Discussion on Channel Characteristics and Regulation Ideas of the Braided Reach in the Middle and Lower Reach of the Yangtze River

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Keywords: braided reach; channel characteristics; influential factor; regulation idea

Abstract: This paper provides preliminary analysis on both the morphological characteristics of being wide, curved and branched for braided reach and the influential factors on the channel of the bending braided part. Based on the analysis of a typical river reach as an example, this paper puts forward the channel management ideas for the branched connection reach, i.e. fencing the low beach of the braided reach, limiting the lateral change of the river, firming the bottom land form of the braided entrance area, and shaping the braided reach into a smooth one with reasonable curvature in the dry season.

Morphological characteristics of the head of braided river

The head of braided reach possess the characteristics of straightening and widening segment, which is wide and straight

Because of the existence of the upper reach of the head of sandbar and low beach of low braided reach,the width of the head of the sandbar is generally large. Before entering into the braided reach, water flow is influenced by contracted section of the braided reach in the lower reach. As a consequence, at the widening section of upper reach, this causes a decrease of the gradient of flood freshet and flow velocity, a decrease of sediment transport capacity and a sediment accumulation, which is easy to form a point bar; while when the water level drops, there is an increase of gradient and flow velocity, an increase of sediment transport capacity and also a bed degradation. Water entrance area of Daijiazhou and point bar of Bahe are the examples, which basically follow the change regulation(Fig.1).

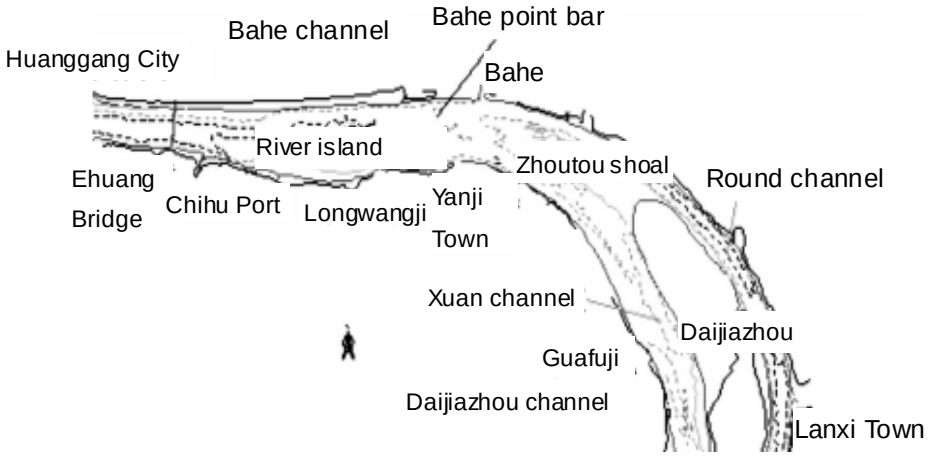

Fig.1 Sketch of the Daijiazhou Reach

Because of the annual and inter-annual changes of incoming water and sediment, the thalweg of the straight section in upper reach has a swing under the natural boundary condition, which leads to unstable increase and decrease of point bars on the two sides of the head of sandbar. It will decrease

or increase or develop in the process of thalweg swing, such as Yaojian channel intake Xinhekou point bar and Yanggouzi point bar Majiaju channel intake Baiweizhou marginal bank and Leijiazhou point bar (Fig.2) etc. When thalweg swings to the left, the right side is in the area of slack water, where sediment deposits and point bar develops, while because of high velocity of the left side, river bed is degraded and point bar is eroded; when thalweg swings to the right, the velocity of left side decreases, sediment deposits and point bar develops, while because of high velocity of the right side, river bed is degraded and point bar is retrogressed; when thalweg is in the middle, it is possible that point bars on both sides can develop. In light of this, in the straight section of alluvial rivers, water flow changes become dominant in the process of interplay between sediment laden flows and river bed.

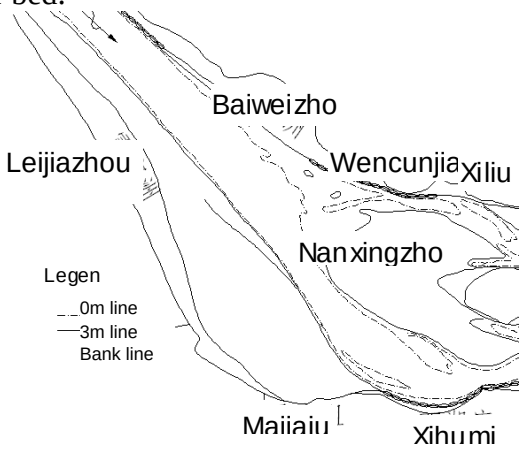

Fig.2 Sketch of Inlet Transition Segment of the Majiaju Reach

The head of braided river type has the characteristics of both bending and branching of bending braided river [1～2]

Most of the heads of the braided reach in the upper and lower reach of Yangtze River exhibit the characteristic of bending a little bit slightly, but circulating in different curved channels in have palpable difference in bending radii. For instance, circulating in curved channel plays a significant role in water channel of Luohuzhou, whose flow in the entrance is short and rapid. Even though water flow of flood season is straighten, the role of circulating in curved channel is still significant; for the water channel of Daijiazhou, its curved channel is far longer and comparatively smooth, so the role of circulating in curved channels, no matter in flood or dry season, is not very significant.

