Comparison of laws, procedures, organizations and technical rules for dams and dikes safety in Poland and France

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English summary

Human errors and random nature processes very often resulted in dams and dikes disasters. Therefore there is a continuous work on improvement of technical rules, laws, procedures and organization related to dikes and dams safety. They concern all stages of a structure's "life": planning, designing, realization and maintenance, which all are equally important.
The present paper has for objective to describe, analyze and compare various aspects related to dam and dike safety, in Poland and France. It presents in both countries the state administrations, public and private organizations which dikes and dams belong or are submitted to, Next, dikes and dams classification is characterized. This helps as a basis to present the procedures, administration structures, law acts and rules for the planning, building, designing and maintenance, and also the methods for minimizing hazards and failure risks. Finally Polish and French laws and technical rules concerning dams and dikes dimensioning are presented.

Résumé français : *Comparaison des lois, procédures, organisations et règles techniques relatives à la sécurité des barrages et des digues en Pologne et en France*

Les erreurs humaines et les processus aléatoires de la nature ont très souvent eu comme conséquence des catastrophes sur des barrages et des digues. Par conséquent, il y a un travail continu sur l'amélioration des règles techniques, des lois, des procédures et de l'organisation, liées à la sécurité des digues et barrages. Ces aspects concernent toutes les étapes de la "vie" d'une structure : planification, conception, réalisation et entretien, qui sont toutes également importantes. Le présent article a pour objectif de décrire, d'analyser et comparer divers aspects relatifs à la sécurité des barrages et des digues, en Pologne et en France. Il présente dans un premier temps les Administrations de l'Etat et les organisations publiques et privées auxquelles les digues et les barrages appartiennent ou sont soumis, dans chacun des deux pays. Puis, la classification des digues et des barrages est présentée. Ceci sert de base pour présenter ensuite les procédures, les structures administratives, les lois et règlements relatifs à la planification, à la construction, à la conception et à l'entretien, ainsi que les méthodes destinées à réduire au minimum les risques de rupture. Enfin, les lois et règles techniques polonaises et françaises au sujet du dimensionnement des barrages et des digues sont présentées.

Streszczenie polskie : *Porównanie praw, procedur i struktur oraz wybranych zasad technicznych w zakresie bezpieczeństwa wałów i zapór w Polsce i we Francji*

Ludzka omylność i nieprzewidywalność natury niejednokrotnie wcześniej prowadziły już do katastrof zapór i wałów. Dlatego też ciągle dąży się do poprawiania i ulepszania istniejących już procedur i struktur, praw i całokształtu zasad sztuki technicznej mających zapewnić bezpieczeństwo tym obiektom. Dotyczy to wszystkich etapów "życia" wałów i zapór, a więc ich: planowania, projektowania i budowania, oraz eksploatacji.
Celem poniższego artykułu jest omówienie i analiza szeregu aspektów dotyczących zapewnienia bezpieczeństwa wałom i zaporom w Polsce i we Francji. Przedstawiono w nim kolejno organy państwowe, oraz publiczne i prywatne struktury związane z wałami i zaporami w obu krajach. Następnie scharakteryzowano podział wałów i zapór w Polsce i we Francji, który to jest bazą do przedstawienia procedur, struktur administracyjnych, praw i zasad technicznych dotyczących planowania, realizacji, nadzoru a także metod zmniejszania ryzyka awarii i katastrofy tychże obiektów. Na końcu przedstawiono polskie i francuskie prawa i reguły dotyczące generalnie wybranych zasad wymiarowania wałów i zapór

