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PHYSICAL STATUS OF TORRENT CONTROL STRUCTURES IN ROMANIA

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Abstract

Torrential watershed management actions should be integrated and their results designed to last for a long time. In Romania and in other countries, these actions cover the entire area of the watershed (slopes, banks, and riverbeds). They consist of complex sets of structural and non-structural measures and works designed to control runoffs and erosion, protect social-economic objectives and improve degraded lands. The most vulnerable structures are the hydrotechnical structures, which are placed on riverbeds in direct contact with torrential flows. Being limited by environmental factors (such as violent flash floods loaded with sediments and woody debris) and isolated conditions, these works should be monitored continuously and systematically. Research focusing on the deficiencies uncovered during torrent control structure servicing led to a substantiated monitoring system based on repeated inventories (once every 5-10 years). This paper presents the evolution of the physical states of 192 transverse structures between two successive inventories. It analyses the influence of some features (structure's age, initial condition rate, height, building materials) on a structure's condition rate variation. The results reveal the high influence of a structure's height on the annual decay of the structure. Due to the poor quality of building materials and improper technologies used after 2000, those structures have more damaged between inventories. The functionality of torrent control structures is affected by various factors that cause unembedding, undermining, cracks, breaks, and abrasions. In order to improve the maintenance of these structures, a substantiated monitoring system is required, as well as a well-trained staff (designers and builders).

Key words: damages, dysfunctions, failure mode, monitoring system, torrent control structures

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1. Introduction

Mountainous watersheds are predisposed to generate flash floods triggered by heavy rains or sudden snowmelt. The runoff varies widely within watershed boundaries and is highly variable over time (Haidu et al., 2017; Kasanin-Grubin and Bryan, 2007; Kuhn and Yair, 2004).

Excessive runoff generates fast leakage and erosion leading to torrential phenomena closely related to torrential flow which, accompanied in this case by a mudflow (Beilicci et al., 2017; Cartacuzescu et al., 2014). The most effective torrent control in terms of land use is forested lands (Clinciu and Gaspar, 2005; Munteanu et al., 1985; Snelder and Bryan, 1995), but often forest cover is not enough or a convenient forest cover is not possible (Bombino et al., 2008; Gaspar et al., 1972; Mazzorana and Fuchs, 2010a; Mongil-Manso et al., 2016; Munteanu et al., 1985; Pintilie et al., 2014; Ramos-Diez et al., 2016; Üblagger, 1972; Yolanda et al., 2018). In order to control stream erosion, stabilize the river bed and protect downstream areas, check dams of different design are frequently built (Armanini et al., 1991,

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Armanini and Larcher, 2000; Franks et al., 2004; Kostadinov and Dragovic, 2013; Lenzi, 2002; Marchi et al., 2010; Mazzorana and Fuchs, 2010b; Rey and Berger, 2002; Rey, 2003; Wehrmann et al., 2006; Zollinger, 1984). Torrent control structures (check dams, overflow channels and so forth) are part of sustainable landscape management, with their primary function being environmental preservation while enhancing environment reconstruction (Mazzorana, 2008; Mirjam, 2018). In 1881, the first Romanian Forest Code integrated torrential watershed management into the forest management concept. From the beginning of the 20th century, more than 18,000 torrent control structures were built in Romania, improving more than 2400 km of torrential streambeds (Adorjani et al., 2008). Torrent control structures, placed on mountainous riverbeds with steep and unstable riverbanks, are vulnerable to environmental conditions, and their behavior is highly influenced by violent flash floods (Davidescu, 2013). Different studies were made to illustrate the efficiency of the structure (Niță et al., 2016; Piton et al., 2019; Tacnet et al., 2014), different damages and relationship between events (Clinciu et al., 2015; Dell'Agnese et al., 2013; Fuchs et al., 2007) or case studies where events are larger than structure are design (Mazzorana et al., 2009).

Morphological changes from river basins are essential for understanding the evolution of sediment transport. At the same time can be observed landfill changes by analyzing deposits evolution (Boix-Faios et al., 2007). These morphological changes contribute with sediments in the torrential flow, which conduce to erosion, washing away successive layers of the dams (abrasions).

