

ENVIRONMENTAL ASSESSMENT AND SEDIMENTATION MANAGEMENT OF SANMENXIA RESERVOIR

BAOSHENG WU¹ and JUNQIAN XIA²

¹Professor, Department of Hydraulic Engineering,
Tsinghua University, Beijing 10084, China
(Tel: +86-10-62772097, Fax: +86-10-62772463, e-mail: baosheng@tsinghua.edu.cn)

²Lecturer, Department of Hydraulic Engineering,
Tsinghua University, Beijing 10084, China
(Tel: +86-10-62795132, Fax: +86-10-62772463, e-mail: xiajq@tsinghua.edu.cn)

The Sanmenxia Dam, located on the lower part of the middle reach of the Yellow River in China, is notorious for its sedimentation problems in both upstream and downstream reaches. Since the impoundment of water commenced in September 1960, the dam has been reconstructed and dam operation has been changed in order to stop the upstream extension of backwater sediment deposition. Reconstruction of outlet structures has significantly increased the discharge capacity, providing the dam with the necessary facility for avoiding significant detention of flood water which is important for maintaining sediment balance across the impounded reach in the reservoir. On top of this, the operation scheme was changed to controlled release beginning in November 1974, meaning that relatively clear water is stored during the non-flood season (November-June) and muddy water is disposed during the flood season (July - October). In the period since November 1974, the reservoir has operated at a high water level in non-flood seasons, and at a low storage level during flood seasons, and all the outlets are opened in times of flood peaks to sluice as much sediment as possible.

As shown in Fig. 1, the elevation of Tongguan (flow stage corresponding to a discharge of $1,000\text{m}^3/\text{s}$, which is an indication of the upstream extension of the delta) remained almost constant from 1974 to 1985, indicating that in general a sediment balance was achieved during this time period. However, after 1986 the elevation of Tongguan started to rise again in response to the reduction of flow runoff and the change of flow pattern. This exacerbated the channel bed aggradation and flooding hazard in the lower Wei River, a tributary immediately upstream of Tongguan.

Debates on adjustments of the reservoir's operation level have continued for several years. Some experts have proposed that the power generation function of the Sanmenxia Dam should be abandoned and the sluices should be open year-round so as to reduce the channel bed elevation at Tongguan. Some others have responded by suggesting that the channel bed rising at Tongguan was not caused solely by the operating mode of Sanmenxia Dam in the past years and that it was closely related to the reduction in flow runoff. So even if the Sanmenxia Dam was decommissioned, it is not certain that the channel bed rising at Tongguan would be solved (Li, 2003; Wu and Wang, 2004; Wu et al., 2004).

The purpose of this paper is to study the complex sedimentation processes in Sanmenxia Reservoir with attention given to the consequences of upstream extension of delta deposition and to discuss possible sediment management alternatives to lower the channel bed at Tongguan. The analysis presented in this paper has reached the following conclusions:

(1) The controlled release that stores relatively clear water during the non-flood season and disposes muddy water during the flood season is still a generally valid concept for dam

operation. However, the operation level used in the controlled release period determined based on earlier inflow conditions is no longer compatible with the changed inflow conditions, requiring that the reservoir's operation scheme that has been in use since 1974 be adjusted to properly regulate the water and sediment in order to maintain balanced deposition in the reservoir area in response to the reduced flow runoff and changed flow pattern.

(2) In the non-flood season, the critical pool level that affects the rise in the elevation of Tongguan as well as the channel aggradation near Tongguan is 315 m. When the pool level was greater than 315 m, the speed of channel aggradation near Tongguan became faster. Therefore, it has been suggested that the operational pool level in the non-flood season should not be higher than 315 m. In the flood season, increasing the flow runoff and lowering the pool level are necessary to enhance both the streamwise and headward erosion.

(3) The objective of adjustment of dam operation is to prevent upstream extension of backwater deposition, or alternatively to lower the elevation of Tongguan and to maintain it at a relatively low elevation. At the same time, appropriate consideration should be given to the newly formed ecological system in the reservoir area below Tongguan in the past 40 years' dam operation and the benefit of hydropower generation. Besides the adjustment of the pool level, other countermeasures need to be thoroughly investigated, such as river training in the river reaches upstream and downstream of the backwater zone, dredging the channel in the vicinity of the backwater zone, strengthening soil conservation practices in the loess plateau areas, and building sediment detention reservoirs on river reaches above the Sanmenxia Dam.

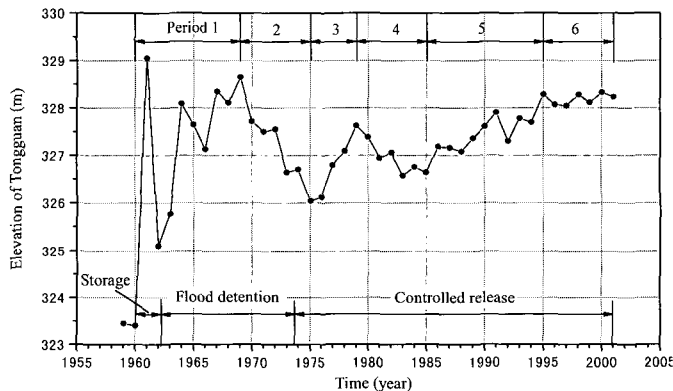


Fig. 1 Variation of the elevation of Tongguan(flow stage corresponding to a discharge of $1,000 \text{ m}^3/\text{s}$ at Tongguan station)

REFERENCES

- Li, G.Y. (2003), "Ponderation and Practice of the Yellow River Control," Yellow River Conservancy Press, Zhengzhou, China.
- Wu, B.S. and Wang, Z.Y. (2004). "Impacts of Sanmenxia Dam and Management Strategies," Proceedings of the International Conference on Hydraulics of Dams and River Structures, Tehran, Iran, pp. 213-227.
- Wu, B.S., Wang, G.W., Wang, Z.Y., and Xia, J.Q. (2004). "Effect of Changes in Flow Runoff on the Elevation of Tongguan in Sanmenxia Reservoir", Chinese Science Bulletin, 49(15), 1658-1664.