1. Introduction

Human errors and random nature processes very often resulted in dams and dikes disasters. We can mention the catastrophe in Malpasset where 500 people were killed because of the wave that was created after the dam's failure, or dikes catastrophes during 2002 floods in Poland and France where many people perished and moreover very large flood looses occurred. In Poland there are 174 higher dams (they belong to classes from I to III; chapter 2,1 Polish dams and dikes classification), 650 lower ones (class IV), and almost 9700 km of dikes. In France there are about 300 dams higher than 20m, 200 dams lower than 20m but nonetheless interesting public safety and from 7500 to 12000km of dikes (their amount isn't sure because they are still being identified). These values show the scale of the possible risk for large inhabited areas in both countries. So, there is a continuous work on improving technical rules, laws, procedures and organization related to dikes and dams safety. They concern all stages of a structure's "life": planning, designing, realization and maintenance, which all are equally important. But in many cases particular elements and aspects of these stages have different solutions in both countries. It is very interesting, or even necessary, to compare them between themselves in order to chose the best one, or suitable one depending on needs. Therefore this article was written to present this comparison, as a result of collaboration between Polish Cracow University of Technology and French Cemagref.

2. Dams and dikes classification.

There are different attitudes towards dams and dikes classification in France and Poland. While in France for dikes and dams there is a classification of works interesting or not public safety, in Poland both dams and dikes are classified into one of four classes depending on different indicators.

2.1 Polish dams and dikes classification.

In Poland, dams and dikes are classified into one of four classes of hydraulic structures. A structure belongs to the class which has the lowest indicator pointed by any from the checked ones. There are nine indicators and, in Table 1, the five most important ones related to public safety are presented. Class of construction defines : technical conditions for calculating flows, coefficients to structure stability analysis, minimal freeboard, but also limits of preliminary design studies and main project studies, level of monitoring equipment and range of control.

Name, profile or function of the structure	Description of indicator	Value of indicator for **class I**	Value of indicator for **class II**	Value of indicator for **class III**	Value of indicator for **class IV**
Type of foundation: a) bed-rock b) not bed-rock	Maximum water level H [m]	H>30 m	15<H<=30 m	5<H<= 15 m	2<H<= 5 m
		H>20 m	10<H<=20 m	5<H<= 10 m	2<H<= 5 m
Structures whose failure can cause emptying of reservoir and flood wave	a) Capacity of reservoir V [m^3]	V>50 hm^3	20<V<=50 hm^3	5<V<=20 hm^3	0,2<V<= 5 hm^3
	b) Submersion area caused by the wave for Normal Water Level F [km^2]	F>50 km^2	10<F<=50 km^2	1<F<= 10 km^2	F<=1 km^2
	c) Number of people in submersion area L [amount of persons]	L>300 people	80<L<= 300 people	10<L<= 80 people	L<=10 people
Structures for flood protection	Protected area F [m^2]	F>300km^2	150<F<= 300 k m^2	10<F<= 150 km^2	F<=10 km^2

Table 1. Simplified classification of Polish dams and dikes

2.2 French dams and dikes classification.

Dams and dikes in France can be classified into a group interesting or not public safety.

A dam is classified as “interesting public safety” if it is higher than 20m, or lower than 20m but whose failure can cause hazard for inhabited area or important communication ways. For dams interesting public safety there are obligations and control rules that concern the building stage and, later, structure maintenance. For dams which are not interesting public safety, the only general law is about owner responsibility for looses to any outside party, including particularly the case of failure. Classification of French dikes was recently introduced by ministerial circular on 6 August 2003. On the base of a national dikes inventory, which is being realized (starting from 1999), and already prepared atlases of submersible areas, all existing dikes must be classified as interesting or not public safety. Of course , this classification also will be applied to dikes which will be built in the future. To the group of dikes important for public safety belongs the ones which failure threatens people’s life, important communication or telecommunication lines, or can create serious pollution.