Check dams can be undermined by floods and pressure can build up causing fractures and eventual failure (Gaspar et al., 1972). Undermining is produced by a local washing immediately downstream from the terminal spur or structure body. A series of traverse and check dams change the local characteristics of the flow, causing the water to be concentrated in the spillway area and resulting in an immediate local washing phenomenon, due to the waterfall (Comiti et al., 2004). Studying the effectiveness of check dams and finding some environmentally friendly solutions to integrating streambed improvements (using mainly hydrotechnical works) into general watershed management (including land use management, water management, and so on), taking into account check dam maintenance, substantiates the development of management strategies (Bombino et al., 2008).

All torrent control structures should always be functional in order to ensure needed protection against natural hazards for the entire infrastructure endangered by possible flash floods. Structures in gullies, torrents, and other ephemeral streams require permanent monitoring after strong floods and regular maintenance that should be anticipated by at least 10 years, to put in safe possible degraded structures or the prevent some bad consequences (DEP, 2003). Tracking the deficiencies that occur during the operation of hydrotechnical works is necessary in order to identify the most vulnerable types and systems of torrent control structures (Mazzorana, 2008; Von Maravic, 2010). Special attention should be given to those structures designed from the beginning with a certain risk factor embedded (stretching effort on the upstream facing of the structures or undersized torrential structures). The continuous monitoring of torrent control structures, emphasizing the permanent aggression of water (physicochemical phenomena, water infiltration through cracks and pores, thermal expansion, uneven ground compaction) and the impact of violent flash floods (boulder and other floating material shocks, vibrations and abrasions due to rapid leakage of water filled with sediments, and so forth) is needed in order to improve the techniques and technologies used for torrential streambed management (Munteanu et al., 1985).

Different studies (Clinciu and Gaspar, 2005; Gancz, 2012; Lupașcu, 2009) conducted in torrential watersheds all around Romania have highlighted the impacts of time and flash floods on check dams and drain channels and led to a classification and ranking of different behavioural events (damages and dysfunctionalities) based on visual evaluations and frequencies of occurrence. A system for monitoring torrent control structures was substantiated based on the results of these studies and inventories done on more than 3500 torrent control structures between 2009 and 2015 (Davidescu, 2013).

The system assigns a condition rating, an indicator of the cumulative effect of the different damages which have occurred, to describe the physical status of each of the torrent control structures (Davidescu et al., 2012). This objective index with values between 0 and 100 is established through an algorithm that uses measurable features. Hence, the condition rate can be used to establish the repair priority for damaged structures (Davidescu, 2013; Tudose et al., 2015) or to emphasize the roles of different environmental factors (e.g., watershed area, riverbed slope, river network length, land use within the watershed, and so forth) and structural elements (e.g., height, age, structure type and function, event type and presence or absence of earlier damages) in the degradation of these hydrotechnical works (Davidescu, 2013; Dell'Agnese et al., 2013; Teșileanu, 2015).

Based on the analysis of two successive inventories (done in a 5-8-year interval), the main objective of this paper is to emphasize the behavior of 192 check dams placed in different conditions, leading to the substantiation of the impact of flash floods on torrent control structures. First, the paper will present an evaluation of the physical state of the studied check dams based on the damage types and their frequency of occurrence. Further, the evolution of the physical states of these dams will be interpreted using the dynamics of the condition rate between two successive inventories while depending on some construction elements of the dams (structure's age, initial condition rate, height, and building materials).

2. Method of study

2.1. Study areas

The studied check dams are located on 35 torrential streambeds in eight major river basins in Central and Western Romania (Fig. 1, Table 1). The torrent control structures in this area were built between 1963 and 2008 using mainly concrete and stone masonry, with maximum registered height of 5.5 m.

