station was retired. In June of 1976, the station was moved downstream, and was changed into Hengshi Station II, with a catchment area of 426km^2. It was located at E114°38'41", and N29°31 ', responsible for testing precipitation, water level and rate of flow. After investigation and analysis, there is no large and medium-sized water conservancy projects found at the upstream of the station, so the data is consistent and representative, can be used as the design basis for the hydraulic calculation of Baoshi River.

Xiapu hydrological station is at the mainstream of Xiapu River adjacent. The station is a national base. The observation methods and data reorganization all meet the requirements of hydrological test, which is precise and reviewed year by year, so it can be taken as the bench-mark station for this project.

3.2.2 Flood Analysis

A. The characteristics of storm flood

Since the flood in this basin is all caused by storm, according to the statistics of Hengshi Sation II, heavy rain mainly happens from April to October each year, and in some special year, it also may occur earlier in March or later in November, of which, June and July are the two months have frequent heavy rains. The annual maximum 1h rainfall usually occurs in April to October, of which the highest frequency occurs from June to August. The annual maximum 1d rainfall occurs in March to August, and the highest frequency appears in June. Hengshi River is a mountain stream fed by rainfall and flood. The basin is rich in small streams and floods. As it comes to flood season, the flood rises and falls sharply in a short period with a mass flow. The flood comes with storms, starting from April, the most powerful in May and June, and the annual maximum flood usually comes from April to July, which is caused by plum rain season. So if with the advancing or postpone of the plum rain season, or due to extraordinary weather, the annual maximum flood would probably advanced to March or postponed to September. According to the peak data measured by Hengshi Station II, the largest flood in history happened in 1967, with a flow rate of 2100 m^3/ s.

B. The maximum flood in history

According to historical surveys, there was a largest flood in Hengshi River which occurred in June 1967, with a peak discharge of 2100m^3/s. The data is reliable. Considering that it happened in the actually measured flood system, so the design flood will not be handled as extra large value.

C. Design Flood of the Reference Station

(a)Design Flood in the bench-mark station

Hengshi Station II has a hydrological control area of 426km^2. The study is based on the peak flow data collected in last 31 years from 1961 to 2011(the measurement was stopped from 1966 to 1980 and the measurement from 1992 to 1993 is missing), as well as the peak flow data of adjacent Xiapu Station from 1964 to 1986. Considering that Hengshi

Station II and Xiapu Station have almost the same features of storms and floods for the two basins are both rich in water, the missing data is supplemented by 2/3 power of the area ratio of peak flow actually measured in Xiapu Station. Along with the historical records in 1967, it forms the maximum peak flow series of Hengshi Station II from 1961 to 2011 (the data of 1992 and 1993 are missing), a total of 48 years. A frequency analysis is then carried out on this series. With the help of P-Ⅲ line fitting method, the design floods of Hengshi Station II studied in this research is obtained. See Table 1 and Figure 2 as follows.

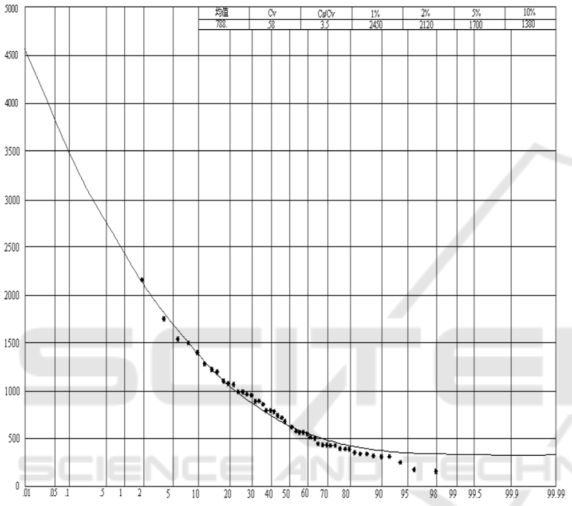

Figure 2: Peak discharge frequency curve of Hengshi Station II.

(b)Design Flood of the drainage basin of the project

Design Flood of the drainage basin in Baoshi River is calculated based on the below formula with the values as flow. Design flood outcomes of Baoshi River Basin see Table 2 as follows.

$$Q_{design}=(F_{design}/F_{parameter})^{2/3}Q_{parameter}$$

Where Q -flow, m^3/s; F-drainage area, km^2

3.3 Planning for River Regulation

3.3.1 Project Scope and Building Scale

According to the principle of control, the river channel of 2.3km in the upper reaches of the two grade power station of the Baoshi river should be cleared, and 6.4km range of the lower reaches of the river is governed by the requirements of the ecological environment. Among them, the newly-built roller compacted rockfill slope revetment on both Banks of the upper reaches of Baoshi ancient dwellings is 1.6km, and the left bank of the 3.2km channel should built between the upper and lower reaches of the highway bridge, the embankment is the gravity type river embankment, the wall is 4 to 6m high, the 5m green belts which set up after the wall. The other river embankments are the natural rivers in the countryside, the soil slope is consolidated and strengthened, and the greening protective belt which planted. For treatment, the protection standard is 10 years. Because the houses are on the river bank, the local embankment is protected by gravity retaining wall.