3. Structures concerning dikes and dams.

The main difference between French and Polish organisational structures concerning dams and dikes is that the Polish ones are much more complicated.
In France there are three ministries: Transport, Industry and Environment in which area of responsibility are dams and dikes. Each one has its own control service organisation. Control service is supported by special technical service. For example, dams for flood protection, alimentation in drinking water, irrigation, sport and recreation, production of hydroelectric power < 4500KW and also flood dikes and dikes of irrigation canals are under control of the ministry in charge of environment. Water Police, which is their service control, receives technical assistance from Cemagref (Agricultural and Environmental Engineering Research Center).
In France there are three levels of territorial division: State -> Region -> Department -> Communes. In every France region (or department), Water Police is subordinate to prefecture. The prefecture is responsible for dams and dikes project authorization or declaration approval. Additionally in France, for dams higher than 20m, was created (in 1966, six years after dam's catastrophe in Malpasset) a special inter-ministry committee of specialists called CTPB (Dams Permanent Technical Committee) to check and give advice on every project (building or big repairs).
In Poland there are also three levels of territorial division: State -> voivodshipes -> local district -> communes. On every level of this structure there are both a state administration and a self-government. And almost all of these levels of administrative structures are engaged in procedures of dam or dike project authorization. It would be very long to write about them all, so only voivodship, level, as the most important, will be presented here. There are voivoda - representative of state administration, and voivodship, marshal - representative of self government. Voivoda among other things is responsible for "water supply and sewage effluent disposal consent" and "building license" in the stage of any dams and dikes project authorization. The state is the owner of most of the flood dikes in Poland. Voivodship marshal is its representative in their management. He authorizes Lands Reclamation Authority (WZiR) to realize this function.
Moreover there are three other important institutions for dams and dikes in Poland. The first one is Water Management Board. It divides Poland into six regions, which generally corresponds to the catchments of main Polish rivers. Directors of regional Water Management Departments, among other things, are responsible for agreements concerning water economy ventures, water management planning and controlling, water cadaster, acting of owner to hydraulic structure (there are also dams and dikes) subordinated to them, coordination of flood control measures. Inspectors of Water Management Departments controls water law application. The second one is General Office of Building. It is a central unit of state administration in charge of architectural and building administration and building inspection. In these maters voivoda of each voivodship, is subordinated to General Office of Building, which by means of:
a) Voivodship, Architectural-Building Department (among other things), gives building license and structure use permit.
b) Voivodship, Inspector of Building Control controls building law fulfillment.

The last one is Committee for Technical Assessment of Dams (OTKZ) in Institute of Meteorology and Water Management (National Research Institution). OTKZ is a service control for the dams of I and II class. It realizes every year control visits for every dam in classes I and II.

4. Stages in the life of dams and dikes and their importance to safety

All elements of all dams' and flood dikes' "life" stages are important for their safety. Here are presented some chosen ones.

4.1 Stage of designing

In France every project of dam or flood dike must be authorized or declared in prefecture. If necessary, prefecture sends design documentation to other institutions (like, for example, service control) where it is checked or where opinions about it are expressed, and then it goes back to prefecture. In a project's authorization act, the Prefect can add obligations that have to be fulfilled.
For dams higher than 20m the project must also be checked by the special committee CTPB. This committee checks the dam project. Its advices can concern the project but also the building stage and maintenance.
Here also should be mentioned the French Committee on Large Dams (CFGB), which is affiliated to International Committee on Large Dams (ICOLD). It is a scientific society made from experts in all domains related to dams, which produces scientific recommendations for them. It has a large influence on technical guidelines concerning dams in France.
In Poland, as it was written in chapter 3, dams' or dikes' project authorization is subject to some authorizations in different parts of administrative structures. The most important are "water supply and sewage effluent disposal consent" which states rules, conditions and obligations for water use, and "building license" which is given after control if all designing solutions in the project are in accordance to the law. Building license is the base to start building. There is no special commission to check project as CTPB in France, but every project (also dam and dike) must be checked by a second design engineer.
The elements of design documentation are similar in both countries. There are: Environmental impact report, Project, Geotechnical studies (in France this is a part of project) and Studies of structure failure consequences (not for every project, in France, mainly for dams and dikes interesting Public safety).

