Internationales Symposion
INTERPRAEVENT 2004 – RIVA / TRIENT

EXPERIENCE FROM THE TORRENT CONTROL IN THE CZECH REPUBLIC BETWEEN 1884 – 2003

ERFAHRUNG MIT DER WILDBACHVERBAUUNG IN DER TSCHECHISCHEN REPUBLIK ZWISCHEN 1884 – 2003

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ABSTRACT

The torrent control in the Czech Republic has a more than 100 year long history with the experience how to damp the torrent erosion and to prevent damages caused by floods. The extraordinarily great floods in 1997 and 2002 demonstrated the need of better readiness in case of their next repetition. They showed that it is not possible to remove floods in watersheds but it is possible to reduce damages caused. The effects of protection works have to be intensified by the use of meteo- and hydrologic data measured in torrential watersheds, analysis of damages, experience from preventive measures. But the works are economically limited and they need to get support of both specialists and general public. The torrent control made by static objects in the dynamic environment demand to seek for new methods of it, to document goals and efficient.

Key words: effects of control, economical limit, dynamics of environment

KURZFASSUNG

Die Wildbachverbauung hat in der Tschechischen Republik nach mehr als hundertjähriger Historie viele Erfahrungen mit dem Dämpfen der wilden Erosion und der Sanierung der Hochwasserschäden gewonnen. Außerordentliche Hochwässer in 1997 und 2002 haben die Notwendigkeit erwiesen, bereitfähiger für die Wiederholung zu sein. Es ist nicht möglich, die Wiederholung der Flutwellen in den Einzugsgebieten zu verhindern, doch man muß die Schäden streng herabsetzen. Man muß auch die Wirksamkeit der Schutzmaßnahmen mit besserer Ausnutzung der gemessenen Klima- und Abflußdaten, den Ergebnissen der analysierten Hochwasserschäden und den Erfahrungen nach den Schutzmaßnahmen verbessern. Diese Arbeiten sind leider ökonomisch limitiert, sie müssen von den Fachmännern und der Öffentlichkeit unterstützt werden. Die vorherige Wildbachverbauung mit den statischen Objekten in der dynamischen Umwelt regt die Suche nach neuen Arbeitsmethoden mit höherer Auswirkung und besserer wirtschaftlichen Zweckmäßigkeit an.

Key words: Effektivität der Verbauung, ökonomische Grenze, Dynamik der Umwelt

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INTRODUCTION

The Czech Republic (CR) is a middle-European country with one third of its area lying between 500 - 1 000 m o.s.l. The torrents rise in the mountains and their watersheds have more than two thirds of forest cover with spruce as the dominate wood being for 30 years damaged and killed by air pollution. After rainstorms or regional rain the kinetic energy of outflowing water erodes rills and gullies on steep slopes, initiates slides, inundates land in valleys and endangers people.

The torrents in the CR are 19 730 km long, managed by the state enterprise Forests of the Czech Republic in Hradec Kralove. Only a small part of torrents designed as 'important streams' are managed by the state enterprise 'Povodi' (Watershed) called according to the main rivers. Between 1884 - 2003 only 1 300 km (6.5%) of torrents and 130 km of gullies were controlled. An inventory in 1981 summed up 850 check dams, 1 500 other objects and 6 300 sills on the bottom of torrents. The prevailing length of torrents has a natural channel. But 40 % of the length of brooks and rivers under hills and in plains were regulated during the 150 years to be protected from floods and to obtain new lands for residences and industry . However, these regulations are often criticised for the damage of the environment.

THE HISTORY AND PROGRESS OF THE TORRENT CONTROL

In 1884 the CR was a part of the Austrian – Hungarian Monarchy. After passing the Act No.117/1884 the first section of torrent control was set up in Tesin operating for Silesia. Further new centres in Landskron in 1888, Königliche Weinberge (a part of Prague) in 1890, Troppau in 1906 and Brünn 1909 followed. The goal was to control the torrents most afflicted by erosion and to reforestate the area of 1 300 km^2 with devastated soils. Till 1918 the conception of control works was estimated by the Austrian specialists (Görner, Hanisch, Willomitzer, Schnürch, Armani etc.). Not many Czechs (Buček) were working in the Alps. After 1918 were founded forest faculties in Prague and Brünn where Professor Kaisler and Professor Müller educated successful specialists in the torrent control in Czechoslovakia.

