Standardized stress model for design of torrential barriers under impact by debris flow (according to Austrian Standard Regulation 24801)

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STANDARDIZATION FOR DESIGN OF TORRENTIAL BARRIERS

Torrential barriers with energy-dissipating, filtering or deflecting function for debris flow are subject to extreme dynamic stress that presupposes the application of high safety standards for design, construction and maintenance. The newly issued Austrian Standard ONR 24801 provides a standardized model for the design of torrential barriers under debris flow impact, which has been developed from comparative calculation of common debris flow models from engineering practice in torrent control and calibrated by impact measurements of debris flow events. The model is based on a combined static-dynamic stress approach and also takes into account the impulse by a single object (block, tree trunk).

The ONR 24801 is the last part of a newly issued series of Austrian Standards concerning technical torrent, avalanche and rock-fall protection works. Since 2008 the following standards concerning torrent control works were published:

- Protection works for torrent control - Terms and their definitions as well as classification, ONR 24800:2009 02 15
- Protection works for torrent control - Static and dynamic actions on structures, ONR 24801:2013 08 15
- Protection works for torrent control - Design of structures, ONR 24802:2011 01 01
- Protection works for torrent control - Operation, monitoring, maintenance, ONR 24803:2008 02 01

STRESS MODEL FOR CHANNEL PROCESSES RELATED TO DEBRIS FLOW

For the schematic assessment of impact by channel processes on structures, a process model and a stress model are combined at a characteristic interface (Fig. 1). The process model simulates the behavior of a debris flow process according to its physical properties. At the interface characteristic parameters of the debris flow process (e.g. energy, density, flow height, flow velocity) are transferred to the impact model, which simulates the interaction of the process with the structure and comprises the representative stress (areal or single load) and the related load distribution.

Fig. 1 Combination of process model and stress model for the design of torrential barriers for the impact of debris flow (including impact of large single components) (according to ONR 24801)
The standardized stress model in ONR 24801 combines the static and dynamic load by debris flow impact on the structure. The flow stress results from the translation of debris material with specific components of water, fine and coarse sediments. For this model it is supposed that the highest impact energy results from the initial contact of the debris flow with the barrier structure. Alluvial sediments behind the barrier act depressant on the process and reduce the impact pressure on the structure. The model covers all soil and water pressure resulting from the debris flow.

For the calculation of impacts forces on the barrier a superposition of a static ($F_{st}$) and dynamic ($F_{dyn}$) load proportion is used.

$$F_{st} = 0.5 \cdot \rho_{M} \cdot g \cdot A_{st}$$

(1)

$$F_{dyn} = \rho_{M} \cdot A_{Qdyn} \cdot v^2$$

(2)

The static impact force is calculated analogously to water pressure (with debris flow density $\rho_{M}$) and acts upon the barriers as a triangular load distribution over the total construction height and dynamic width of debris flow $b_{dyn}$ (= static impact area $A_{st}$). The impact force of the dynamic component is calculated according to the law of impetus and acts as a uniformly distributed load (= dynamic impact area $A_{dyn}$). ($g$ is the acceleration due to gravity, $v$ is the average flow velocity of the debris flow.)

The impact area of the dynamic component $A_{dyn}$ is derived from a characteristic discharge area of debris flow ($A_{QM}$) corresponding to the design event, which is found at a characteristic cross-section up-water of the barrier. According to ONR 24801, for Alpine regions the flow depths $h_f$ at this cross-section is assumed with 4 m. The dynamic impact area $A_{dyn}$ is a rectangle equal to $A_{QM}$ and is assumed to be situated directly below the discharge cross section of the barrier central at the river axis. The height of the impact area $h_{dyn}$ is assumed between 2 and 4 m, dependent on the type of debris flow (mudflow or stony debris flow). The dynamic width of the debris flow $b_{dyn}$ is calculated from division of $A_{dyn}$ by $h_{dyn}$.

Other soil pressure on the barriers (outside of the dynamic width of the debris flow $b_{dyn}$) has to be calculated according to the relevant national geotechnical standards.

| Channel process<sup>a</sup> | Debris flood (Hyperconcentrated flow) | Debris flow stony | Debris flow muddy |
|-----------------------------|--------------------------------------|------------------|------------------|
| desity $\rho$, in kg/m$^3$  | 1300 to 1700                         | 1700 to 2000     | 2000 to 2300     |
| Average flow velocity $v$, in m/s | 3 to 5                      | 3 to 6            | 5 to 10          |

<sup>a</sup> These parameters represent a possible bandwidth. The relevant values have to be chosen by an expert on torrent control.

This standardized stress model for debris flow impact on torrential barriers was calibrated with available impact measurements of real debris flow events and is in good agreement with the common design methods of engineering practice in Austria. The ONR 24801 offers a rather simple model adapted to the requirements of use in engineering practice, which delivers realistic results and seems to be appropriate for safety design of torrential barriers as was already proven by several application examples.

**Keywords:** debris flow, torrential barrier, impact stress, standard model