4.2 Stage of building

In France with the authorization of the dam's or dike's project, the Prefect can also give (as it was described in last paragraph) obligations which must be fulfilled. All conditions established by CTPB for dams which are subordinate to it must also be realized, if the Prefect asks for it.
At all time a dam's or dike's building is supervised by a design engineer. The Control service can control the area of building whenever it wants, but in case of a dam, first of all, they check foundations before they are covered, and finally they check the finished dam to agree for first filling. These control procedures applied to

dams concern only dams interesting public safety. For the other ones there are no obligated rules. It is left to the control service appreciation.
After dike completion or dam first filling, reports for the control service must be prepared. For dams higher than 20m a special report for CTPB is also necessary.
In Poland as in France dam's and dike's building are supervised by a design engineer. But additionally there is also an investor supervisor who confirms realization of works (particularly that which are covered) and confirms also faulty works corrections. In case of a dam first filling, they both belong, with other necessary specialists, to the "first filling commission" which controls dams' first filling.
Voivodship Inspector of Building Control has power to control building whenever he wants, particularly in case of a building law not being fulfilled. He is also a member of the commission which controls a dike when the building is finished or a dam before its first filling.

4.3 Stage of maintenance and methods for minimizing hazard and failure risk

4.3.1 Stage of dike's maintenance.

The new circular from August 2003, which was already mentioned in this article, changed attitude to dikes maintenance in France. French dikes may now (as dams) be classified into a group of dikes interesting or not public safety. Rules of their classification are presented in the chapter 2,2 "French dam's and dike's classification". Because many dikes haven't been controlled for years until now, some necessary steps after their classification must be realized (they are also described by new circular). The first step is the owner identification . The next step is complement of dike's documentation: administrative, technical, management. Then takes place a diagnostic visit in presence of control service, which results in obligation of necessary repairs. And after a time of this "orders", the owner must prepare the dike's book of maintenance rules and procedures which should then be approved by control service and used by himself.
In the new circular also are introduced very important obligations concerning dike control visit. Owner has to organize at least one dike's visit each year with his contractor (consultant engineer), or two times per year if there were high water levels. Another important rule is the organization of a control visit, at least one every two years, in presence of Water Police with a complete report (written by owner's contractor) about observations and notices.
In Poland dike's maintenance looks a little different because Lands Reclamation Authority (WZiR), which manages most of dikes in Poland, has it own control structures. The sections of dikes are division between WZiR's inspectors, who are obligated to visit them in spring and autumn and who prepare post visit report. Voivodship, Inspectors of Building Control controls if control visit and report are done (at least one per year).

4.3.2 Stage of dam's maintenance

There is an interesting difference between French and Polish dams maintenance. It concerns control visits. In France dams important for public safety have an annual control visit which is realized by the control service in the presence of owner and owner's contractor (consultant engineer). Owner's contractor also prepares an annual report. Every second year this report includes a deeper analysis of monitoring measurements. Finally, every ten years the visit is to be done with emptied reservoir (except for justified exceptions).
In Poland control visits are realized every year by the dam's owner contractor (engineer), who also prepares post visit report. Every fifth year, as it was written in chapter about Polish structure, OTKZ controls the correctness of these annual control visits for class I and II dams . Moreover, Voivodship Inspectors of Building Control controls if every annual report is done for all dam's classes.
Surely it is a very good idea to organize every ten years a visit with reservoir emptying, as it really shows a dam's condition, particularly of its usually hidden parts.

