Constraints and Methods of Refurbishment Measures of Dikes

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Abstract

This article summarizes clearly and briefly current requirements and technical methods for dike refurbishment measures. It is based upon a research and development project lasting two and a half years, which broadly examined the topic “Refurbishment of Flood Protection Dikes”. The engineer’s task is to choose the most appropriate method of refurbishing for adapting dikes to comply with national technical standards, taking into consideration the dominant constraints. Standards such as those described in DIN 19712 (1997) provide a degree of protection dependent on the potential for damage within the floodplain. Dikes in Germany are usually designed to support water levels in excess of the design water level up to crest level. Constraints include not only technical challenges relating to existing older dikes such as, monitoring and maintenance but also environmental, landscape and townscape issues as well as being subject to public law.

Key words dike; levee; refurbishment; sealing; geosynthetics;

INTRODUCTION

Recent flood events in Bavaria in the years 1999, 2002 and 2005 resulting in damage caused by dike failures emphasised the need for refurbishment measures of flood protection dikes on rivers. Therefore Bavarian water management authorities have initiated a refurbishment program that should ensure completion of refurbishment works on affected dikes quickly. In support of this undertaking a development and research project was carried out at the Institute of Hydraulic and Water Resources Engineering of the Technische Universität München working in close collaboration with water management authorities, engineering consultants and construction companies. The 2.5 year lasting project was completed in mid-2005. The basic aim of the project was to compile an all-embracing and precise document to be used as a tool for all parties involved in dike refurbishment measures, particularly water management authorities. (Haselsteiner & Strobl 2005)

CONSTRAINTS

For planning, design, construction and maintenance both technical and public law aspects must be taken into consideration along with financial and budgetary constraints. Assessment of an “aged dike” of unknown design and condition, built many decades ago with insufficient compaction techniques based on a lack of design criteria is one technical challenge that has to be met. Maintenance, control and monitoring of dikes should be respected e. g. by the placement of dike roads on the inner face. Moreover dike defence can be carried more easily and safely where access is provided. Only in some cases is sufficient land area available for enlargement of the dike base. In most cases ownership structures or the close proximity of buildings to the dike are responsible for expensive and long lasting measures e. g. employing static walls and sealing elements. Furthermore public law in Germany grants affected parties within the corresponding legal procedures the right to object to construction, which increases the construction period and costs. Taking into consideration the necessary legal procedures and the arrangement of operating schedules construction work should be delayed to coincide with a flood free season, e. g. winter time in the south of Bavaria. The extent of legal procedures depends on the method of refurbishment and the impacts of conducted measures. Installation of sealing elements, care for natural cover or removal of wood may be conducted within maintenance programming without going through planning approval procedures or requiring an environmental risk assessment. In contrast, relocation or heightening of dikes will normally mean that these procedures are necessary (Rasp 2003). Last but not least, ecological aspects as well as considerations of landscape or township amenity should not be neglected e.g. by adapting slopes or employing ecologically advantageous grasses.

METHODS OF DIKE REFURBISHMENT

Need for Action / Priorisation of Measures

After completing site investigation and soil exploration the current state of the dike is compared to the acknowledged standards as described in technical specifications such as DIN 19712. Where the dike is found to be deficient measured against the standards there is a need for action. If the dike conforms to the standards only maintenance and control need be conducted according to regulations.

Due to restricted funds and time the refurbishment programme should be prioritised according to predetermined criteria. These criteria should measure the potential for damage on floodplains against the current state of dikes which is represented by a certain risk value.

$$risk = probability\ of\ occurrence \times damage\ potential \tag{1}$$

Safe dikes with a high damage potential has the same risk as an old, unstable dike with a low damage potential to floodplain areas. A classification of prioritisation can be divided to immediate, medium-term or long-term categories dependent on the urgency of the need for action (Fig. 1). Where there is an immediate need for action urgent construction measures or emergency temporary works may be required to increase the stability of dikes without delay.