The river centre body in the lower reach of braided river separates the water channel into two branches and it is an inevitable existence that one side scours and another side silts. Because almost entire Jiangxinzhou is submerged into the water under big flood, the water channel is in the type of single channel. As the low part of the margin is partly submerged, the emersion body is still very small even though in the middle of flood season. Therefore, water is braided when it is low but water joins when it is high, which is one characteristic of braided channel of this type.

Change characteristics of approach channel in the head of braided reach[2～3]

Change characteristics of approach channel in the beach head.

Before Three Georges complete the water storage, upper reach of the head of braided river in the middle and lower Yangtze River is influenced by the mainstream's swing, which results in a lot of sediment accumulation and souring and silting in the point bar in both sides of widening section and

instability. After Three Georges complete the water storage, incoming water and sediment of channel segment decrease significantly; the space of water transverse variation is gradually compressed; the swing range of dynamic axis of water flow has been narrowed to a certain extent; Meanwhile, periodical change of incoming water and sediment makes riverbed evolution has a certain repeatability: high water level causes big or great change, while low water level causes small or gentle change. Leijiazhou point bar on the right side of Nanxingzhou changes basically in the similar way.

Lower reach riverbed of the head of sandbar is relatively shallow, so objectively there is larger space for the swing of dynamic axis of water flow. Straightening during flood and flexing during low water is one of important factors for the thalweg swing of the head of braided river. The head of Nanxingzhou at the entrance of Majiaju water channel, the head of Wuguizhou at the entrance of Yaojian big water channel and the head of Luohuzhou etc. display such characteristic more or less. On the other hand, the development of point bar at the transition section strengthens the restrictive effects of beach on water flow, reduces the river width of medium and low water and meanwhile decreases thalweg swing. This is extremely good for improving the channel condition of widening river section above the head of sandbar, however the decrease of thalweg swing by point bar makes the head of sandbar is located in the scouring position, which is very unfavorable for improving the channel of channel segment. Thus, the development of point bar at the widening section of the head of sandbar cut both ways for improving channel conditions.

Analysis of influence factors on approach channel of the head of braided reach.

Generally, whether channel condition is good depends on river regime variation and the head of braided river is no exception. When the river regime of both upper and lower reaches are basically stable, whether channel condition is good depends on the change characteristics of both straightening and widening section of upper reach and braided river. Concrete influence factors include the length of straightening and widening section of upper reach, widening rate of straightening and widening section, river width of the braided river entrance in the lower reach, bend radii of two branches and possible development conditions, etc.

Straightening and widening section's over-length in the upper reach of the head of braided river causes the disappearing of circulating flow in the head and also the disjointing between upper and lower reach. Thus the head of channel segment shows the characteristics of being long and straight more often and the head of channel segment is gradually being widening. Dense distribution of point bar in the reach of channel and frequent swing of mainstream lead to the reciprocal changes between the point bars on two sides. Most of the point bars are unstable, so the channel condition is based on shallow navigation obstruction, such as the upper section of Jianli waterway. If the upper section of channel in the head of braided river is straight, short and rapid, the development of transition section is easy to become malformed curving and cause big widening rate. As a consequence, the head of braided reach is easily influenced by relatively stronger circulating in bend channel. Because the channel nearby concave bank is relatively narrow and deep, there are often some problems for channel segment, such as insufficiency of navigation width and swift water flow, such as Jiebei channel segment.

It is unlikely that dynamic axis of mainstream in the head of braided river doesn't change and the scouring position of mother current changes in different water period. This results in the constant change of the head of connecting section of braided river. Especially the shallow beach under water is rather unstable and follows the law of erosion and deposition. During flood period, there is a deposition in the beachhead, while the beachhead will retreat in the water-receding period and dry

reason after flooding. Meanwhile the head of sandbar shows continuous relevant changes, whose obvious characteristic is that the erosion or deposition of point bars on the two sides of widening section of transition section will result in the silting or dredging, which causes the change of entrance of two branches. This will lead to the channel alternation of two branches in lower reach.

The straight branch of braided channel segment in the lower reach of braided river usually develops into the main stream, which is shallow, while the bending branch usually develops into branch channel. This mainly is because of serious unbalancement in length of two branches. As a consequence, the bending branch becomes small because of the big resistance and keeps declining in the long process of change. But main channel, which is the transition process from connection section to straight branch, is in turn affected because of insufficient development, large water resistance and unobvious dominance in comparing water flow between straight and bending branches. This lead to the scattering of transition channel in a certain route and cannot navigate. Conversely, if flow resistance of straight branched channel is low and has obvious dominance compared with the bended branched channel, navigation condition in the head is generally good.

Analysis on channel evolution of the channel segment in braided reach.

