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# DEBRIS FLOWS: Disasters, Risk, Forecast, Protection

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# The theory of the Chain of Functions in debris flow control

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# Контроль селей с помощью цепи функций: теория

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In debris flow control you have two principles, active and passive countermeasures. The passive measures are mainly land-use planning i.e. keeping the endangered areas free of settlements and infrastructure to prevent economic damages. Active countermeasures start at the debris flow source area and are continued through the debris flow course down to the apex and the debris flow fan. These countermeasures cover various functions and their associated structures. From top to bottom, from the debris flow source to the debris flow fan, the functions are chained. That means that each part and respective area of influence of a debris flow can be dealt with by a specific control function and therefore by a specific structure. The first functions to prevent the development of debris flow are afforestation and revegetation to fix the debris source and discharge. In the debris flow middle course we have to deal with stabilising the soil and influencing the energy balance of debris flows. This is done by debris flow breaking either at the debris flow middle course or the apex. The functional chain ends at the debris flow fan with trapping the debris flow mass and their sedimentation. This is the final levelling down of the energy line of the debris flow. All these functions are covered with specific functional types of structures, the chain of functional debris flow control countermeasures.

В контроле селей имеются два принципа: активные и пассивные контрмеры. Пассивные меры - главным образом планирование использования земли, держащее подвергнутые опасности области, свободные от урегулирований и инфраструктуры, чтобы предотвратить экономические убытки. Активные контрмеры начинаются в селевом очаге и далее следуют вдоль русла до селевого конуса. Все функции взаимоувязаны. Это означает, что в каждой зоне досягаемости селя можно иметь дело с определенной функцией контроля. Первая функция, которая предотвращает развитие селя в очаге – лесонасаждение для стабилизации очага и сокращения твердого стока из него. В средней части селевого бассейна осуществляется укрепление берегов и воздействие на баланс энергии селевых потоков. Это проводится путем гашения селевого потока. Цепь функций заканчивается на селевом конусе устройством ловушек для аккумуляции селевой массы. Это – финальная зона, где происходит гашение энергии селевого потока. Все эти функции покрыты определенными функциональными типами структур – цепью функциональных контрмер по контролю селевого потока.

## *1 Introduction*

In the last decenniums of the past century the Austrian Service for Torrent and Avalanche Control Engineering developed new techniques in Torrent – Debris Flow – Landslide – and Flood Control. All these techniques are based on an Environmental Analysis of the belonging watershed. Depending on the state of the catchments and the conditions of the watershed you have to develop the aim of the control system respectively management and as the

next step the basic idea of systematic control and management. In debris flow control we distinguish active control and passive control. Debris flow management can be subdivided into debris flow prevention and debris flow control. Active controls are measures like Structural (Technical) Measures. Passive controls are Landscape Management, Forest Management and Hazard & Risk Mapping.

The master planning of structural countermeasures against debris flow is developed on the basis of debris flow management. Runoff Control, Discharge Control and last but not least Watershed Management are corresponding debris flow prevention. The master planning procedure should always be in a systematical way. The master planning of structures of debris flow countermeasures is the same step to step development like the planning procedure in torrent control (Fiebiger, 1992). Step 1 the Environmental Analysis of the debris flowing watershed ecosystem leads to step 2 Debris Flow Management. At step 3 our decision will be Debris Flow Control. Step 4 let us develop the countermeasures as the basic idea of the system. The master planning of structures of debris flow countermeasures are in general the planning of energy dissipater (structures of energy reduction), dam systems (debris flow training) and single training structures for local control. Energy dissipaters are debris flow breaker, debris flow screens rakes grids and grills, debris flow traps, woody debris traps, woody debris filters, deposit settling and sedimentation basins and structures with a combination of functions. Dam Systems are known as systems of debris flow structures, functional dams (retention and other functions), steel-grid dams and stabilizing systems. Training systems are dykes and channels and alignment dykes.

## *2 The Chain of Functions in Systematic Debris Flow Control*

The functions we will discuss as structures of the chain of functions and base for the deduced control measures are shortly shown on the principles of bedload management (Fiebiger 1988). If we follow them from top to bottom we are talking of the chain of functions, which is necessary to equalize the natural processes and if we put these functions in a systematic control to reach the desired effects we are speaking of the chain of effects or stronger of the chain of impacts.