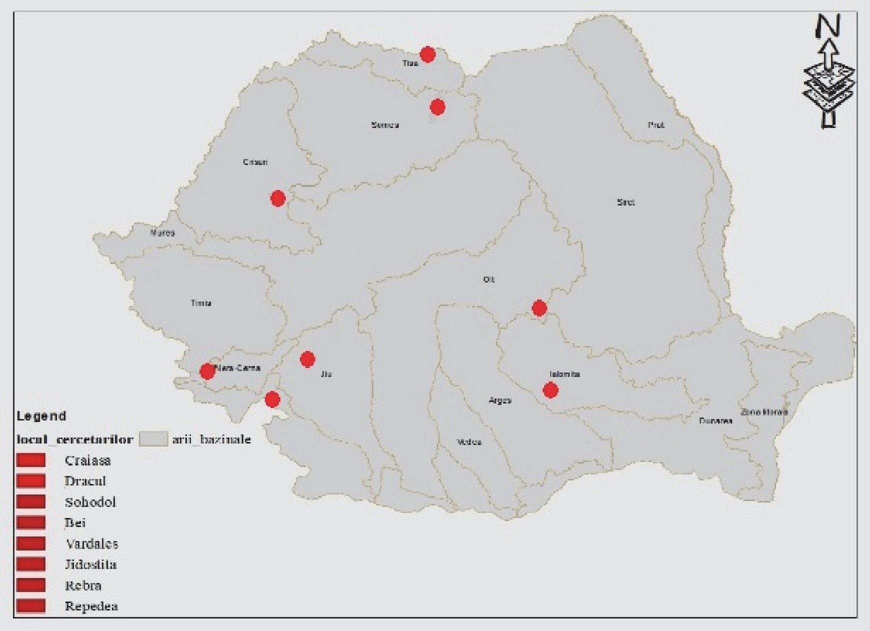


Fig. 1. Study area including eight major river basins in Central and Western Romania

Table 1. Streambeds with inventoried check dams

Major River Basin	***Watershed***	***First inventory***	***Second inventory***	***Years between inventory***	***Torrential stream***	***Check dams inventoried***
Tisa	Repedea Valley	2010	2017	7	Smereceni Creek	4
					Plăic Creek	5
					Ravine 1	1
					Tomnatic Creek	1
					Repedea Valley - main course	18
	TOTAL REPEDEA					29
Someș	Rebra Mare	2009	2017	8	Vâlcele Valley	1
					Coasta Luncii Valley	2
					Brădățelului Valley	1
					Pietrei Valley	1
					Mărului Valley	2
	TOTAL REBRA					7
Crișuri	Crăiasa Valley	2009	2017	8	Ravine Ua 25	1
					Sibișoara Valley	3
					Pietrele Roșii Creek	1
					Crăiasa Valley - main course	46
	TOTAL CRĂIASA					51
Banat	Beiului Valley	2011	2017	6	Chichiregu Bei	5
					Păstrăvărie Creek	2
					Beiului Valey- main course	13
	TOTAL BEIULUI					20
Jiu	Sohodol- Runcu Valley	2011	2016	5	Ravine B189/IV	3
					Ravine B 244	2
					Ravine 1 UP V	6

					Căldării Creek	3
					Molizilor Creek	1
					Sohodol Valley - main course	2
	TOTAL SOHODOL RUNCU					17
Olt	Dracului Valley	2009	2016	7	Ravine 4	1
					Ravine 5	1
					Ravine 6	1
					Ravine 7	1
					Amiaza Creek	3
					Fir principal	13
	TOTAL DRACULUI					20
	Adânca De Jos Creek	2009	2017	8	Adânca De Jos Creek	12
	TOTAL OLT					32
Ialomița	Vârdaleș Valley	2011	2017	6	Ramification Ba62	1
					Ramification Ba53	1
					Vârdaleș Valley - main course	17
	TOTAL VÎRDALEȘ					19
Danube	Jidoștița Valley	2011	2017	6	Cărbunari Creek	9
					Jidoștița Valley - main course	8
	TOTAL JIDOȘNIȚA					17
GENERAL TOTAL						192

2.2. Methodology

The data regarding damages, together with the elements defining the check dams are available on the website of "Arrangement of torrential river basins" project (www.abht.ro). This data was used to establish their physical status, and the condition rates were calculated using Eq. (1) (Davidescu et al., 2012):

$$Y_S = 100(1 - Y_A / Y_A^{REF}) \tag{1}$$

where Y_A^{REF} is a reference value used to normalized the index depending on the existence of the apron (99 for a transverse structure with an apron and 93 for check dams without an apron), Y_A (Eq. 2) is the damage index (Tudose et al., 2015), which is equal by sum of product between damages weight, intensity rates of each damage weight and a particular converting factor (Tudose et al., 2015). In damage index formula is also needed the maximum registered value and relevant intensity (Table 2).

$$Y_A = \sqrt{\sum \gamma i * I_i * F_c} \tag{2}$$

where: γ_i represent damage weight; I_i is damage intensity; F_c represents the conversion unique scale of damage intensity, where the square root has been used to homogenized the values in the formula.

