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New Austrian standard for torrential barriers (ONR 24800 TO ONR 24803)

Нови аустријски стандарди за бујичне преграде (ONR 24800 до ONR 24803)

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Abstract

There are a lot of different types of torrential barriers in different condition levels in Austrian torrents which have to be evaluated regularly with respect to their safety and serviceability. In addition, a lot of new barrier structures will be built in the near future which will be designed according to the EUROCODES (i.e. The standard series EN 1990 to EN 1999). Given those circumstances an interdisciplinary working group (Committee 256) was established at Austrian Standards (AS), which has managed to develop new standards for load models, design and life cycle assessment of torrent control works, the series ONR 24800 (ONR: short for ON-Rule).This paper presents the current state of standardization and is focused on selected requirements for design of torrent protection works.

Keywords: new standard, torrential barriers, torrent control works

Извод

Постоје више разлочитих типова бујичарскох преграда, изграђених у различитим условима у бујичним токовима Аустрије, које би требало оценити имајући у виду њихову стабилност. И поред тога, много нових преграда ће бити пројектоване у блиској будућности према стандарду EUOCODES (т.j. стандарди серија EN 1990 до EN 1999). Имајући у виду ове околности у оквиру Аустријских стандард (AS) формирана је интердисциплинарна радна група (Комитет 256) која је руководила развојем нових стандарда за нове моделе (типове) преграде и њихово оптерећење, процену пројектованог, као и животног циклуса радова на уређењу бујичних токова, серије ONR 24800 (ONR: скраћено за ON- Rule). Овај рад представља садашње стање стандардизације и он је фокусиран на одабране захтеве за пројектовање радова на уређењу бујица.

Кључне речи: нови стандарди, бујичне преграде, уређење бујица

Introduction

Due to the high percentage of mountainous regions within the Austrian federal territory, the protection of human settlements against natural hazards, especially avalanches, rock fall, landslides and torrential hazards, which result from torrent processes (flood, debris floods and debris flows), is of paramount importance for regional development and safety planning. Because of the high influence of these processes onthe human existence, a lot of different technical structures to control torrent processes were designed and built. Until the end of the 1960s, solid barriers were built at the exits of depositional areas to prevent dangerous debris flows from reaching high consequence areas. The development of solid barriers with large slots or slits to regulate sediment transport began with the use of concrete and reinforced concrete during the 1970s. The surplus of solids produced by a debris flow was temporarily stored behind these dams. To reduce the energy of debris flows debris flow breakers were designed in the 1980s. By slowing and depositing the surge front of the debris flow, downstream reaches of the stream channel and settlement areas are exposed to considerably lower dynamic impact.

Currently there are a lot of different types of torrential barriers in different condition levels in Austrian torrents which have to be evaluated regularly concerning their safety and serviceability. In addition a lot of new barrier structures will be built in the near future which will be designed according to the EUROCODES. To provide state of the art design guidelines an interdisciplinary working group,Committee 256,was established at Austrian Standards, which has managed to developed new standards for load models, design and life cycle assessment of torrent control works.During this work the traditional assessment, design and construction concepts were adapted to the EUROCODES. The result of this work was published as ONR 24800-series.

The ONR 24800 - series - Overview

Torrent control works includes by definition all kinds of structures, which are realized in a torrents catchment or stream bed, in order to stabilize the bed and adjacent slopes, to regulate the discharge of floods, to dose runoff and solid transport, to filter large components (blocks, drift wood), to dissipate the energy of debris flow or to deviate (by-pass) hazardous flow processes from objects or areas at risk. [7] Since the beginning of systematic torrent control in Austria 125 years ago barriers were constructed for protection purposes.