4.3.3 The methods for minimizing hazard and failure risk

In the case of dams we can distinguish two types of risks, which are generally connected with two different maintenance states. First, for normal dams maintenance there is a risk for people who can be in the area downstream from the dam, caused by sudden water level increase because of dam operation. In both countries this level of risk is reduced in a similar way by notice boards and local community information, but moreover sound signal is used in Poland. Much more dangerous is the second type of risk, which is connected to dam's failure. In France for dams higher than 20m and with capacity bigger than 15 hm^3 the Prefect prepares Plans for Particular Intervention (PPI). PPI presents menaces created in case of dam's catastrophe. It enumerates the consequences of this situation, but also states what must be installed or organized by the dam's owner to reduce dam's failure consequences(particularly sirens), and measures to alarm diffusion. The base of PPI are risk analysis and analysis of created flood wave. Two other plans are also prepared by Prefect. Plan ORSEC (Organization of help) concerns public and private resources, which should be used in case of any catastrophe, and conditions to use them by pertinent authorities. PSS - Plan of Special Protection is prepared to protect against risks related to dams which are not submitted to PPI.
In Poland for each level of the country division its local authorities should prepare assessment of flood protection. But in case of elemental disaster or technical catastrophe they also lead the actions to limit its results with the help of Crises Management Co-ordination Groups. They prepare Plan for Crisis Management which characterizes: actions for menaces monitoring, state and private services, organization, institution and measures that can be used to limit range of elemental disaster influence and lessen its results, it also presents procedures of cooperation between them and procedures for all actions listed by Plan. One of the basis necessary to prepare Plan are instructions for actions and measures to take in case of dam's failure. They are prepared after dam's first filling.

5. Technical rules related to dams and dikes dimensioning

In this chapter are presented some chosen aspects of the technical rules related to dams and dikes dimensioning in Poland and France. Elements like: design flows, methods and rules related to outlet works discharge and inter dikes distance discharge calculations, safety height of water construction above levels of water and stability analysis are often calculated by different methods in both countries.
A very interesting difference is that in Poland technical rules related to hydraulic structure dimensioning are part of the law, while in France they aren't. In Poland, technical rules are imposed by ministerial decree about technical conditions for hydraulic structures, which was prepared by a team of specialists, on the basis of actual hydraulic engineering knowledge and knowledge about regional conditions. In France technical rules are not defined by a law, but rather by general consensus among technical experts (including work by the committees CFGB, CTPB, …). Law defines general principles, and to what control process structures are submitted or not, but does not rule out technical calculations. So, in France, an engineer is more free as regards hydraulic structure (dams and dikes) general designing and dimensioning. Moreover, comparison of French technical rules for dams higher than 20m with the same ones in Poland is very difficult, because every case of such dams in France is considered in an individual way by CTPB (CTPB and its working are described in chapter 3,2 about stage of designing).
The situation as regards dikes is very similar for dams, there is also no official technical rules. New laws concerning dikes maintenance and their classification were recently introduced, so technical rules consensus among technical experts are still to be established.

5.1 Design flows

One of the basic parameter needed to design a dam or a dike is a flow, aptly called design flow. In Poland, as well as in France, the concept of design flows usually is characterized by its occurrence probability (in France flood return period is rather used).

5.1.1 Poland

There are two kinds of design flood in Poland, and for both, the outlets and spillways of the dam or the inter dikes cross section are checked. These are :
-Base flood Q_m– it is the flood with defined by law probability of appearance for normal maintenance of the hydraulic structure. It is used to determine:

- Maximum Water Level and dimension the spillways and outlets for dams,
- parameters of safety inter dikes distance cross section

-Control flood Q_k- It is maximal possible design flow. Its probability of appearance is defined by law and it is lower than the one for base flood. It is used to calculate exceptional conditions of the hydraulic structures maintenance.
It is used to calculate discharges by spillways and outlets or inter dikes cross-section without any risk of dam or dike failure, but with the possibility of some damages.

Depending on the class of the hydraulic structure (look at chapter 2) the base flood and control flood have a different value for their occurrence probability. It is presented in table 2.