The transition section from Yaojilao waterway to Jianli waterway in medium Yangtze River is a typical transition of the head of braided river (see Fig.3). Upper Yaojilao waterway is smooth and long and has large widening rate. In addition, its mother current rises or slumps within the year and lower Jianjin waterway is bending and braided and has complex changes.

Because waterway of upper Jiaojilao is long, wide with low point bar and thalweg is lifted or slumped within a year, changeable mother current makes the channel of transition section of two waterways unstable. When the mother current of transition section enters into the Wuguijia from deep through and water tends to be downward along convx side. After flooding, entrance of Wuguijia is easy to form navigation channel in the transition stage. The transition of straightening, widening and braided beach does exist in the point bar of Yangouzi, beach in the head of Wuguizhou and point bar of Xinhekou. The changes between them have a direct influence on the ability of runoff scouring at the transition section and furthermore have an influence on navigation condition of the transition section. If point bar of Yangzigou slumps and gets connected to the channel bar of Wuguizhou and meanwhile point bar of Xinhekou develops, and then water erosion ability of entrance of Wuguijia is strong in the water-receding period. At this time, the channel condition is nice. If right side of channel bar of Wuguizhou and the head of Xinhekou are eroded, entrance of Wuguijia is easily to form compound shoals, which are not good for navigation condition. Once the point bar of Yanggouzi recedes to the upper position, low reach of the head of Wuguizhou is scattered. As for Xinhekou, because of its low point bar and scattered flow, the head of Wuguijia is easily to form multiple entrances and cause scattering transition section, This also results in bad navigation condition.

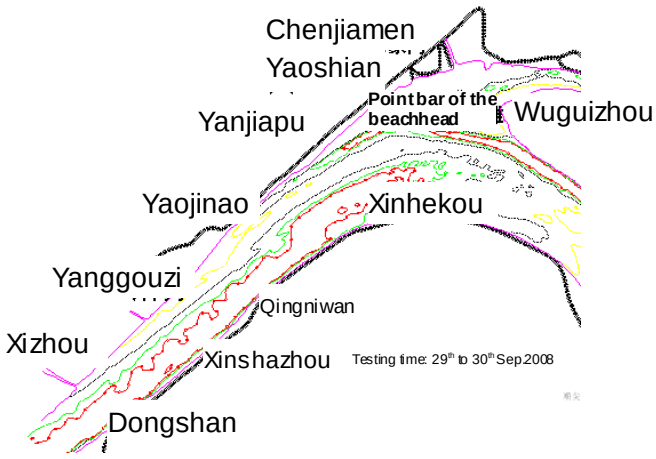

Fig.3 Sketch of the Jianli Reach

Discussion on regulation ideas of the navigation channel in the head of braided reach [4～5]

Three Georges complete water storage, there are unstable factors which exist in most of the head of braided reach. Therefore the following ideas are listed as follows:

With regard to the channel segment with better channel condition and possible shallow navigation obstruction, a certain measure could be used to stabilize morphology of existing channel and shoal, keep riverbed away from adverse transverse deformation and limit the scouring without sediment motion within the planning channel area. This provides better channel condition for channel

For the head of braided reach with serious navigation obstruction, combined with long-term planning, engineering measures should be adopted on the basis of protecting advantageous position of channel and shoal to stabilize the pattern of main and branch fork channels in lower reach and the pattern of braided river entrance. The head of braided reach should be regulated into an approach channel with reasonable curvature to form good channel and shoal patter, which provides a fundamental solution to shallow navigation obstruction and improve channel dimension and navigation condition of ships.

Conclusions

The head of braided river exhibits morphological characteristics of being wide,curved and branched.

Straightening during flood and flexing during low water period is one of important factors for the thalweg swing of the head of braided river. Meanwhile wide riverbed in the head of reach objectively forms larger space for swing of dynamic axis; on the other hand, decreasing the river width of the development of point bar at the transition section strengthens the restrictive effects of reach on water flow, reduces the river width of medium and low water and meanwhile decreases thalweg swing. This is extremely good for improving the channel condition of widen segment in the upper section of braided reach. Therefore, channel characteristics are double affected by straight and bending channels.

The controlling factors which determine if channel in the head of braided reach has navigation obstruction include the length of straightening and widening section, widening rate, river width of the braided river entrance in the lower reach, bend radii and possible development conditions, etc.

The change of mother current in the upper straighten section and the bending of mother current in

the lower bending section lead to the instability of the head of braided reach. After flooding, the river beach is scattered, which makes contracting water weak, leading to worse channel condition.
With regard to the head of braided reach with better channel condition, measures should be adopted to stabilize morphology of existing channel and shoal and guide the scouring without sediment motion to get large space for channel segment; with regard to the head of braided reach with worse navigation obstruction, measures should be mainly based on guiding advantageous part of channel and shoal at the moment and should focus on forming good pattern of channel and shoal.

Acknowledgements

I would like to express my sincere appreciation to the financial support from research project Channel Governance Key Technical Study Three Gorges – Gezhouba Hinge Sandy Gravel Reach (Yichang to Changmenxi)

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