In the damage index equation, the authors applied a multicriterial analysis. Due to different types of structure and constructive components, it was necessary to make individual analysis based on different structures and constructive elements (e.g. simple structures, apron structures, terminal spur damages), to conclude which behavioural event types were the worse. In this way was made a classification of damages that occur in the hydrotechnical works exploitation. The conversion scale factor is calculated by Eq. (3):

$$F_c = \frac{100}{I_{\lim}^{R}} \tag{3}$$

where: $I_{\lim}^{R}$ is the relevant limit intensity that introduce the maximum limit of the respective damage or dysfunction and is used to normalize the index intensity to the condition rate (Table 2) (Tudose et al., 2015).

The dimensionless elements used are: *Ast/ Adr* - embedding depth (m), *Ye* - height of the structure, *H* - spillway height, *P%* - the surface on which the damage acted (% from total constructed element area or length), *Lo* - the length of the horizontal cracks, *B* - the lenght of the crown, *Lv* - the length of the vertical cracks, *A* - damage depth (cm), *N* - number of cracks, *Ndr* - number of energy absorber elements detached, *Np* - initial number of energy absorber elements, *Hz* - wallwings height (m), *Bp* - the length of the terminal spur. All damage types were analyzed and interpreted in terms of frequency of occurrence and intensity. The annual variation in the condition rate between the inventories shows that the physical states of the check dams are influenced not only by the events to which they were exposed but also by the materials with which they were built and their ages.

Table 2. Condition rate equation elements

Transverse structure with apron					
Damage		***Damage intensity***	***Maximum registered value***	***Relevant intensity*** $I^{R}_{\lim}$	***Damage weight*** γ_i
Dam component affected	***Nature***				
Body	Un embedding	$\frac{Ast+Adr}{Ye+H}$	1.5	1	0.92
	Undermining	$A \cdot P\%$	4	2	2.52
	Cracks	$\frac{Lo}{B}+\frac{Lv}{Ye+H}$	9.8	10	0.74
	Detachments on spilled area	$P\%$	1	1	1.9
	Detachments on wall wings	$P\%$	1	1	3.27
	Abrasion	$A \cdot P\%$	90	50	0.82
Apron	Cracks	$N \cdot P\%$	5	5	0.66
	Rupture	$P\%$	1	1	1.33
	Undermining	$A \cdot P\%$	4	1.5	0.24
	Abrasion	$A \cdot P\%$	40	50	0.52
Energy absorber system	Detachments of dissipating blocks	$\frac{Ndr}{Np}$	1	1	0.03
	Detachments of the counter dam	$P\%$	1	1	0.1
Guarding walls	Cracks	$\frac{Lo+Lv}{Lr}$	2.97	5	0.31
	Rupture	$P\%$	1	1	1
	Abrasion	$A \cdot P\%$	60	50	0.18
Spurs	Un embedding	$\frac{Ast+Adr}{Hz}$	8	1	0.59
	Cracks	$\frac{Lo+Lv}{Bp}$	3.96	5	0.45
	Central part ruptures	$P\%$	1	1	1.18
	Abrasion	$A \cdot P\%$	50	50	0.38

3. Results and discussion

The results refer to 192 check dams, of which 33 are sills (the spillway is at channel bed level), 87 are less than 2 m in height, and 72 have an elevation greater than 2 m (up to 6.0 m). The most common constructive type is a “gravity dam” (95%), but check dams with counterforts (3%), concrete tubes filled with stone and gravel (1%) and arch dams (1%) were also identified. The most commonly used building materials are stone masonry and concrete (Fig. 2), but sometimes different materials were used to build different components of the structures (Fig. 3).

Behavioral events noticed during torrent control structure servicing were classified into two categories: damages affecting structure integrity and dysfunctions affecting the functionality of the structure. Damages were classified depending on their appearance and the structural component affected. Thus, the following damage types were defined according to their appearance (Davidescu et al., 2012):

- out-flanking characterized by the loss of the link between the wall wing and the stream bank, affecting the wall wing or the spur wing;
- ruptures or detachments of some parts of the structure;
- undermining means unveiling, immediately downstream, the foundation or the spur;
- cracks, i.e., linear fractures inside the affected components of the structure;
- abrasions, i.e., thin layers of the affected component have been detached or washed away.

The behavioral events identified for the check dams in the sample, and how they evolved between the two inventories, are shown in Table 3.

