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Abstract: The effect of placing obstructions of similar size but different shapes and at different locations on a floodplain adjacent to a meandering channel is considered. The results from the laboratory model tests show that placing a solid obstruction along some parts of a bend has a more significant effect on the upstream and downstream water levels than at other locations. The average increase in water level upstream from the obstructions is compared with the obstruction length and percentage blockage. One result using a permeable obstruction is presented and a 15% reduction in upstream water level is observed compared with a solid obstruction of the same length. The results suggest that maintenance of vegetation is more critical in some areas than in others.

Keywords: flood plain obstructions

1 INTRODUCTION

Rivers engineers now face the challenging problem of maintaining bio-diversity and the ecological value of natural regions of floodplains whilst providing a clear passage for floodwaters to minimise damage as a result of flooding. This careful balance leaves the engineer somewhat juggling the various components in order to satisfy all the criteria all the time. Flood plain management strategies recommend that vegetation be retained on one bank whilst removed from the opposite bank in order to preserve natural habitats whilst keeping the floodplain functional. Retaining vegetation also directly protects banks from erosion by reducing near-bank shear stresses and flow can be deflected by larger vegetation and woody debris. Usually larger vegetation such as shrubs and trees are found in the floodplains adjacent to the main channel and have a major influence on the flow depth and situations such as over-bank flooding, Rahmeyer et al. (1996).

Recent work on compound channels has provided information on the interaction between the main channel and floodplain and further work has been conducted on compound meandering channels. This research has revealed that some parts of the floodplain have a larger conveyance than others and could be designated as more critical to flood relief schemes. It may therefore be possible for some regions of the floodplain to remain as natural habitats whilst more critical areas are kept substantially free from vegetation in order to rapidly convey floodwaters.

Research into the performance of rigid and flexible vegetation on flood plains has in the past concentrated on modelling specific species. Dalton, Smith and Truong (1995) studied the hydraulic characteristics of Vetiver hedging with the purpose of defining minimum hedge spacing to control local soil erosion on flood plains. Klassen and Zwaard (1973) investigated the roughness of hedges and orchards on flood plains and their measurements confirmed that the presence and spacing of vegetation significantly increases the Chezy roughness coefficient and water levels on flood plains.

The effects of obstructing one side of a riverbank on a meandering compound channel is influenced not only by the length of the obstruction but also on the position of the obstruction along the meander length and its position on the side of the bank onto which the obstruction is placed. Work has been conducted at the University of Hertfordshire to determine the effects of obstructions of approximately equal length being placed at different locations on the floodplain of a meandering channel. The results presented here are mainly for solid structures but include initial results using permeable material for comparison, and this is the subject of ongoing experimental work.

2 EXPERIMENTAL METHODOLOGY

The experimental work was carried out using a flume set to a longitudinal slope of 0.0018, containing a meandering main channel of sinuosity 1.3 within a floodplain limited to the width of the meander belt, see figures 1 & 2. The main channel centre line radius to width ratio was 1.8, and further details of this laboratory arrangement are given by Marriott (1998, 1999). The floodplain surface was constructed of varnished marine plywood, with Manning's n value of approximately 0.010. A more detailed calibration of the material employed is contained in Marriott and Day (2000).

A tail weir was set at the downstream end of the flume, and the flow was adjusted to achieve uniform flow at normal depth, by bracketing between measured profiles of M1 backwater and M2 drawdown curves. Once established for the case with no obstructions, the same flow rate and tail weir settings were used with obstructions placed in the channel, as indicated in figure 2. Water levels were measured by vernier point gauge at various locations for comparison. Details of the obstructions used can be found in table 1.

Table 1 Detail of tests

Blockage reference	Length (mm)	Length perpendicular to flow (mm)	% blockage	Material
0	0	0	0	Concrete
1	690	690	68	Concrete
2	806	237	23	Concrete
3	819	453	45	Concrete
4	819	453	45	Concrete
5	690	690	-	Horsehair

3 RESULTS

Different obstructions result in different water surface levels along the flood plain. An obstruction placed at location 1 has the most significant effect as may be expected since this completely obstructs the full width of the floodplain and results in all the flow being forced to pass through the main channel. This causes a significant rise in water level at locations A and C and on the outside of the bend at section E whilst the inside of the bend shows the water drawn down. A much lower water level is then observed on the floodplain at section G where the flow was observed to be supercritical on the floodplain, with a full recovery seen by section I and the water surface at the same level as without the obstruction.