Type of hydraulic structure	Flood flow	Occurrence probability of flood p% / flood return perion in years, for different structure's class:			
		I	II	III	IV
Dams which will be destroyed in case of overflowing (for example earth dam) but not dike	Base flow Q_m	0,1/1000	0,3/333	0,5/200	1,0/100
	Control flow Q_K	0,02/5000	0,05/2000	0,2/500	0,5/200
a)Dam which won't be destroyed in case of overflowing b)Dike	Base flow Q_m	0,5/200	1,0/100	2,0/50	3,0/33
	Control flow Q_K	0,1/1000	0,3/333	0,5/200	1,0/100

Table 2. Occurrence probability of base floods and control floods for dams and dikes in Poland

5.1.2 France

In France, there are also, for important hydraulic works, two kinds of design flow which are taken into the calculation of dams. These are: design flood and safety flood**.**

Design flood is the flood with the smallest occurrence probability considered in the reservoir. It is used to determine the Maximum water level and to dimension the spillway(s).

For dams, the value of the design flood's occurrence probability depends on the parameter $H^2\sqrt{V}$ (where H- dam height in metres, V- reservoir volume in hm^3), for embankment dam, is presented in table 3. But when a dam belongs to a group of dams interesting public safety (look at chapter 2), the minimal occurrence probability should never be less than 0,1.

$H^2\sqrt{V}$	<5	5 to 30	30 to 100	100 to 700	>700
Occurrence probability of the design flood p% / flood return period in years,	1,0/100	0,5/200	0,1/1000	0,05/2000	0,01/10000

Table 3. Occurrence probability of the design flood for an French earthfill dam without vulnerability downstream

(where: H: dam height in m, V reservoir volume in millions of m^3)

Safety flood- this is the worst flood that can occur to the dam without any risk of failure. For example for a dam with an impervious core, it is the flood for which the reservoir water level will rise to the level of the core.

And it is important to say again that, for dam higher then 20m, occurrence probability of the design flood and safety flood is definitely established after individual analysis by CTPB.

For French dikes there are no official rules now and no guidelines about design flows either. But generally the attitude to this matter should be similar to the one towards dams. So we can distinguish a design flood for which protected area is not protected anymore (flooding by weirs), but the dike is not destroyed. Second flood is similar to the safety flood for dams: it is the worst flood that can occur in the space between the dikes without any risk of their failure.
In France the design flood's occurrence probability for dikes is usually assumed higher than for dams, it's from 10% to 0,1%. For more important industrial, and inhabited areas or communication ways (roads or trains) these values can be smaller. The most important conclusion concerning flood's occurrence probability for dams and dikes in Poland and France is that in both countries it is connected to level of risk for the sidestream area and balanced by cost of safety protection.

5.2 Methods of Design flows calculations

The next logical step after presentation of flow's occurrence probability is the presentation of Design flows calculation methods.
They are very similar in both countries. We can distinguish:
-Empirical formulas and regional formulas – In both countries these are used for small dams and dikes if their failure is not susceptible to cause heavy damages and if there is no other hydrological data.
-Method of an analogy to a similar catchment – In Poland this method is considered to be more accurate than empirical formulas, and for dams where there is no hydrological data it is used to lengthen the data series. In France it isn't used very often, except for small catchments (<500km2)
-The PMP-PMF method - (Probable Maximum Precipitation – Probable Maximum Flood). It is an American method, which consists in calculating the Probable Maximum Flood on the base of observed precipitation data and maximizing the meteorological parameters linked to rainfall (PNP). It is rather rarely used in France and Poland.
-Statistical methods – There is no official statistical method now in Poland and France and different methods are used. They are constantly in progress. In Poland the old official method, based on Pearson type III and quantiles method, lost its validity. In France the most popular method is now GRADEX method, where the main parameter is proportional to the standard deviation of maximum precipitation values; it gives highly different results from the previous one, which is quite frowned upon.
-Modeling – There are many models in both countries without any official rules. These are hydrological or hydraulic models or combination of both types. Models of flood scenario simulation are also used, which have the advantage to produce realistic flood scenario, better adapted to outlet dimensioning than rough maximum flood calculation.