In the past the technological development of these constructions was only guided by the experiences of engineering practice while an institutionalized process of standardization comparable to other engineering branches was not existent. This gap was closed by the publication of the ONR 24800-series, which consists of the following parts:

- ONR 24800, Protection works for torrent control - Terms, definitions and classification (published 2008)
- ONR 24801, Protection works for torrent control - Actions on structures (published 2013)
- ONR 24802, Protection works for torrent control - Design of structures (published 2011)
- ONR 24803, Protection works for torrent control - Operation, monitoring, maintenance (published 2009)
- RestlicheTeile!?

These documents are based on and interact with EN 1990 (basic of structural design), EN 1992-1-1 (design of concrete structures), EN 1997-1 (geotechnical design) and the related documents for the Austrian national specifications (NAD) (Figure. 1) The development of these standards was accompanied by the publication of the first comprehensive technical handbook on torrent control engineering "state of the art" [1].

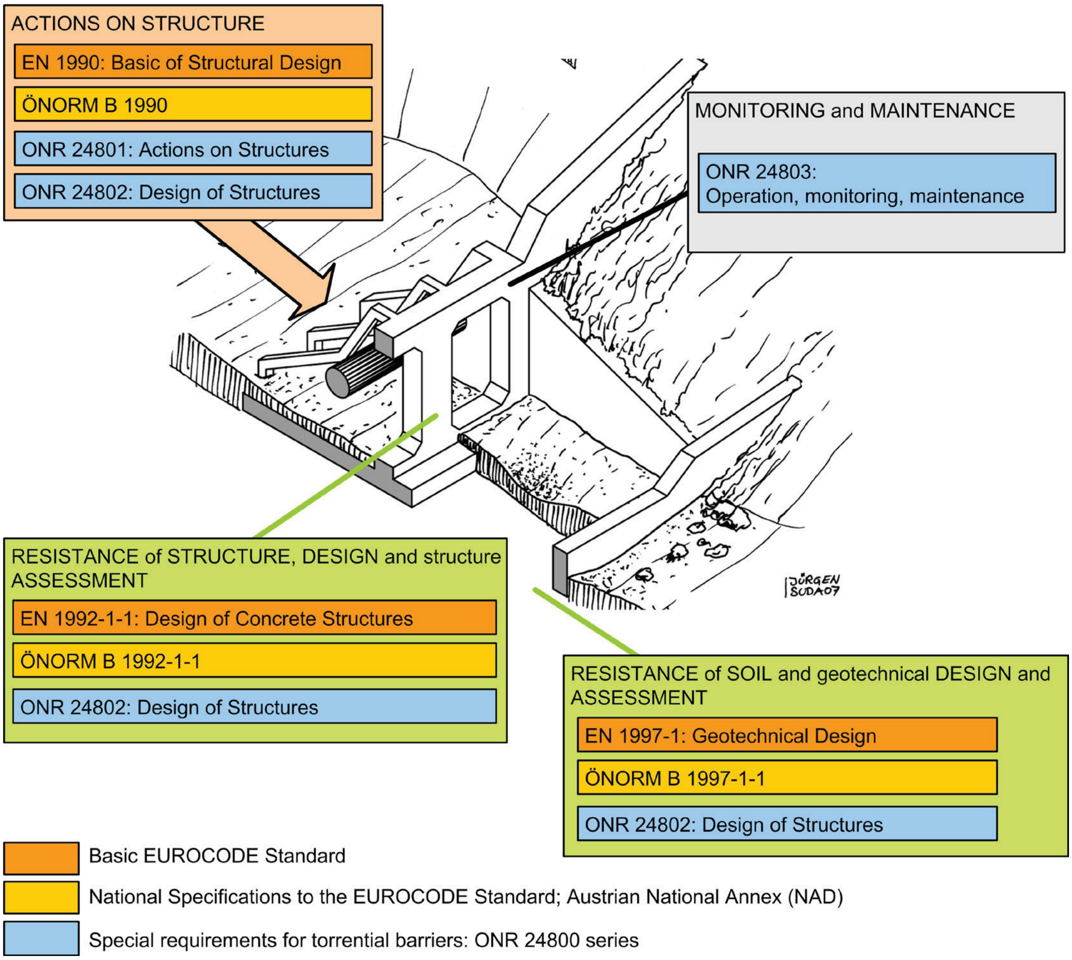

Figure 1 Interaction of EUROCODE Standards (EN 19xx), national specifications and special re quirements (ÖNORM B 19xx) for torrent control works (ONR 24800)