It was noted that reconstructing by erosion most devastated parts of torrents were adapted. But we see now that the causes of the accelerated erosion has to be analysed to be able to remove them not only in channels but also completely on the whole watersheds. The forests were (and they are) described as an irreplaceable factor protecting areas against erosion. It was, however, an essential goal to investigate and to prove its favourable affect on precipitation and outflows. Beginning with 1928 Assistant Professor Válek iniciated thirty-year long measurements of hydrological cycles in the small watersheds of Kýchová (fully forested) and Zděchov (with law forest cover) similarly as in Sperbel- and Rappengraben in Switzerland. New experimental watersheds were founded in the Beskydy Mts. in 1953 (at present with the fifty-year long-time series of measurements) and later also in other watersheds.

The structure of service on the torrent control was not much changed until the beginning of the1950s. The engineers started their work in the nature in the warm period of years and have made projects of new parts in cold months. The torrential watersheds in the CR are in comparison with the Alps less threatened with shocks after rainstorm or regional rain followed by dangerous floods and accelerated erosion. The resistance against the kinetic energy of water is greater in the CR than in the Alps but the catastrophes threaten at every time. That is why the timely adequate and reasonable control remains to be very important. It is not always possible to forecast the time and place of dangerous floods. But the preventive measures between floods are not interesting any more. But other opinions exist concerning the control methods: to substitute technical and economical works by biological ones (objects, measures etc). It was important to place the service into the state management of forests and to direct the protection works into the forested watersheds. But to cover expenses by the finance of forest enterprise is limited and therefore it is difficult to do useful and prompt preventive measures at time.

EXTREME RAINS IN THE CZECH TORRENT WATERSHEDS

Causes of outflows in torrents, brooks and rivers are hearty or extreme rainfalls coming in the warm (May – September) period of year. The number of rainy days, their repetition and intensity are naturally fluctuating. The balance of outflows from watersheds seems not to be ecologically harmful. Advective rains and convective stormrains are the product of climatic fronts. It is important to measure climatic data to obtain the basis for correct functional and economical protection. It is necessary to measure everywhere and for a long period of time because such climatic crises do not repeat (fortunately!) often. The Czech Hydro-Meteorological Institute is charged to measure climatic and hydrologic phenomena but it is not possible to carry them out only in many stations in valleys and plain seds but also on the mountain ridges.

Only two recent catastrophic floods stimulated to compile data on 67 extreme daily sums of rainfalls ≥ 150 mm in the period from 1879 to 2000 in an overview with their synoptic causes. 56 of them were registered on small torrent watersheds. Only one was on 1.11.1924 and not on a torrent, the others were in warm months. The highest daily sums were 237 mm in one hour on 25.5.1872 in Mladotice (near of Pilsen) and 289 mm during 18 hours at 25. – 26.6.1872 in Měcholupy (near of Prague). The absolute daily maximum of rainfall 345.1 mm was measured on 29.7.1897 at the station Nova louka (altitude 780 m) in the Jizerske hory Mts. and longer rain (e.g. three – six days 4.-9.7.1997) with the sums of 537 – 625 mm at the station Šance in the Beskydy Mts. The 'precipitation-producting' cyclone of the last two passed to Central Europe along the southern trajectory of disturbances Vb, i.e. from the region of the Mediterranean (Štekl et al. 2001).

Evaluating the forest experimental measurements in the Beskydy Mts. (Biba et al. 2001) in 1954-2003 we found out that the highest rainstorm was on 25.7.1966 with the daily sum of 237 mm in the Mala Raztoka watershed followed by the catastrophe with the peak flow q = 3 144.9 $l.s^{-1}.km^{-2}$. The highest peak flow in the Cervik watershed (with its shadow of precipitations behind the high range of the mountains) followed the storm with 60 mm sum and 44.2 mm of it during 20 minutes, with q_{max} = 1 576.8 $l.s^{-1}.km^{-2}$. Neither of the peaks were broken even by the rain in July 1997. The causes of catastrophic floods on the CR territory like Germany (Vogelbacher et al. 1998) are the following:

- more frequent convective (stormy) rainfalls covering an area smaller than some hundred km^2 with the intensity of $i \cong 2$ $mm.min^{-1}$ and shorter than one hour. In the Jeseniky Mts. 196.5 mm rain with 134 mm in two hours fell on 1.6.1921 followed by catastrophic flood. The ascending part of the wave after such a stormrain does not depend on the saturation of the watershed, more on the intensity of rain. Boundaries of the area afflicted are strongly distinguished from the other. Peaks of waves may be overstepped as they lie in an open interval. This is dangerous for small torrential watersheds with their sudden and violent affliction. May be that in a torrent watershed rainfalls and outflows are not registered but we have to use only professional hydrological evaluation of such events.
- advective (regional) rains do not fall very often. They cover a greater area - thousands km^2 falling two – four days but with the intensity of 0.1 – 0.2 $mm.min^{-1}$. Sums are influenced measurably by orography. In July 1997 the sum reached 400 – 600 mm after eighty hours on the windy slopes of mountains in the CR. They have had one peak flow in the Hrubý Jeseník Mts. (Altvatergebirge) but two in the Beskydy Mts.

Rainfalls in 1845, 1872, 1890, 1897, 1903, 1925, 1941, 1997 and 2002 caused great damages in the CR area. Rains with sums ≥150 mm were not described by Štekl et al. (2001) if they were not registered by a climatic station. Their frequency as a consequence of human activities has not been proved by now. But the citizens are now better informed about the threat and the readiness of rescue parties thanks to the satellites and radar.

CATASTROPHIC FLOODS IN TORRENTS

Any mathematical models are ready to forecast outflow waves in rivers but they have to be checked and controlled by measured data. Outflow waves always pass suddenly and shortly in the watersheds of torrents. We are forced to measure data digitally, to register them per minutes and to hand them over fluently for evaluations with possible warning orders. We have not had many of such stations in the CR but the experience from 1997 and 2002 impressed upon us the need to complete and re-equip them.

On the beginning of an outflow wave we are well informed by specific outflow (runoff) q in $l.s^{-1}.km^{-2}$ about the saturation of the watershed by water. The yearly quantity q_a characterises the water balance in the watershed. Small outflows are subsidised by baseflow but after a heavy rain they rise by inter- and surface (overland) flow. The soil capacity of retention is limited in forests. The percolation is limited too. The interflow causes discharges of water on foots of mountain slopes and in valleys. The water flows out on the surface of forest soils flatly too, concentrates into older rills with the growing kinetic energy.

Natural fluctuation (variation) is typical for the regime of precipitations (rains) and outflows (discharges) of water. People are only partly able to correct (influence) this regime. But in small watershed groves parts of areas developed, compacted or reinforced soils which prevent from percolation of water. On records of discharges from small rains we saw that the water falling on torrent level gets mild but it does not rise this level very much. More active are reinforced soils, paved roads and roofs of buildings. Forest roads, cross-cutting and sorting lines are very important in the forest hydrology and in controlling works. The measurements in small watersheds proved that the low-impact harvesting technology at the forest renewing process causes no environmental disturbance and no great influence of outflow waves. Probably is it in force in small watersheds with the Picea sp. afflicted by air pollution too.

The hydrometry of peak flows in torrents is fast impracticable from temporal and technical reasons. New experience shows that peaks may be overvalued. The dry parts of torrent streambed have herbaceous invasion (torrent discharges fluctuate 1:6 000 in the CR !) every year. The roots have reinforcing effect, the upper parts of wood weaken a part of kinetic energy as well as the discharge capacity. Parts of streambed covered by vegetation are related to the hydrological regime.

The retention capacity on watersheds is important for the floods protection with accelerated erosion. It is calculated in relation with the balance of water during last 30 or 5 days before the beginning of waves. The retention depends on geology, geomorphology, deepness and physical characteristics of soils, slope, vegetation etc. on the watershed. In the flysh area of the Beskydy Mts. we measured the retention round 50 mm. The outflows depend proportionately on the rainfall intensity: 3.33 m^3 of water falls in a regional rain with the of intensity 0.2 $mm.min^{-1}$ in one second, thus the outflow coefficient is (outflow/rain) $f \cong 0.8$. In a stormrain with the intensity of 2.0 $mm.min^{-1}$ the waves are shorter but higher.