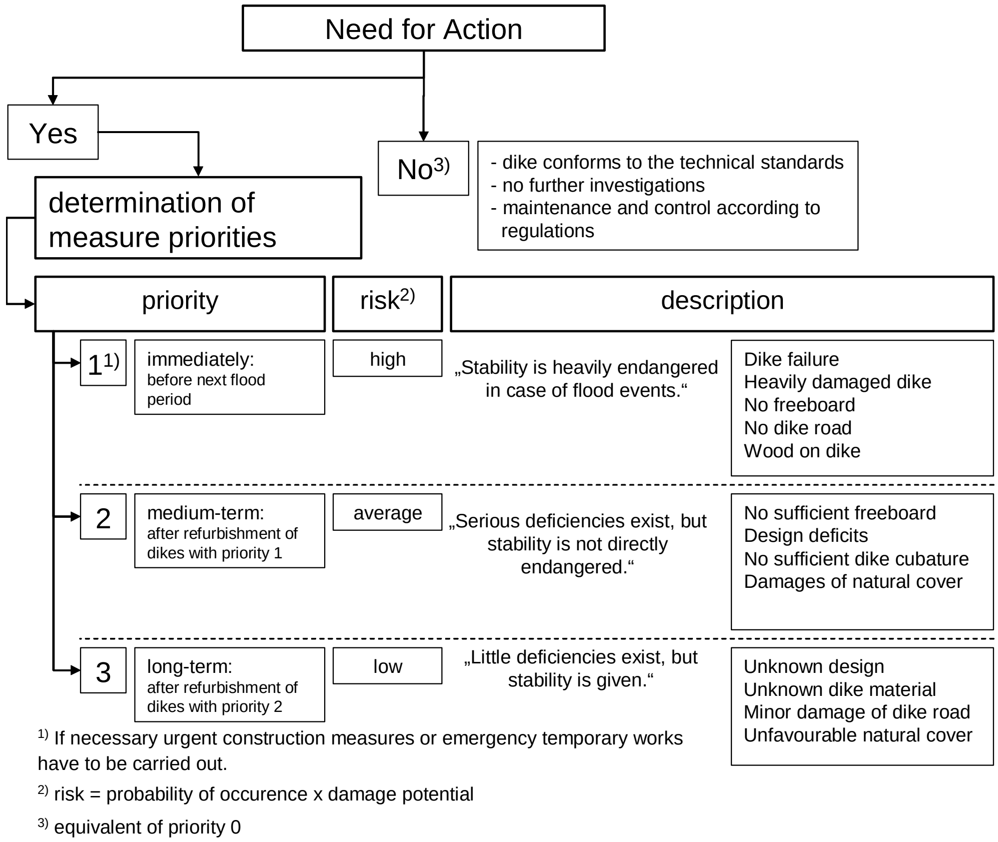

Fig. 1: Feasible priorisation of refurbishment measures in three categories

Earth Moving Methods

Removal of a whole dike or only parts of it and relocation are necessary methods in cases where the current dike cannot be integrated into new design recommendations. In this case only by using earth moving techniques measures, such as flattening embankment slopes, increasing crest width and construction of downstream berms, can stability and serviceability of dike structures be increased crucially (Fig. 2). Work on interface zones between the existing dike and newly placed soil material must be carried out very accurately. Soil layer height before compaction varies between 10 and 60 centimetres depending on material and applied compaction machines. The necessary Proctor density is 95% for cohesive soils and 97% for non-cohesive soils (DIN 19712).

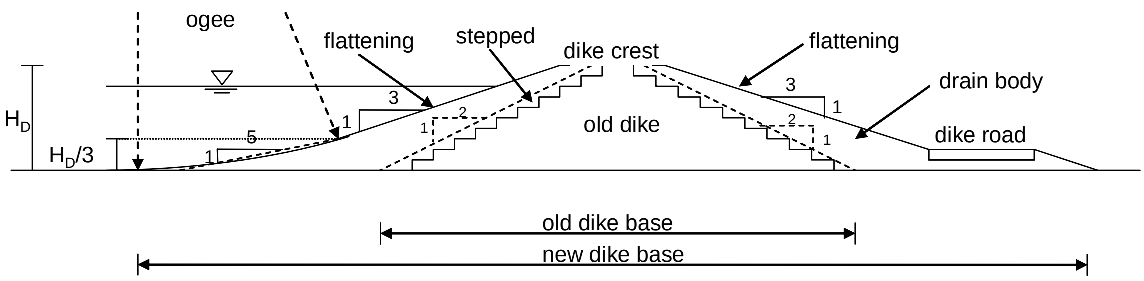

Fig. 2: A dike improved using earth moving techniques

Sealing Elements

The design of sealing depends on geology, hydraulic conditions and the dike design itself. The purpose of sealing elements is to reduce seepage flow and erosion. Natural (mineral) soil material (Fig. 3) if sufficient material is available or geosynthetic clay liners are commonly used. Core seals are normally constructed as diaphragm walls, cutoff-walls or steel piles. Recently soil mixing methods are increasingly being employed for both economic and technical reasons. Soil-cement walls may be reinforced with steel bars and are therefore able to carry static loads as well as steel piles. The critical load case is therefore derived from the assumption of slope failure, overtopping or failure of a single tree. Surface seals can be installed after removing the top soil layer. Center sealings are usually installed from the dike crest (DWA 2005).

