An attempt to classify malfunctions of steep channel flows justifying building of open check dams or other torrent control works

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An attempt to classify malfunctions of steep channel flows justifying building of open check dams or other torrent control works

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ABSTRACT
Open check dams are widely used in mountainous regions as structures for flood hazard mitigation. They can have diverse shapes enabling to serve various purposes. If ill-design or not perfectly tailored to the catchment flow processes and hazard sources, they sometimes result in excessive downstream sediment starving, too high dredging costs or functional failures. The adjustment of the protection system to the catchment is thus a key step in any natural hazard mitigation study. This extended abstract is a first attempt to propose a classification of the typical malfunctions occurring in steep stream channels. These malfunctions are briefly described and contexts where an open check dams may be a solution are highlighted as well as other protection options.

1 TORRENTIAL HAZARDS AND MITIGATION

Designing protection systems in mountain catchments is complex because several quite different malfunctions may result in flooding and massive depositions. In other words, they are several causes to the symptoms of fan flooding. Alluvial fans regularly experience flood hazards with massive sediment deposits and / or large wood jams. The river channel would have the capacity to convey the water discharge if it would be pure water. The additional solid inputs can however create multiple troubles triggering and / or aggravating flood problems.

Torrent control works seek to mitigate such adverse phenomena. Thousands of catchments are thus equipped with protection systems composed of embankments, bank protections, check dams and open check dams. Open check dams can specifically be designed to optimize a given function. Austrian standards for instance stress that four typical functions can be achieved with open check dams [1]:

(1) *Retention structures* aims at trapping a given sediment volume. They are not supposed to self-clean or only marginally.

(2) *Dosing structures* aims at trapping sediment during high transport stages and later at self-cleaning to simply buffer sediment transport peak discharges.

(3) *Filtering structures* are usually dedicated to trap large woods pieces.

(4) *Debris flow breakers* are regularly designed to trap boulders of granular debris flows fronts.

Design criteria to determine opening sizes, deposition processes and managing large wood troubles have been recently reviewed [2,3] but engineers still need guidelines to help determining which kind of structure is adapted to each case-study. We present here a first attempt to a classification of the typical malfunctions occurring in steep stream channels (Figure 1).

2 FOUR CHANNEL FLOW MALFUNCTIONS

In debris flow-prone torrents, large boulders are regularly transported. If the channel is steep and deep enough and the downstream confluence able to buffer the whole debris flow volume, it should be entirely conveyed until the river. However, bridges or ill-design narrow and mild channel sections regularly experience boulder jamming. The boulder accumulation then dams the torrent and trigger channel filling and avulsion (Fig. 1a). In such cases, the protection system should merely seek to remove boulders from the flows using debris flow breakers or steep and wide channelized areas enabling the debris flow front to spread by a lack of confinement.

Large wood pieces must be removed with filtering open check dams upstream of sections with structures prone to large wood jams as bridge with piles (Fig. 1b) and small freeboard.

If the flow discharge overpasses the channel capacity, bank overtopping occurs. It may result in lateral levees deposition, avulsion or loss of water discharge increasing deposition trends (Fig. 1c). In such cases solid transport regulation should be sought using dosing open check dams or large and long alluvial reaches buffering sediment. Alternatively, channel capacity may be enhanced with embankments.

Massive sediment deposition may also occur due to an excess of total volume, for instance because of a low buffering capacity of the river confluence. In such cases, all or part of the sediment volume must be trapped and removed from the stream. It can be done with a retention dam and on the long term by erosion control with reforestation and check dams.

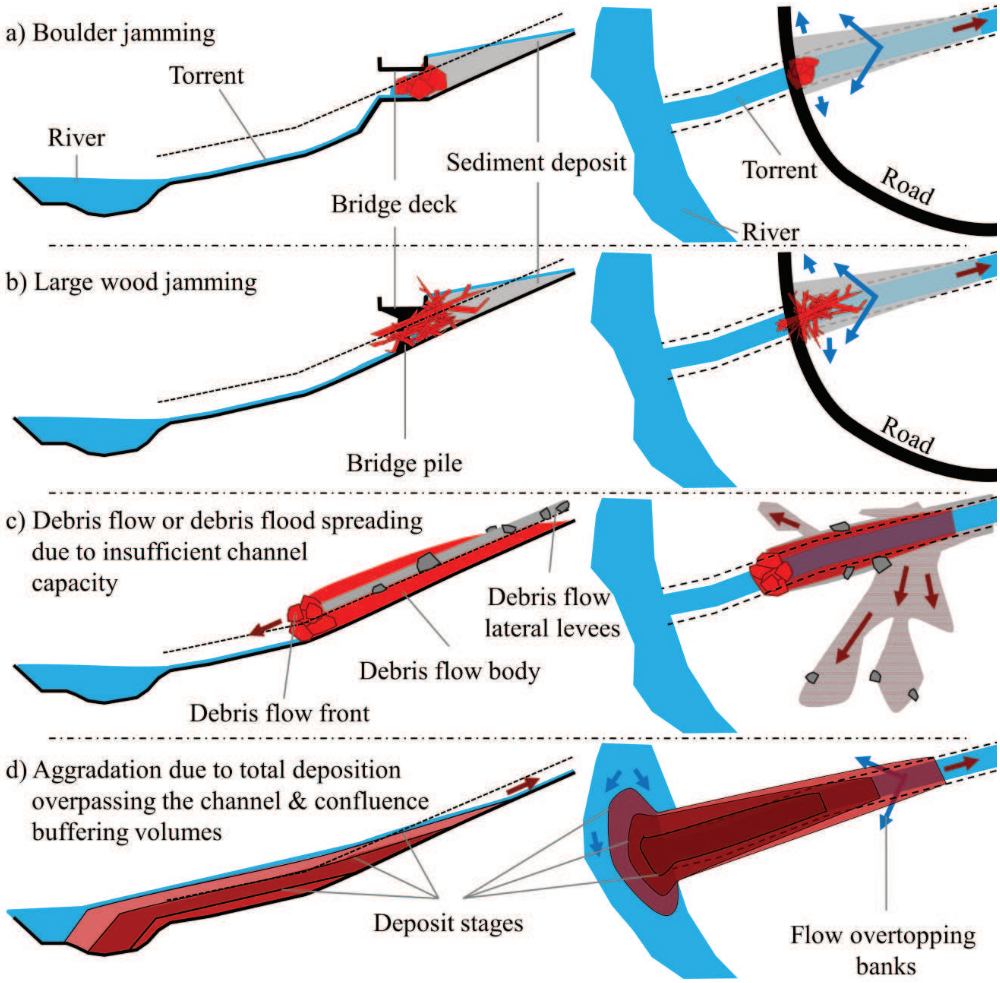

Figure 1. Longitudinal and plan views of the four typical malfunctions occurring during sediment-laden floods and resulting in massive sediment depositions and fan flooding; The triggering process is colored in red: (a) **Boulder** jamming: accumulation in a bottle-neck section resulting in channel obstruction, upstream deposition and bank overtopping. (b) **Large wood** jamming against a bridge or any other narrow section, same consequences than the boulder jamming. (c) Debris flow or debris flood spreading, **excessive solid transport** overpassing the channel capacity to convey the total discharge. Lateral muddy, boulder and gravel levees formation, local avulsion at bank overtopping. Deposition processes mostly propagate downward. (d) Upward propagating deposit resulting from an **excess in total volume of sediment** compared to the buffering capacity of the stream – river confluence: massive deposition progressively filling the channel by aggradation, backfilling propagating mostly upward.

3 ACKNOWLEDGEMENT

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