Слика 1 *Интеракција EUROCODE стандарда (EN 19xx) националне спецификације и специјалних захтева (ÖNORM B 19xx) за радове на уређењу бујица (ONR 24800)*

ONR 24800: Terms, definitions and classification

This ONR gives basic recommendations about terms, definitions and classification, which are used in the other parts of this series. The most important classification for the design and assessment are the functions of torrential barriers. According to ONR 24800:2008 they can be divided in the following functional types:

- Conduction includes all measures to direct the debris flow on the shortest way through a potentially endangered area.
- Stabilizationleads to a protection of the channel bed and the embankments against depth and lateral erosion.
- Consolidation supports adjacent slopes of the channel by raising the channel bed and reducing the stream gradient.
- Bypassing involves all measures to collect and redirect surface water around an erosion prone area to avoid excessive sediment recruitment along specific channel reaches.
- Retention leads to a more or less permanent deposition of sediments. The sediments have to be dredged after each event with the help of machinery (earth moving equipment?).
- Dosing covers all measures that allow a temporary deposition of sediments. After the event the deposits should be released if the tail water is deficient of sediments. The intermediate storage of the accumulated material is designed to balance hazard mitigation and a healthy riverine (?) environment.
- Filtering allows particle segregation by grain size to allow only a given grain size to pass the structure.
- Measures with energy dissipation are designed to reduce debris flow energy ([4][5]). By slowing and depositing the surge front of the debris flow, downstream reaches of the stream channel and settlement areas are exposed to considerably lower dynamic impact.
- Deflection directs debris flows towards areas of low consequences. This requires the existence of areas with low economic value in which debris flows maybe deposited.

Besides this the classification of the discharge and solid transport processes in torrents are necessary for the assessment of barriers. Torrents are per definition perennially or intermittently running water courses with steep slope, rapidly changing discharge and massive solid transport (debris, bedload, drift wood) at times[7]. According to ONR 24800:2008 4definable displacement processes ([3],[2],[6]) can be distinguished:

- floods,
- fluvial solid transport,
- hyper-concentrated solid transport (debris floods)
- and debris flow (stony debris flow or mud-earth flow).

The characteristic displacement processes of torrential events (floods, fluvial solid transport, debris floods, debris flow) are definable by physical parameters like the rheology (newtonian/non-newtonian), the volumetric concentration of solids, the density of the liquid-solid-mixture, the kinematic viscosity, the flow velocity or the relative discharge (ratio of total discharge to water discharge).

Functional categories

According to ONR 24803:2009 the functional category has to be determined for each torrent control structure. Two functional categories of structures can be distinguished depending on the magnitude of consequences of a functional or structural failure (e.g. dam failure) for the protection system itself or the area at risk (ONR 24803:2009):

- key structures
- standard structures

This classification follows the principles of the ÖNORM EN 1990, depending on the extent of potential damages. Torrential dams can be classified according to the functions listed above. In any case, dams with retaining, dosing, filtering and energy dissipating function count among the key structures. Hence the stability and usability of these structures is of major importance for the safety of a whole protection system.

ONR 24801: Actions on structures

This ONR gives detailed recommendations for loads and load models on torrential barriers. Stresses on torrential barriers result from water (hydrostatic, dynamic), earth and debris flow impact. In special cases effects from avalanches, falling rocks and earth-quakes must also be considered. There are load models for all 3 displacement processes defined. As example the pressure of debris flowsresults from dynamic relocation processes with varying amounts of water, fine and coarse sediment. The debris flow drains in the channel and interacts with the structure during impact (Figure 2). It is assumed that during the initial impact contribute the highest forces on the lock. Any deposits behind the barrier have a damping effect and reduce the pressures occurring from a mudslide.