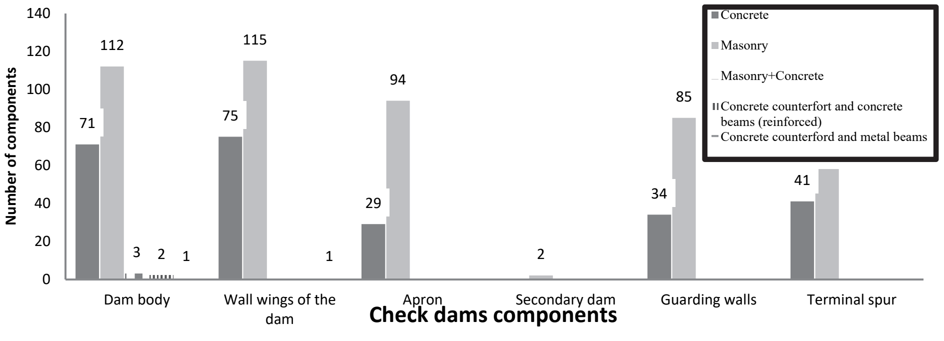


Fig. 2. Building materials used

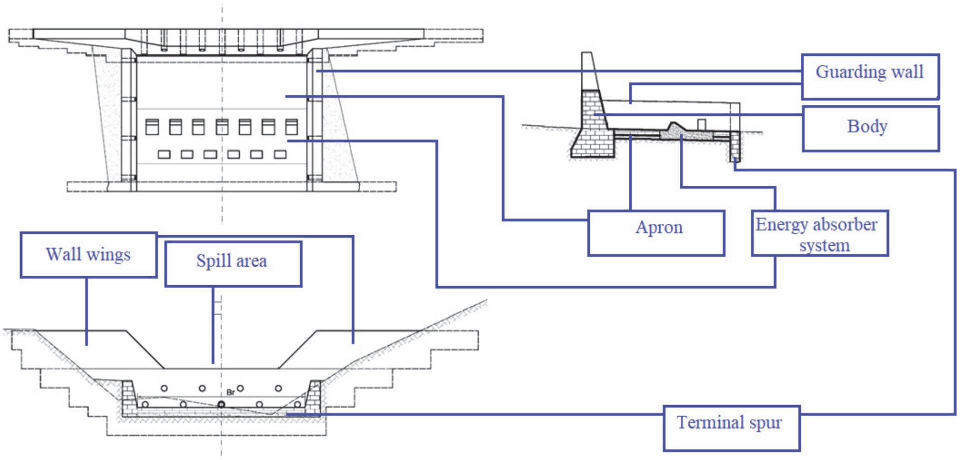


Fig. 3. Transversal hydrotechnical structure components (top, side and downstream views)

Table 3. Behavioral events affecting studied torrent control structures

Behavioral events		***2009-2011***			***2016-2017***			***Change in condition rate***
Component affected	***Damage type /dysfunctionality***	***Pieces***	***%***	***Condition rate***	***Pieces***	***%***	***Condition rate***	
Body	Un embedding	20	10	64.08±0.27	29	15	61.2±0.43	2.88±0.3
	Undermining	47	25	74.65±1.13	63	33	67.98±1.41	6.67±0.29
	Cracks	26	14	74.14±0.77	45	23	69.26±1.55	4.88±0.36
	Ruptures	50	26	68.71±0.59	71	37	53.14±0.41	15.57±0.2
	Abrasion	51	27	69.01±0.61	83	43	67.91±1.6	1.1±0.69
Apron	Cracks	0	0	100±0	6	4.9	68.77±0.51	31.23±0.06
	Ruptures	43	23	61.64±0.34	59	48	59.65±0.55	1.99±0.44
	Abrasion	50	26	72.63±0.87	55	45	70.38±2.31	2.25±0.24
Guarding walls	Cracks	17	9	74.71±0.68	29	12	68.09±0.98	6.62±0.25
	Ruptures	27	14	57.64±0.23	36	15	53.62±0.3	4.02±0.27
	Abrasion	42	22	66±0.44	61	26	61.72±0.66	4.28±0.38
Terminal spur	Unembedding	5	3	58.98±0.1	9	9.1	57.23±0.18	1.75±0.23
	Undermining	46	24	79.95±8.67	46	37	72.86±9.23	7.09±0
	Cracks	-	-	-	-	-	-	-
	Ruptures	6	3	52.45±0.09	11	11	54.15±0.17	-1.7±0.41
	Abrasion	6	3	72.28±0.29	7	7.1	66.51±0.37	5.77±0.08
Dysfunctions	Overflow silting	61	32	79.68±7.39	85	44	76.18±3.57	3.5±0.46
	Apron silting	76	40	79.54±7.31	75	61	75.15±5.57	4.39±0.09
	Incomplete sedimentation	36	19	79.1±3.68	41	26	72.54±6.07	6.56±0.16
	Unwanted vegetation upstream	54	28	76.24±1.63	180	94	73.18±32.38	3.06±1.1
	Unwanted vegetation downstream	43	22	74.03±0.98	179	93	73.07±25.78	2.59±1.2
	Downstream section reduction	57	30	79.4±5.68	73	38	73.92±25.82	5.48±0.32