The motion of bedload and other sediments changes the specific gravity of the mixture with water and influences its kinetic energy and the resistance of streambed (Weinmeister 2000). Parts of kinetic energy are changed and it is good for the stability of soils and streambed. The experience showed that the interference into the outflow regime of torrent have to be done in the whole watershed too if the control function should be kept for a long time.

Ouflow waves take with them vegetal parts and even wood with stock and other solid human articles. They show that the torrent and its watershed were not maintained adequately. But the water cleans the biosystem from bad or luck subelements cuting parts of the kinetic energy and forming new niche. It threatens with stopping transversely a channel, culverts or bridges and flooding the plots.The remove of harms is always very expensive (Fig.1).

SOME DESIGNS ON THE TORRENT CONTROL

For these protective measures similarly as for other human activities dynamic development proportionate to the living standard in the cultural landscape is very important. They stay longer useful if they in harmony with ecology. This holds for solid concrete (stony) objects in torrent streambeds – sills, check dams impermeable for organisms, retaining walls and pitchings on banks.
The Czech Technical Standard ČSN 75 2106 – Torrent and gully control – was revised in 1998 to support the practical experience. It contents any progressive ideas and ecologically more favourable direction with enclosed formulas being used in the projection (design) of controlling works. Nowadays the damages from 1997 and 2002 are still being removed but no preventive works has been done. There are sufficient productive forces with mechanisms in the CR now but costs are only insufficiently covered. Only 15% of calculations was paid from the budget, the insurance paid twice as much. The rest has to be paid by regional authorities, businessmen and citizens. Important laws and ordinances were revised, meteorological and hydrological measurements with the following analyses of data, as well as modelling of outflows, help to the safety precautions of citizens and statement of flood hazard. Equally to the three hazard classes of floods, rescue parties are ready to help authorities and citizens without economic claims at every time. We need to keep in mind that damage occurs not only in the time of flood sed but it is also felt in the production. We must also think of the fact that the citizens‘ way of thinking is changed and the need for preventive work is strengthened. The notes on influated land in 1997 and 2002 are transformed into the land-use planning by authorities so that preventive measures could be taken into accounts, however, many citizens protest against the decision to move into other more secure houses or flats.

FINAL RECOMMENDATION

Experience from the hundred year long history on the territory of the CR gives many impulses to carry out the torrent control in the 21th century using the modern scientific knowedge concerning ecology and technological process on more than only national level of knowledge economically. Actual tasks are the following:

- to raise the density of climatic and hydrologic stations with digital measurements and to transmit data from torrential watersheds promptly. To improve the operative measurements in areas endangered by flooding, to improve the basis of torrent control projection, availability of data to create better rain – discharge modells;
- to introduce the evaluation of flood damages by the DOMODIS method in the CR;
- to work out an evidence and to evaluate the natural conditions of torrents in the ecosystem controlled earlier, to evaluate the effects of works related to floods in watersheds. To evaluate the regime of the kinetic energy in watersheds using GIS, its adequate and fluent dampening by all kinds of resistances; to evaluate methods of computations of flow capacity, stability of dampening energy by sills and other objects of torrent control, to improve modells for PC;
- to determine useful and economical principles of integrated control in relation to the hydrologic regime of watersheds, dampening of accelerated erosion, changes of landscape but all useful measurements have to be done in harmony with landscape ecology;

- forest management plans recharge by the detection of disturbed forest soils and water-bearing capacity of watersheds. To propose measurements how to subdue the surface- and interflow following rainstorms and regional rains to prevent the outflow waves causing accelerated erosion of soils, gullies and streambeds.

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Fig.1 View of the Opa torrent in the Hrubý Jeseník Mts. after the flood in July 1997
Blick auf den Opa-Wildbach im Altvatergebirge nach dem Hochwasser in Juli 1997
Photo Břetislav Tureček

Fig.2 The torrent after remove of wood is naturally revitalized with self-seeding of Alnus Sp. on all deposits of gravel now
Derselbe Wildbach nach der Ausbringung des Unholzes hat sich selbst renatulisiert mit eigener Besamung von Alnus sp. auf den Schotterbänken
Photo Milan Jařabáč