The model for debris flows is designed in way that on an interface, the parameters of the process model to the action model will be passed. The modeling of the processes is performed usually by an expert for torrent control. The nature of the process model is determined by the analysis of the catchment area and the relevant characteristics of the debris flow relocation process. The impact on the building model is defined in cooperation with the responsible structural engineer.The following parameters have to be defined on the interface (Figure 2):

- type of discharge process (stony debris flow or mud-earth flow),
- drainage area of the debris flow (AQM) in the characteristic canal cross section,
- velocity (v),
- density (r M),
- dynamic height hdyn to determine the dynamic load width.

The action model consists of the following components (Figure 2 B):

- dynamic pressure (Pdyn),
- static pressure (pst),
- vertical load (pa),
- Force resulting from the impact of a single component (e.g. tree trunk, big block), (Pimp).

The results obtained from the model effects have to be considered as characteristic values for design and assessment.

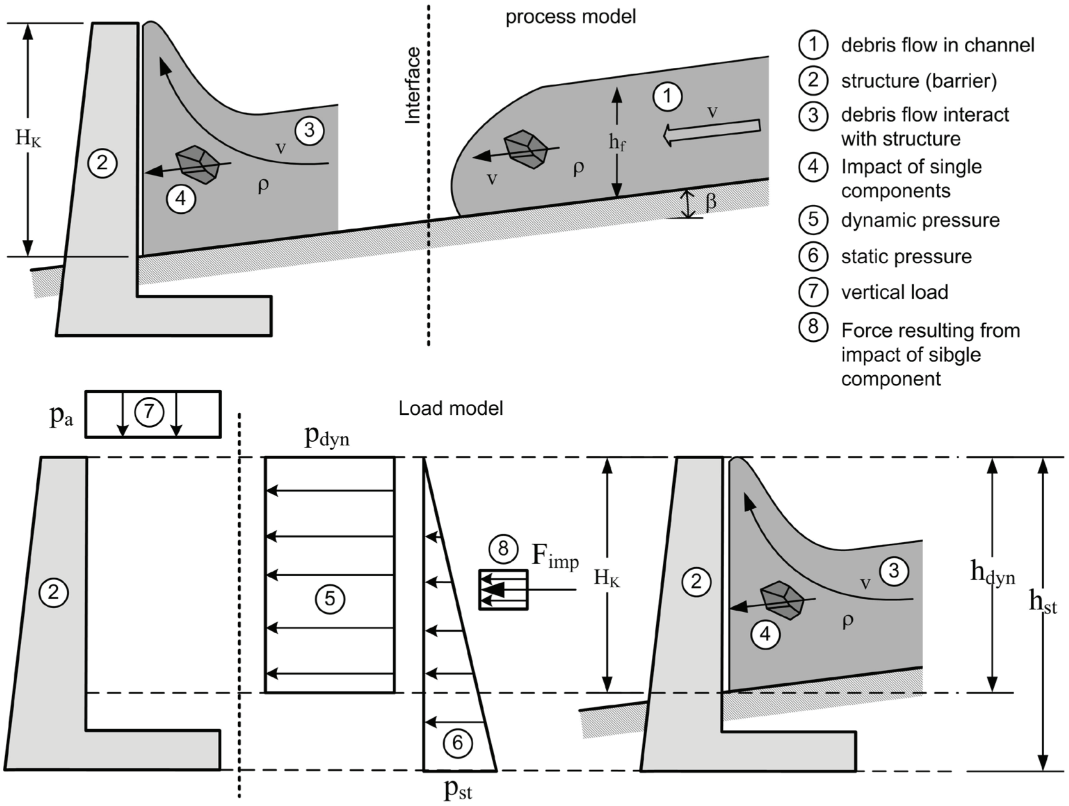

Figure 1 Load model and process model for debris flows according to ONR 24801

Слика 1 *Модел оптерећења и процесни модел за бујичну лаву према ONR 24801*

ONR 24802: Design of structures

This ONR is the main part of the series. It gives recommendation for the design and the assessment of barriers. Stress combinations and partial load factors depending on the functional type, the type of displacement process and functional category are defined.In addition specific design rules are given. Specific design rules are very important to achieverobust barriers which are able to fulfil their function over the expected lifetime.