Over time, as shown by the data in the table, the overall physical status of the analyzed check dams got worse, highlighted by the decreasing trend in the condition rate and by a higher occurrence of different damage types. Also, when analyzing only structures affected by a specific behavioral event, we observed, as a rule, an increase in terms of intensity for all damages and dysfunctions. In spite of this general note, in the case of undermining, a full 17.0% of the structures affected at the body level (Fig. 4) and 32.6% of those affected at the spur level (Fig. 5) were found to have less intense undermining during the second inventory. Due to some detachments from the spill area or the wall wings along with ruptures, the works have been destabilized, the slope between structures increased, volume and level of sediments retained by each structure were washed. Those washed sediments contributed to fill the scouring holes (3 cases observed) between the two inventories.

(a)

inventory. With the torrent control structures in place, the "calm" needed for vegetation to thrive was achieved, but the natural way in which sediment deposits were forested led to the chaotic disposal of trees, negatively influencing the hydrodynamics of the stream next to the hydrotechnical works.

External factors can have a rapid impact when they come as consequences of flash floods or accidental incidents. The wear on the works is progressive and slow by the structure agging (Davidescu, 2013; Teșileanu 2015), the degradation of the structures takes place also in the absence of flash flow. The condition rate, as an indicator of all the damages that have occurred, is analyzed further in terms of the yearly decay in its value (between the inventories) according to the following factors: structure's age, initial value of the condition rate (at the first inventory), building materials and the height of the dam.

3.1. Influence of the structure age's on the downward trend in the condition rate

As a result of the fieldwork and the research carried out on the structures, it became clear that the dams more than 30 years old behaved better through time than the recently constructed works. This observation is also evidenced by the results obtained from the processing of the data taken from the field. Our opinion on the above-mentioned state of the art is that the materials used for the construction of the recent works are of inferior quality compared to those used 30 years ago (Fig. 7). The aging of works over 30 years old is normal, but works over 40 years old are degrading slowly even if the service life has been exceeded. Taking in account that the older structures may have recorded a strong degradation in the first years after construction, and the rate of degradation later declined, the condition rate for the recently build check dams we believe that the quality of the materials, and not the influence of age, may be the reason for the state of the works.

3.2. Influence of the initial physical status of the check dams on the yearly variation in the overall condition rate

Depending on their condition rates (Fig. 8), the inventoried check dams were ranked in classes of 10-unit condition rate for a better highlighting the structures degradation tendency according to the considered parameters. The variability at individual level is also altered by many other parameters (slope, channel bed materials, presence/ absence of a forestry road, etc.) which we didn't consider in our analysis. Thus, to highlight only the influence of the considered parameters we divided the variation of the condition rate in 10 unit classes. Even though, most structures belong to the upper classes (at the first inventory, 116 structures had a condition rate between 80 and 100), some of them had lower values. Because in class 4 (31-40) were only 3 structures that were eliminated from the graph. The main reason for this situation is differences in the condition rate of each structure from this class, which have reached the maximum value of the annual failure rate reported to the individual number of works from each category (-0.49 compared to -0.08). The average for this class reached -1.46±0.39. The 5th class registered the yearly variation value -0.24±0.23 because about half of the structures from this class have insignificant damage rate registered over time. Amongst the first and second inventory, occurred significant differences in the condition rates; the variation was influenced directly by the initial condition of the works. So, the check dams having initially a very good physical status suffered degradations equivalent to a decrease of up to 1.2±0.053 condition rate points compared to the 0 - 0.2±0.23 points in the case of structures in bad condition at the first inventory. This may be due to the low age of the works since the works with higher status condition rates the first inventory had been built recently. On the other hand, there are works of greater ages, which, even when characterized as having an advanced state of degradation at the first inventory, have recorded a constant condition rate at the second inventory. This finding can be justified both by the ages of the works and also by the continuous process of degradation to which they have been exposed over time. At the same time, the new structures were constructed in the active catchments, which are characterized by higher sediment transport and speed rate, which conduce to an early degradation process.

