DESIGN OF RETENTION GRASS STRIPS IN THE CULTURAL AGRICULTURAL LANDSCAPE

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Abstract
Reducing the size of soil blocks of agricultural land, especially in areas threatened by water erosion, leads to the need to implement anti-erosion measures in the landscape. One of them is anti-erosion grass strips. These strips act as protection against water erosion, increase the retention capacity of the landscape, are home to many animals, increase the aesthetic value of the landscape. The diverse cultural landscape will also increase the potential of tourism and recreation in the landscape. The costs of implementing these elements in the landscape are relatively low (compared to other technical anti-erosion measures). Anti-erosion grass strips (in combination with other landscape measures) positively transform the agricultural landscape into an ecologically more stable and aesthetically valuable area. For the correct function of grass strips in protection against water erosion, the design of retention strips is essential - a suitable shape respecting the morphology of the terrain, the width of the strip, the location in the area of the land (slope). A software application is currently being developed for this purpose. Through this simple application landscape engineers, farmers, can easily find out the appropriate technical solution of retention strips for the selected soil block.

Key words: Grass strips; water erosion; water retention; tourism; landscape

Introduction
In the Czech Republic (CR), more than 50% of farmland is threatened by soil erosion (Dostál et al. 2006; Podhrázská et al., 2015, Podhrázská et al., 2019). The main reasons of the high erosion threat in CR were insensitive human interventions into the landscape in the second half of the 20th century. Until this period, agricultural production exploited land blocks of a mean size of 0.5 ha. Appropriate anti-erosion measures must be implemented to reduce the risk of water erosion. One of these multifunctional measures is anti-erosion grass strip. Protective grass strip must be placed on the slope along the contour. Retention grass strips have an anti-erosion and retention function. They can be implemented as technical anti-erosion measures, which serve to interrupt the surface runoff and to infiltrate it. It recommends determining their width by calculation. The same possibility is mentioned by many authors of publications, eg Holý, M. 1994, Dýrová, E. 1988, Kasprzak, K. 1989, Doležal, et al. 2015, Dumbrovský, M. et al., 2021. For the purpose of dimensioning the width of anti - erosion grass strips, the method published in Holý, M., 1994 was chosen. The principle of this method is based on the assumption that the proposed anti-erosion grass strip captures and absorbs into the soil all the water that has flowed into it from the land above.

Methods and Results
The width of the anti-erosion strip is calculated according to the following equation (Holý, M. 1994):

$$D = \frac{\varphi_L * i_s * L}{(i_v - i_s)}$$

where:
i_s is the intensity of precipitation [m.s^{-1}],
L is the length of the unprotected slope [m],
D is the width of the anti-erosion grass strip [m],
i_v is the intensity of water infiltration into the grassland [m.s^{-1}],
φ_L is the volume runoff coefficient, calculated as the product of n_3 * n_4
n_3 is a factor expressing the slope of the study area
n_4 is the coefficient expressing soil permeability

Fig. 1: Example of anti-erosion grass strip in cadastral area Strarovice

Determination of values of input parameters for calculation of anti-erosion strip width

For the purposes of calculating the parameters of the anti-erosion strip, we recommend using the following procedure and verified data sources:

i_s is intensity of precipitation [m.s^{-1}]

We choose the intensity of the precipitation (with an average repetition time) at N = 10 years (H_S, N10) and the duration is 60 minutes. Precipitation parameters (total hourly precipitation with average repetition time) can be obtained from the CHMI station network for a specific area, or taken over from the ČVUT Praha application listed at https://rain1.fsv.cvut.cz/webapp/d-rain-point (Kavka, P., Muller, M. et al. 2018).

L is the length of the unprotected slope [m]

This is the longest slope length from the boundary of the catchment area in the direction of the slope to the anti-erosion strip. This length must be calculated based on a digital terrain model.

i_v is the intensity of water infiltration into the grassland [m.s^{-1}]

However, the intensity of permanent grassland depends on the hydrological properties of the soils, vegetation cover, the agrotechnics used and the method of management. The right choice of water infiltration into the soil is essential for the correct dimensioning of the width of the anti-erosion grass strip. Extensive literature searches by a number of domestic and foreign authors, who dealt with infiltration and experimentally measured it, were prepared to determine the recommended value of water infiltration into the soil of permanent grassland. Domestic authors include, for example, Holý, M. (1994), Dýrová, E. (1988), Kaprzak, K. (1989), Vičanová et al. (2008), Hejduk, S., Kasprzak, K. (2010), Hejduk, S. (2011), Sochorec, M., Hejduk, S. (2012), Sochorec, M. (2016), Kučera J. and kol. (2021). We also rely on a large number of measurements of infiltration properties of grasslands in the model areas Starovice - Hustopeče u Brna and Větřkovice u Vítkova. These are model areas of VÚMOP, v.v.i., where model anti-erosion grass strips are implemented, continuous monitoring of precipitation-runoff events as well as infiltration experiments are performed on them.

Tab. 1: Determined rates of water infiltration into the soil in permanent grasslands

Permanent grassland	Intensity of infiltration (mm.min^{-1})
farmed by heavy machinery (tractors), mowed 1-2 times a year	2.8
manually farmed without moving agricultural machinery	9.9
grazed by cattle	1.5

φ_L is volume runoff coefficient l

The volume runoff coefficient is calculated in the used equation (Holý, M., 1994) as the product n_3 * n_4.

where n_3 denotes the coefficient expressing the influence of the slope of the area and n_4 denotes the coefficient expressing the permeability of the soil. Values are given, for example, by Holý (1994).