Five overflow dams were constructed in the middle and lower reaches and Jiepai branch, which are used for water storage and the improvement of bridge landscape. The width of the riverbed is 28m-87m, the height for water storage of the overflow dam is 1.0-1.5m. The dam is an overflow gravity dam and its weir crest is 1.5m in width, golden silvering type filling is used on the dam body, and C20 reinforced concrete that is 50cm in thickness is used on the outer layer of the dam body, while enrockment is used inside. The two dam abutment enters the bank slope with the depth of 1.5m. The upstream face of the dam body is a vertical face, while the downstream face is a WES practical weir face. C20 concrete apron with the thickness of 40cm is set up for the riverbed, and the length is 10.0m. Embankments planning in the middle and down streams of Baoshi River see Table 3 as follows.

Table 1: Hengshi Station II design flood outcomes.

Item	parameters			frequency(%)				
	Average value	Cv	Cs/Cv	2	5	10	20	50
peak discharge(m^3/s)	788	0.58	3.5	2120	1700	1380	1067	646

Table 2: Design flood outcomes of Baoshi River Basin(m^3/s)

Section Position	Frequency(%)				
	2	5	10	20	50
Secondary Power Station(CS1#)	985	790	641	496	300
Baoshihe Power Station(CS2#)	1281	1027	834	645	390
Confluence(CS3#)	1340	1073	871	673	408

Table 3: Embankments planning in the middle and down streams of Baoshi River.

Serial Number	Geographic name	Design flood level(m)	Dike slope elevation (m)	Dike type		Length (km)
1	Cheping ~Chuangwang highway bridgein the upper stream (Baoshi Ancient Dewelling)	92.86~91.12	93.76~92.12	Left bank	RCC slope revetment	1.6
				Right bank	RCC slope revetment	
2	Chuangwang highway bridgein the upper stream (Baoshi Ancient Dewelling)~ Chuangwang highway bridge in the down stream(Liujiafan Village)	91.12~80.36	92.12~81.36	Left bank	Gravity retaining walls	3.2
				Right bank	Soil slope strengthening	
3	Chuangwang highway bridge in the down stream(Liujiafan)~ confluence of Baoshi River(Wangjiafan)	80.36~79.99	81.36~80.89	Left bank	Soil slope strengthening	1.6

3.3.2 Project Grade and Standard

According to the 'flood control standards' (GB50201 - 94), and the he relevant provisions in the 'code for design of levee engineering'(GB50286 - 98), the grade of flood prevention and protection project in the section of Baoshi Town is grade 4, while the other sections is grade 5. According to the service life of the civil synthetic materials, the normal service life of the project is greater than 50 years.

3.3.3 Overtopping Elevation

According to the 'standard' provisions, the overtopping elevation is confirmed based on the levee crest of the design flood. The design flood is once-in-ten-year level, and the flood level is79.99m~92.86m. The design storm wave height, damming, and free board elevation is 80.89m~93.76m.According to the above principles and designs, the planning research of the middle and lower reaches of gemstone river studied in this project is shown in Table 3.

3.3.4 Main Engineering Quantity

According to the layout of the project, the length of the river channel silting is 2.3km, and the length of the RCC slope revetment is 3.2km, the length of newly constructed gravity retaining wall is 3.2km, and the length of the soil slope strengthening is the 6.4km. Besides, five overflow dams are constructed.

4 CONCLUSIONS

According to the relevant standards, river regulation planning in Baoshi River conforms to the general planning of Tongshan County and its flood prevention plan, so it is feasible in technology. Meanwhile, it has combined the regulation planning of water and soil conservation as well as the water ecology and landscape planning. The flood

prevention and shore protection project is necessary and urgent from the perspectives and requirements to improve the flood prevention standard, reduce flood damage, prevent the life and property of residents along the river, speed up the urban development and improve the environment. This project is not only a life project that is related to the economic development and living of residents in this area, but also is an image project to improve local ecological environment, invest in environment protection and tourist environment, so the project should be implemented as soon as possible and play its positive role on these aspects.

ACKNOWLEDGEMENTS

Partial financial support of the work presented in this paper from China's National Natural Science Foundation of China (No.51509014, No. 51579014 and No.91647117) are gratefully acknowledged.

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