3.3. Influence of construction materials on the variation in condition rate

With a total of 113 check dams built using masonry and 77 made using concrete, the research focused on these two categories of construction materials. The structures built using other materials were assimilated into these two categories, depending on the main materials used. Compared to another study, where concrete structures reach a smaller damage rate (Dell'Agnese et al., 2013), in our case concrete works have been found to be weaker in terms of behavior and durability (because of the concrete quality and construction technology), and the average condition rate for concrete structures went down 10.56 points between the two inventories, representing a maximum yearly variation of -1.9±0.77 (Fig. 9). Masonry performed better, with the average condition rate of these structures going down only 4.94 points, resulting in a maximum yearly variation of -1.0±0.08 (Fig. 9). If the 4th category from the masonry chart is excluded, where a structure was excessively affected before the first inventory (structure 42 M 4.0 – Ravine 1 Tisa Basin) and two others were excessively damaged by voluntary human action, for a bridge construction (structure 20 M 2.5 - Ravine 1 Jiu Basin) and overcrossing creek right before the structure combined with exceptional torrential flow during time (structure 180 M 1.0 - Crăiasa Valley Crișuri Basin), is obtained a 0.703 correlation index value.

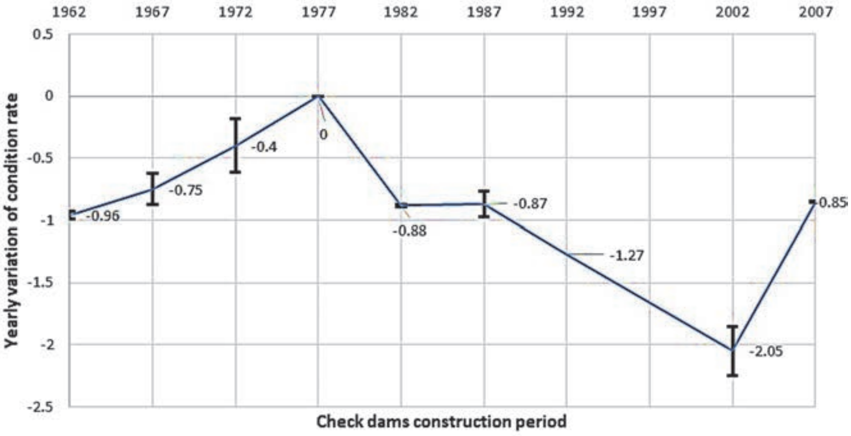


Fig. 7. Influence of the check dams age against the yearly variation of the condition rate

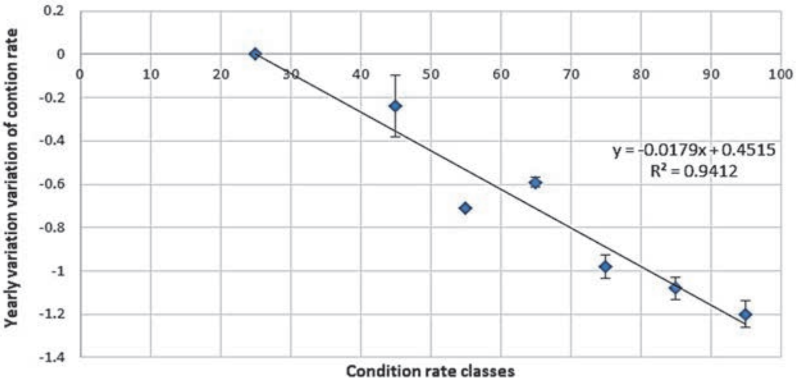
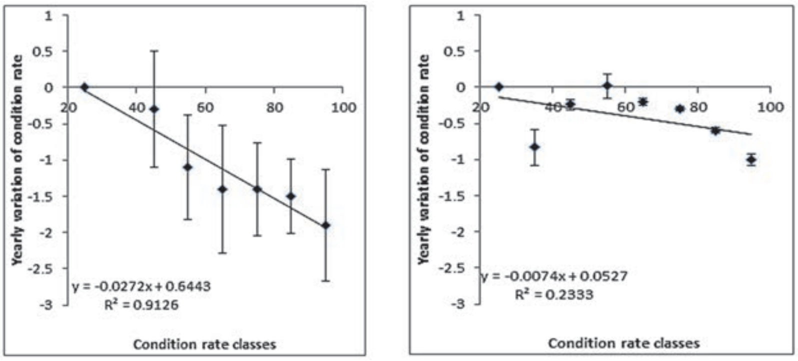