Impacts on torrent control works are according to ÖNORM EN 1990 categorized in permanent, variable and accidental actions. According to ONR 24802:2010 accidental impacts are either caused by extreme events exceeding the design event or correlated to processes whichare not covered by the systematical function of the structure (e.g. earth quakes).The proof of the hydraulic capacity of a torrent control work based on the design discharge comprises the following verifications:

• proof of the capacity of the discharge section (the hydraulic capacity has to exceed the design flood taking into account a freeboard),

• proof of the capacity of large openings (slits),

• dimensioning of spilling pool (overflow).

ONR 24802:2010 defines the limit states for the proof the stability and serviceability of the torrent control works and supportingstructures. In order to provide these proofs the following impacts have to be taken into account for the design of torrent control works:own weight of structure, soil pressure, water pressure (design water level, water pressure in tension cracks), ground water pressure (water pressure at basis), dynamic water pressure of design event (flood, debris flow), dynamic water pressure exceeding the design event, water pressure due to unplanned backwater and traffic loads. In specific cases additional impacts caused byslope failure, rock fall, avalanches, earth-quakes or extreme floods have to be taken into account. The magnitude of these impact forces and the relevant load distribution figure are defined in ONR 24801.

According to ONR 24802:2010 the relevant impacts for the dimensioning of torrent control structures have to be combined according to the predominant displacement process. These characteristic combinations of loads are qualified as standardized stress combinations (SC). In SC A (Figure 3a), the state before backfill, the hydrostatic water pressure from the backwater (WowS) is acting on the barrier. The specific gravity of the water, depending on the content of bed load in the pure water, ranging from □W = 10 to 20 kN/m³. If there is a water flow behind the bottom side of the barriers foundation a reduced hydrostatic water pressure in the soil body can be used. In this stress combination the buoyancy force (WA) is acting on the barriers bottom side. This force reduces the external stability of the barrier. The downstream water pressure (Wuw) must not be used as a resistance for the barrier.

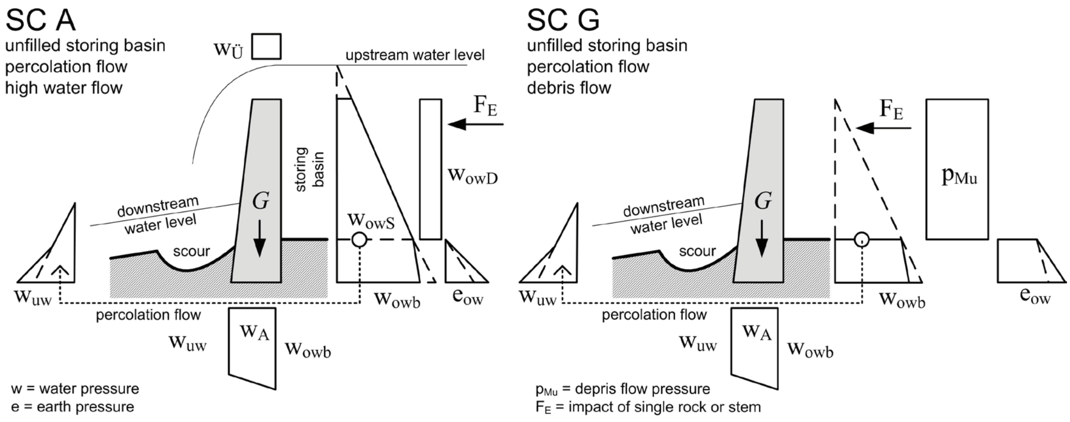

Figure 3 Stress combinations (a, left) for retention, dosing and filtering barriers and (b, right) for energy dissipation barriers (debris flow breaker); according to ONR 24802