Tab. 2: Coefficient n3 (Holý, 1994)

slope [%]	**coefficient n_3**	**slope [%]**	**coefficient n_3**	**slope [%]**	**coefficient n_3**	**slope [%]**
0	0,00	7	0,47	14	0,67	21
1	0,18	8	0,51	15	0,70	22
2	0,25	9	0,54	16	0,72	23
3	0,31	10	0,57	17	0,74	24
4	0,36	11	0,60	18	0,77	25
5	0,40	12	0,62	19	0,79	
6	0,44	13	0,65	20	0,81	

The coefficient n_4 expresses the permeability of the soil. It is defined by soil type and expresses the ability of soil to release water through its profile. Holý, M., 1994 defines 4 groups of soil types according to permeability and assigns them the value of the coefficient n_4. For simplification and universal applicability, these 4 soil groups can be assigned a hydrological soil group defined according to BPEJ.

Tab. 3: Values of the n4 factor and their assigned hydrological soil groups

Soil	***n_4***	**Hydrological soil groups**
Very permeable (sandstone of the outer flysch, brown soil, sanding sand and gravel, chernozem with sand).	0,45	A
Permeable (sands, sandy siltstones, calcareous chernozem, brown aluminous sandy soils).	0,65	B
Less permeable (sands, sandy ventilating rocks, loose sands, gray forest soils, gray loamy soils).	0,8	C
Impermeable (peat, bogs, mountain meadows, rocks, crystalline clays and loess, muddy soils and marshes.	0,95	D

D is the width of the anti-erosion grass strip [m]

This is the calculated width of the anti-erosion grass strip.

These findings were implemented in a new web application, which is used to design the location and dimensioning of anti-erosion grass strips in the landscape. The application is freely available at www.protieroznipasy.vumop.cz. As part of the application, a drain line can be drawn on the slope, for which the application will suggest a suitable place to break the slope and a suitable width of the anti-erosion grass strip.

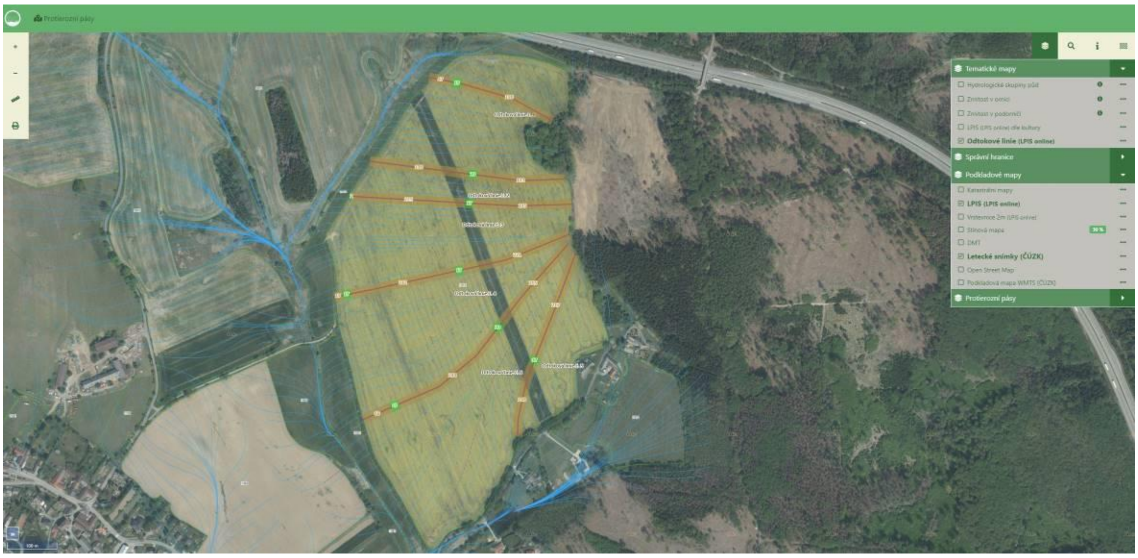

Fig. 2: Demonstration of a web application for designing anti-erosion grass strips (www.protieroznipasy.vumop.cz)

Conclusion

The anti-erosion grass strip is a technical anti-erosion measure with the correct dimensioning of the width and shape (including adaptation to local conditions). In the calculation of the long-term average soil loss by water erosion using the USLE method, the factor L (slope length factor) interrupts. Dimensioning of parameters of anti-erosion grass strips is based on the equation published in Holý, M., 1994. The principle of the method is based on the assumption that the designed strip captures and absorbs into the soil all water that flowed on it from the land, including water that fell on it. The input factors of this equation (values) were adapted to current conditions and long-term research findings of VÚMOP, v.v.i. Anti-erosion grass strips are suitable for the protection of agricultural land in the catchment area (not for the protection of urban areas from flash floods). A web application was developed for the design of anti-erosion grass strips, which is available at www.protieroznipasy.vumop.cz.

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Souhrn
Protierozní travní pás je při správném dimenzování šířky a tvaru (včetně přizpůsobení místním podmínkám) technické protierozní opatření. Ve výpočtu dlouhodobé průměrné ztráty půdy vodní erozí metodou USLE přerušuje faktor L (faktor délky svahu). Dimenzování parametrů protierozních travních pásů vychází z rovnice publikované v práci Holý, M., 1994. Princip metody vychází z předpokladu, že navržený pás zachytí a do půdy vsákne veškerou vodu, která na něj přitekla z výše položeného pozemku včetně vody, která na něj spadla. Vstupní faktory této rovnice (hodnoty) byly přizpůsobeny současným podmínkám a dlouhodobým výzkumným poznatkům VÚMOP, v.v.i. Protierozní travní pásy jsou vhodné k ochraně zemědělské půdy v ploše povodí (nikoliv ochraně intravilánu před bleskovými povodněmi). Pro navrhování protierozních travních pásů byla vyvinuta webová aplikace, která je dostupná na adrese www.protieroznipasy.vumop.cz.

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