River groynes for the future

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Abstract
The Island Groyne contains significant improvements in terms of quality of the fairway (mainly through minimising depth limitations and improving the flow conveyance), ecological connectivity and potential (in line with the EU Habitats Directive and Water Framework Directive), quality of landscape and the perception of groynes in it, sustainability, and morphological stability of the river. It is also possible to effectively reverse on-going bed degradation. The morphological improvements result in a significant reduction in the amount of maintenance dredging required, as well as structural maintenance (outflanking), which makes innovative groynes economically attractive.

Background
In the Netherlands, since 1830, river groynes have been needed to fix the fairway in the river bed and to improve the (safe) discharge of ice. These conventional groynes have proven to be reasonably effective up until today. However, the current context of the river groyne has changed significantly and their performance must now be considered in a modern and far more complex context. This contemporary context comprises contradictory demands, such as reduction of peak water levels and improvement of the fairway in terms of navigability. Additionally, it is considered necessary to restore and improve ecological values, spatial quality and to reverse the ongoing bed degradation of the river caused primarily through river normalisation and training.
These modern demands have given rise to reconsideration of the current river groynes and harmonisation of river hydraulics and morphology. As the responsible authority for navigation and flood safety on the main rivers in the Netherlands, Rijkswaterstaat, in association with CUR, organised the design competition “Groynes for the Future”: the 21th century demands were to be united in an innovative groyne design (CUR, 2006). This paper briefly reviews a prize-winning design of this competition: the Island Groyne. For a detailed description of an environmental assessment and a cost-benefit analysis reference is made to Van Heereveld et al. (2006).

Figure 1. Artist impression of the Island Groyne.

The Island Groyne
The Island Groyne (Fig. 1) consists of an opening made in the existing groyne and a lengthened groyne head in the direction of flow (the Island). The opening is about 60 m^2 and is constructed near the groyne head where flow intensity is greatest. The opening is submerged for about 300 days per year and allows for a reduction in peak water level of about 7 cm. A larger opening would be more difficult to compensate in terms of negative effects on the fairway quality and compromise the optimum balance between reduction of peak water levels, fairway improvement, ecology, quality of landscape and reversing the on-going bed degradation. This practical limitation also implies that a significant part of the existing groynes can remain intact which is not only favourable for ecology and quality of landscape but also for sustainability and cost. Moreover, since the opening is made near the groyne head, current attack is diverted from the river bank improving bank stability, fairway morphology and the need for maintenance on the groynes themselves (mainly outflanking and removal of vegetation).
In case of the conventional groynes, sediment is deposited in the groyne fields during periods that groynes are submerged, while ship-induced water motion is the primary driver for sediments eroding from the groyne fields during low water season (emerged state). The opening in the Island Groyne results in a more gradual flow distribution from the main channel to the river bank. The resulting sheltering effect will decrease the amount of sediment

exchange between groyne field and fairway so that more sediment can be held in the groyne fields. Hence, sediment load on the fairway is limited during low water season as well as the local shortage of water depth due to temporal bed changes in the fairway.
The Island further enhances the sheltering effect of the opening on the conditions in the groyne fields and also lowers (ship-)wave intensity. The visibility and navigability improves because the river is better defined when seen from the bridge of a vessel. Also, the Island can be fitted with two rather than one radar beacon as a further improvement of the fairway.
The primary reason for lengthening the groyne head is to limit the amount of constriction scour and the downstream deposit of eroded material, which is important for depth limitation in the fairway. Altogether, the current amount of maintenance dredging required to keep the fairway navigable (usually during emerged state) is significant, but will be minimised through the Island, and effectively compensate the increasing flow area on the quality of the fairway. Over-compensation is also possible so that bed degradation may be stopped.

Exciting ecological improvements

The opening in the groyne and the shelter created in the groyne fields offers opportunities for improving ecological development. An increase in number and diversity of species is expected. Migration of species is also improved as the lower flow velocities in the opening are easily negotiated as opposed to the higher flow velocities around the groyne head and in the main channel in the existing situation. The sheltering also offers a more gradual transition from main channel to land, which is important for the quality of landscape and the way the landscape is perceived. By keeping the existing groynes intact and using familiar materials to construct the new parts, the cultural heritage that the groynes represent in the Dutch river landscape is justified. Yet, the Island Groyne bears a clear 21st century signature.

Meeting cost-effective high standards

In terms of cost, the Island Groyne is competitive because use is made of the existing river training structures, doing justice to the capital it represents. Taking into account the lower cost of maintenance of the fairway and the groyne itself, the Island Groyne is even more competitive and sustainable than other types of groynes which do not comprise the optimum benefits of the Island Groyne.

Conclusions

With the Island Groyne, it is possible to establish peak water level reduction without consequences for the quality of the fairway. Moreover, improvement is possible, including the reversal of the on-going bed degradation. The design of the Island Groyne is robust and flexible: its performance under current and future conditions is easy to maintain, adding to the designs sustainability.

References

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