Слика 3 *Комбинација притиска (а, лево) за ретенционе, дозирне и филтерске преграде и (б, десно) за преграде за расипање енергије тока (разбијање бујичне лаве), према ONR 24802*

ONR 24803: Operation, monitoring, maintenance

Currently a lot of different types of protection works (e.g. barriers, dams, sills, ramps) in different condition levels exist in Austrian torrents. There are different types of design, design age, material, and combination of materials. On the other hand the protection concepts have changed and the values of the protected regions depending of the type of land use have significantly increased in the last years. So there are protection works which are not needed any more. In other regions new structural mitigation measures hadto be built to protect expandinghuman settlement areas. Besides these new developments, in the last decade many projects concerned with maintenance, improvement and restructuring were initiated. All these activities have to be considered taking account the limited public funds of the communities, federal states and the republic on the one hand and the statutoryprovisions on the other hand.

The number in design of new torrent protection works decreases whilst the amount of maintenance and rebuildingmeasures increases. A fundamental task is the regular supervision and monitoring of existing measures concerning their condition and effectiveness. This task is mainly the duty of the holder of title of the protection works (communities, beneficiaries, water cooperatives or others); technical supervision is also carried out by the Austrian Torrent and Avalanche Control Service.

By using a suitable area-wide monitoring concept with adjusted decision tools the available fundscanbe used more efficiently and a longer-term planning of maintenance measures is possible (based on life-cycle costs). The recommendations of ONR 24803 weredeveloped considering economical, practical and safety aspects.

The monitoring concept in ONR 24803 is divided in two parts, the inspection and the measurement or intervention part (Figure 4). The main target of the inspection is to assess the condition and the reliability in a comprehensive manner. This is achievedby the comparison of the actual state with a reference state. To identify the actual condition, standardized instruments are developed. These instruments can be divided in the operational instruments, like three different control levels, and the instruments of documentation, like the control minutes and database and the instruments of assessment. The three control levels take into account economic limits. In the level 1 all structures will be periodically inspected e.g. by lumbermen during the annual inspection of the Austrian torrents (task of the community due to the Austrian Forest Act). If there is damage identified on a structure a level 2 inspection will take place. A competent expert will perform this level 2 inspection. If there is no possibility to assess the actual condition of the structure a level 3 inspection will be done. Level 1 and 2 is done with visual inspection methods. The level 3 inspection will be done, using complex engineering methods, like analyses of material samples, measuring systems, static and hydraulic simulations or else. In the ideal case this inspection level is carriedout by an interdisciplinary expert team.

The aim of the inspection is to classify the structure in one of six condition levels. Level 1-buildings are new or as good as new, level 6-buildings are completely destroyed. The given standardized instruments allow a comparable classification of condition levels for the whole of Austria.

A consistent and comparable description of the damages of the structures is assured by well-developed control protocolsand a damage catalogue for torrent protection works. This catalogue is based on the experience of practitioners and on the theoretical background of researchers. The catalogue contents a classification of the damages and detailed descriptions for several types of damages. The classification scheme divides the damage-types in those with relations to