These functions are:

| | |
|---|---|
| STABILIZING: | Fixation of debris flow channels in a wanted level to stop and/or prevent depth erosion. The main goal of debris flow control is stabilization of the debris flow bed to prevent further hazards and damages. |
| CONSOLIDATING: | Elevating of debris flow bed to support and/or prevent debris sources and gliding/creeping slopes and therefore lateral erosion. Bank Stabilisation. |
| RETAINING: | Storage and deposition of bedload transport or a debris flow until it's aggradations up to the retention capacity. |
| SORTING & SIZING: | Filtrations and/or storage of undesirable bedload components during a debris flow or a hazardous bedload transport. |
| Bedload Sizing: | Filtration and storage the large pieces of bedload during bedload transport or a debris flow. |
| Wood Grading (Filtering) | Filtration of undesirable wood during woody debris transport or a debris flow. |
| BREAKING OF DEBRIS FLOW: | Decrease the high energy level of a debris flow to a lower level under particular energy exchange. |
| DOSING: | Parting of a large mass of bedload transport or of a debris flow in small amounts (Kettl, 1984) |
| Bedload Dosing: | Quantitatively dosing and discharging of intermediate stored debris flow and bedload by declining floods and mean waters (Ueblagger, 1972) |
| Flood (Water) dosing | Quantitative change of the water discharge by qualitative change of the flood hydrograph at a specific site (Kettl, 1972) |

The dosing of bedload disasters and debris flows depends on the water bedload ratio of debris flow and related disasters and their grading. Therefore needs the constructions of debris

flow-dosing dams and of bedload-dosing dams a well founded planning and research and if possible model experiments.

Water dosing dams allow us to control the medium of origin and transport of debris flow. Therefore the requirement is the existence of enough voluminous reservoirs in front of the erosion track. These types of construction are the quintessence of debris flow management, because by making the medium of transport and it's dosing to a harmless bulk the transport medium (debris flow and bedload) goes secondary importance.

*3 Functions and their related measures (Huebl & Fiebiger 2005)*

The usual functional dam-types like sills, bed-sills, consolidation-, retention-dams and deposit-dams, which are defined also as bedload-strengthening structures as well as bedload storages structures (Leys, 1973) will be not be discussed. These dams are not new developments and the state of the art can be granted. Only some new types of functional dams will be discussed without demand for completeness (Fiebiger, 1984).

DOSING-DAMS: the function (dosing) described previously can be filled only under following prerequisites. The bed-forming mean discharge must be able to flow through the dam as unhindered as possible.

Bedload Dosing-Dam: During a flood the bedload mass must be reduced and an intermediate storage must be possible. Theoretically, the entire grain-distribution is handed over again by mean discharge and small floods into the lower course after temporary bedload storage and temporary deposition.

Flood Dosing-Dam: The main condition for this structure is the exist of enough storage capacity to store the difference between incoming flood and reduced outgoing discharge. This demand is the reason that flood doing-dams cannot be planned and constructed very often. The existing storage capacities are usually too small and are not able to store the necessary flood charge.

SORTING (SIZING) – DAMS: The desirable sorting effect will be only reached under the condition of enough storage capacity and enough amount of discharge for spilling after the disaster event, flood or debris flow or bedload disaster (Stauder, 1972a; Stauder, 1972b).

Bedload Sizing (Sorting)-Dam: The large destructive components of the bedload must be sedimented in the backwater of the storage basins root and the sorting–openings should not be locked by woody debris. The storage capacity of the sorting (sizing)-dam should be equal to the torrents disaster potency.

WOODY DEBRIS RAKES (Gratings, Grills, Filter): These dams have to fulfil the function of grading the woody debris out of the discharge. The bedload transport should continue however preferably unhindered. In function-combined dams in torrents with a large amount of woody debris to prevent the locking of the opening a woody debris grill must be constructed to protect the function of the openings. As appears from the experience, inclined gratings and grills are preferred to the vertical beam-fields. Newer developments showed that crestfallen grills promote the rolling up of woody debris during the starting event.

DEBRIS FLOW BREAKERS: The desirable function, energy dissipation during a debris flow, can be reached on two ways. The first is to carry out a massive construction. The second is the combination with a sorting-dam considering decreasing the impact-energy at the structure. The regular structure used for a debris flow breaker is the second way.