Placing the same curved blockage at locations 3 and 4 leads to different results. A slightly higher water level was observed across section A with the obstruction placed at 4 than at 3 but with a much smaller increase in stage than for the first case. This effect was repeated at section C. The highest stage recorded at section E was for obstruction 4 with 3 giving a slightly lower stage on the floodplain whilst slightly higher in the main channel. The change in water level was not recorded at section E for obstruction 1 since this is the location of obstruction 1. Again at section I the surface levels have recovered to the no obstruction case although a slightly lower depth was recorded in the main channel for obstruction 3.

Obstruction 2 is a curved obstruction that is placed on the inside section of the bend at location E. Flow could continue in both the main channel and in the section behind the obstruction and this obstruction caused the smallest effect. The measured water level at all sections is similar to that for the no obstruction case with the exception of section E where a small effect was observed. On the floodplain, behind the obstruction a small decrease in the surface level was noted, and similarly in the main channel.

4 DISCUSSION

The results for the different blockages and locations have been compared for sections A and C, upstream of the position of the obstructions with the results from section C shown here. Figure 3 shows blockage length versus percentage change in water surface level. Considering blockage length, it can be seen that similar lengths of blockage lead to similar, but not identical changes in stage depending on location in the channel. If the projected length perpendicular to the flow is considered as opposed to actual blockage length then some correlation can be seen, as shown in figure 4. The results with the largest blockage perpendicular to the flow leads to the largest increase in flow depth at location G whilst the smallest blockage length perpendicular to the flow results in the smallest increase in flow depth. However some disparity in the results remains as a result of position in the channel. Moving the same blockage from section 3 to section 4 halved the increase in water level at section G.

Test 5 was conducted using a permeable blockage. The material used was horsehair matting, often used for flow straightening purposes. This test was considered more representative of vegetative obstructions on flood plains. A section through the material is shown in figure 5. The material is mainly voids and has a very high porosity, >99%. Comparing the solid and the permeable blockages of the same length the water level at both section A and C reduced by 15.5% with the permeable obstruction. Taking the section of the material shown in figure 5 and enlarging in order to count the pixels along a vertical and a horizontal line 87.5% of the pixels were shaded, indicating some degree of blockage and 12.5% white. Assuming that 87.5% of the material is solid gives a length of 604mm as the equivalent solid length leading to 60% of the channel being blocked. This value is also shown in figure 4 and it can be seen that reducing the length to an equivalent solid length maps the result back close to the expected position. This could indicate that this technique might be useful in the future for quantifying head loss at obstructions by considering the passage of light through the material. A method of calibrating flow resistance to vegetative density is being developed at the University of Hertfordshire that may assist in quantifying the effects of floodplain vegetation.

5 CONCLUSIONS

Based on the results from these current tests two main conclusions can be drawn:

(1) That the magnitude of the effect on water levels of obstructing flood plain flow depends strongly on the location of the obstruction within the meander belt. Consequently care should be taken when planning and managing the development of vegetation on floodplains to ensure that vegetation is located in areas likely to have minimal impact on water levels.

(2) A method of measuring the density of permeable obstructions has been reported and results indicate that this method may have some advantages when comparing these with solid objects. In particular this may enable permeable obstructions such as hedges of various thicknesses to be analysed in a consistent manner with other forms of flow blockage. This technique warrants further investigation with a greater variety of materials and densities.

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Figs 1-4 unavailable

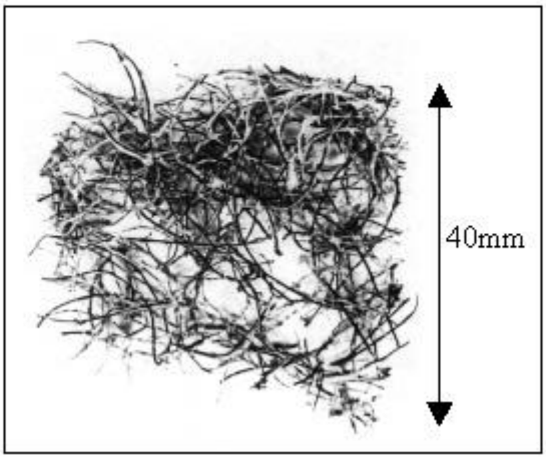

Fig.5 Section of horsehair matting