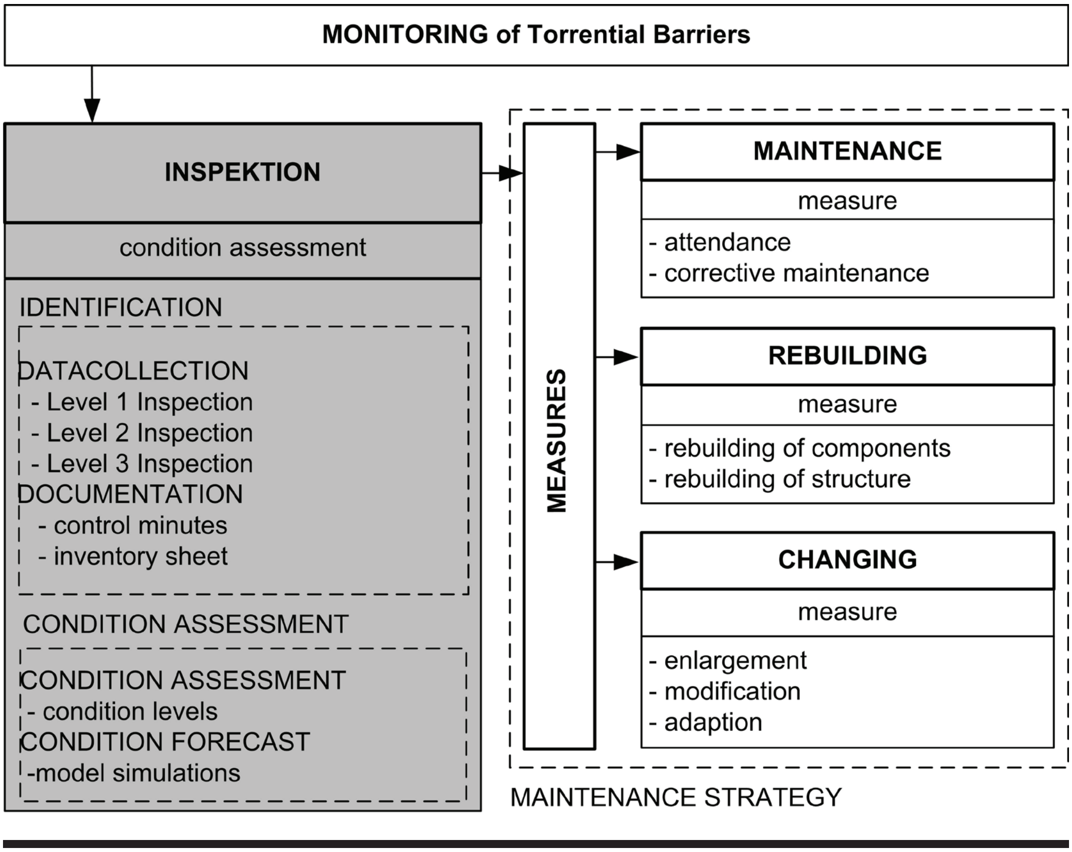

Figure 1 Monitoring concept for torrent protection works, according to ONR 24803

Слика 1 *Концепт мониторинга за радове на заштити од бујица према ONR 24803*

the ultimate limit state, the serviceability limit state and the durability limit state (terms in according to EUROCODE 0). Beside this the classification also takes into account the type of structure and the design material. These developed instruments enable effective decisions regarding the type of measures, the time of measures and also a realistic assessment of the state of the structure. Typical measures are rebuilding, maintenance and modification of the structure. The collected data is to be stored in a database of the so called torrent and avalanche Cadastre (WLK). This data base will be used for maintenance and inspection planning to avoid a precise and efficient maintenance by minimizing costs. It is also the base for simulations of further developments of the barrier systems depending on different maintenance scenarios.

Conclusion

The ONR 24800-series constitutes a new dimension in torrent control engineering. The application of these standards will favor the efficiency and cost-effectiveness of protection structures and secure a high standard of quality concerning the functionality, stability and safety of barrier structures. After the completion of the new Austrian standards in the spring of 2013 a phase of testing and evaluation will help to gather experiences with the practical application of these regulations.

The highest uncertainty in attaining adequate design and assessment of barriers lies on the action side. Due to this fact, specific design rules are essential to achieve robust barriers which are able to fulfil their function over the expected lifetime.

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