COMBINED BI (MULTI) FUNCTIONAL DAMS: In accordance with the possibilities of the combinations of functions, bifunctional or multifunctional structures are developed. The most frequent types are the combination of consolidation and sizing-dam, consolidation & dosing-dam, sizing-dam with woody debris filter, sizing-dam and debris flow breaker. The constructions of bi(multi)functional dams are in future certainly increasing. The increase is promoted by high economic value.

*4 Debris Flow Control by the Chain of Functions*

Debris flow Control stands in the chain of functions of torrent control on the top of the systematic control together with landslide control afforestation reforestation and runoff control. On the other side there is landslide control for itself independent (Marui, 1988) and not influenced by torrent or streams. Such landslides can influence debris flows and torrents seriously. In systematic debris flow control (SDBC) you have two principles, active and passive

measures. The passive measures are mainly land-use planning keeping the endangered areas free of settlements and infrastructure to prevent economic damages. Active measures start at the debris flow origin and source and are continued through the reaches of debris flow development down to the middle course at the end to the debris flow cone the zone of deposition. The measures cover various functions and their belonging structures. The functions are like in systematic torrent and/or avalanche control chained.

Preventive works partially or completely stops debris flow origin using structures. The first functional countermeasures to prevent the origin of a debris flow are afforestation and revegetation to fix the debris flow source and drainage the areas around the main debris source and control the displacing and displaced debris, to check and to take away the transporting medium (water) from and out of the debris flow source.

The Chain of Functions carries out the sequence of functions to influence the energy balance of debris flow and leads to the Chain of Functional Structures and the Systematic Debris Flow Control (SDFC).

In principal, if the debris flow occurs frequently, preventive measures are not effective and their installations are difficult. Control measures such as drainage and the stabilization of debris sources should be implemented beforehand. After the systematic control of the debris flow and the levelling down of energy and frequency, preventive measures and implementations could start.

*References*

Kettl W. Sorting-dams in the Pongau: theories and experience. – WLV, Vol. 37, No. 1, 1972, p. 15–23. (German).

Leys E. Suggestions for a systematic view to dams and longitudinal structures used in torrent control. – WLV, Vol. 37, No. 2, 1973, p. 43–60.

Stauder S. Different constructions of beam-dams in: colloquium on torrent-dams Mitt. D. FBV Vienna. Vol. 102, 1972 a, p. 335 – 372. Agrarian-publishing house Vienna 1973 (German).

Stauder S. Beam-dams in the Ziller-valley. – WLV, Vol. 36, No. 1, 1972 b, p. 1–45 (German).

Ueblagger G. Retaining, dosing and sorting. – Colloquium on torrent-dams. 1972. Mitt. D. FBVA Vienna. Vol. 102. Vienna: Agrarian-publishing house, 1973, p. 335–372 (German).

Fiebiger G. Functional structures of torrent control on the base of bedload management. – Proceedings INTERPRAEVENT, 1984, Vol. 1, p. 123–134. Research Society for Flood Prevention INTERPRAEVENT; Villach 1984 (German).

Kettl W. Techniken der Wasser- und Geschiebebewirtschaftung als Beitrag zur Stabilisierung von Ökosystemen, Wildbach- und Lawinenverbauung. – Jg. 58, 1984, H. 126, S. 41 – 45. (German).

Fiebiger G. Bedload management in torrent control by functional check dams. – Contributions to the research in erosion, torrent and avalanches. Mitt. D. FBVA Vienna volume 159; p. 325–331; Agrarian-publishing house Vienna 1988 (German).

Marui H. Landslide prevention measures. – FAO watershed management field manual. FAO conservation guide 13/4. Rome: Food and Agriculture Organisation of the United Nations, 1988.

Fiebiger G. The planning procedure in Torrent Control under special regard of the development of the basic ideas of their Master Plans. – International Symposium INTERPRAEVENT, 1992, Vol.6, p. 377–406; Research Society for Flood Prevention INTERPRAEVENT; Villach 1992 (also in German and Japanese).

Huebl J., Fiebiger G. Debris-flow mitigation measures. – Chapter 18 in: Jakob M, Hungr O. (eds): Debris-flow Hazards and Related Phenomena. Berlin, Heidelberg, New York: Springer Praxis Books in Geophysical Sciences, 2005, p. 445–487.