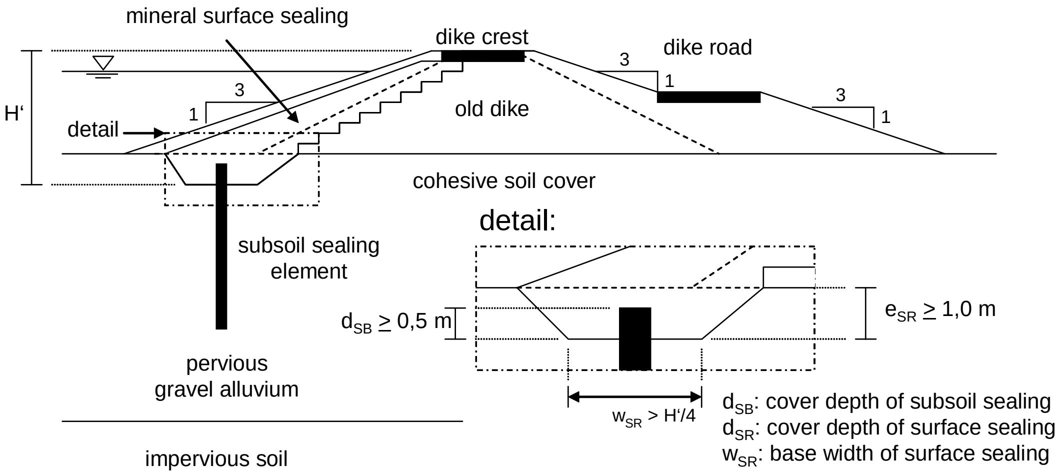

Fig. 3: Mineral surface sealing on water side slope of existing dike in combination with subsoil sealing element

Other Methods

Walls and similar barrier constructions are equally adequate methods for increasing the height in addition to earth moving techniques or sealing elements reaching over the crest level.

Geosynthetics can be employed according to their whole application area (Saathoff 2003). Installing geotextiles, geogrids or geocomposites may improve the stability of dike slopes or soils under roads as a reinforcement layer or are even able to assume other tasks such as protection, separation, filtration, drainage or packing (Fig. 4).

Other measures to improve, stabilize or compact soil may be employed as well when permeability or shear parameters has to be adapted to the loads (Schnell & Vahland 1997).

In some cases dikes need to be designed for overflow. Regular overflow scenarios put huge forces on crests, slopes as well as dike toes. The protection measures range from natural stone revetments to concrete or asphalt structures (Powledge et al. 1989).

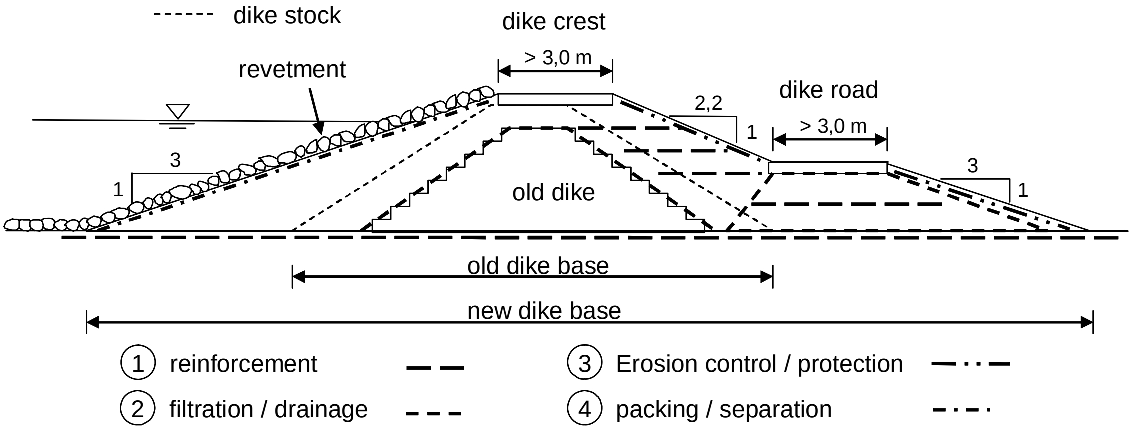

Fig. 4: Application area of geosynthetics for dike refurbishment measures

SUMMARY

Refurbishment measures on flood protection dikes have to be planned and carried out very carefully. Only when taking all constraints into account and knowing all available techniques, economical and secure solutions may be found. First of all dikes and floodplains need to be evaluated determine their risk category in order that the dike sections and flood plains that are most susceptible can be addressed first. The engineer's task is then to choose from all the technical instruments the one which best fits the constraints and the design criteria of the regulations. Expensive solutions in city areas with demountable walls or similar structures or dikes with high ecological value with trees should be exceptions to the rule while cheap refurbishment measures such as the earth moving techniques described are available. After refurbishment work is complete it is important to follow up with maintenance and control to guarantee a durable design.

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