Fig. 8. Influence of the initial status against the annual change in the status index

3.4. Influence of the structure's height on the variation in condition rate

Another criterion for classifying the condition rate is the height of the structures. With a total of 192 check dams, which have heights varying between 0 (channel bed level, 33 traverses), less than 2 m in height (87), and elevations greater than 2 m (maximum height of 6.0 m for 72 dams), we can observe that a moderate height of a check dam is transposed into a lower variation in its condition rate. Compared to greater height check dams, structures between 0 to 2 m are more damaged due to the torrential transport. After the available storage volume for sediments of each structure is full, the sediments transported over the dams is re-established, which may create substantial erosions. Small structures with small retension capacity are consequently more rapidly subject to overtopping of sediment transport and the related abrasion problems. The influence of the height is also confirmed by the Fisher test, which indicates that the height is significant for check dam physical status, this result is obtained in other studies (Dell'Agnese et al., 2013). After the graphical representation and statistical analysis of the yearly average condition rate in relation to the height, the trend-line has a correlation index of 0.988 for structures less than 4 m (Fig. 10).



(a) (b)

Fig. 9. Influence of the construction materials: (a) Concrete; (b) Masonry

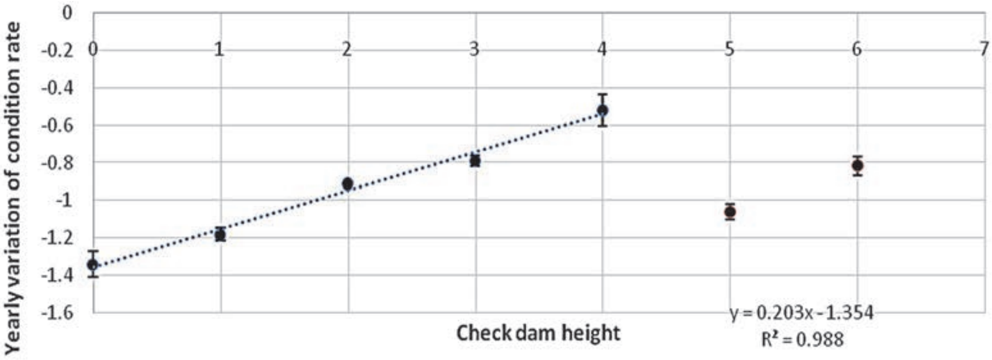


Fig. 10. Variation of the state index gradient in the function of the height of the work

Structures with height over 4 m are vulnerable, the principal reason being works age, all those works being constructed before the 1970s. In the first inventory, the operating time of those works was already outdated. Another reason can be degradation which causes further damages, water loaded with sediments being the decisive factor. Water discharged throw the overflow of the weir, where kinetic energy increases in accordance with heights create premature abrasions and intensify undermining. Therefore, dams with height between 2 - 4 m thus experience less damage average.

4. Conclusions

This study aimed was to analyze the behavior of the several check dams placed in different conditions. For this purpose, 192 check dams were twice inventoried, done in a 5-8-year interval. In this study the influence of age, construction material and height of the check dams on the condition rate variation were analyzed. Based on the 2 classes of construction material adopted was identified that the concrete structures were weaker than masonry structure with a yearly variation of -1.9±0.77 compared to -1.0±0.08, quality of the materials (poor concrete quality) and construction technology were relevant in the structure damages evolution. It was found that the check dams with a good physical status in the first inventory suffered severe degradation over time compared to a structure with a bad condition in the first.

In the Romanian case, it has been proven that recent dams have a high yearly variation, with an average of -1.5 condition rate point for structure constructed after 2005. Regarding the height of the dams was understood that height between 0-2 m and structures over 4 m height degraded faster compared to the 2-4m interval.

It is recommended to evaluate the condition of each check dams from the valley, necessary after all violent flow, with torrential transport or after the spring period (after the snowmelt) to establish the necessary interventions and to evaluate check dams situation. In other words, without any evaluation and observation from the field, all systems from one valley can be put in danger due to a single structure with severe damages or, why not, put out of use.

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