5.3 Methods and rules for dam's spillways and outlets discharge, and also inter dikes cross-sections discharge calculations.

Accurate hydraulic computation of dam's outlets and spillways and inter dikes cross-section for design flows are significant as regards dams and dikes safety.

Assumptions and conditions taken into consideration in these calculations are very important.

5.3.1 Polish computation rules of inter dikes cross-section discharge

In case of dike designing, the engineer must check two conditions. One for normal dike's maintenance: the freeboard for base flood (Q_m) must be higher than the minimal required one (Table 4). The second condition for exceptional dike's maintenance : the freeboard for control flood (Q_k) must also be higher than the minimal required one (Table 4). The first condition does not seem to be necessary because control flood is always bigger than base flood. The explanation is that the minimal required freeboard for control flood is not the same one as for base flood, but it is lower, as can be seen in Table 4.

Type of hydraulic structure	Conditions of exploitation	Minimal freeboard, for structures for classes I to IV (in metres)							
		Static surface of water				Water level with waving			
		I	II	III	IV	I	II	III	IV
Embankment dams and dikes	Max. water level (only for dams)	2,0	1,5	1,0	0,7	0,7	0,5	0,5	0,5
	Water level for base flow	1,3	1,0	0,7	0,5	0,5	0,3	0,3	0,3
	Water level for exceptional maintenance conditions (control flow)	0,3	0,3	0,3	0,3	without waving			
Concrete hydraulic structures	Max. water level (only for dams)	1,5	1,0	0,7	0,5	0,5	0,4	0,4	0,4
	Water level for base flow	1,0	0,7	0,5	0,5	0,3	0,3	0,3	0,3
	Water level for exceptional maintenance conditions (control flow)	0,1	0,1	0,1	0,1	without waving			

Table 4. Safety height of Polish hydraulic structures crest above water level

5.3.2 French computation rules of inter levee distance discharge

The calculation procedure for dikes in France is the same as in Poland. The design engineer checks if for design flood and safety flood; the necessary freeboard are left. But as it was already written there are no official rules for design flood and safety flood, neither for minimal freeboards for dikes in France. So assessment of their minimal height belongs to design engineer and control service.

5.3.3 Polish and French calculation rules for dam's outlets and spillways discharge

The calculation for dam's spillways and outlets discharge in Poland and France has many rules and conditions which must be fulfilled. They concern outlets and spillways dimensioning and their structural conditions, as well as minimal freeboards. Only the most important ones will be presented here.

Because in Poland law defines most of these conditions, this is a good base to compare them with the French ones where there are no official guidelines for design engineer. Moreover, for dams higher than 20m they are checked by CTPB.
In a general way, about these calculations, the first step in both countries is assumption of Maximal water level (MWL) in a reservoir. It depends on the valley geomorphologic and hydrological parameters and dam's use. Then MWL and associated minimal freeboard give the level of the dam's crest. Simultaneously, it is necessary to calculate the dam's spillways and outlets dimensions for design flows discharge and with respect of the safety freeboard.

This introduction can be developed to the following computational points:

● In Poland; first an assumption of maximal level water and freeboard calculation with and without waving. The value of minimal freeboard is presented in Table 4.
In France there are several guideline formulas for minimum freeboard. One of them is: :$(H^2V^{0,5})^{1/4}/4$ (H-dam height in m, V-reservoir volume in millions of m3 :) but there waving should also be taken into consideration.
● In Poland; checking conditions for normal dam's maintenance (for base flood). In the calculation it must be taken into account that some of the bottom outlets, galleries, siphon spillways and power tunnels don't work (they are closed and this amount is defined in ministerial decree). For example for a number of bottom outlets from 1 to 3, one is calculated as closed, from 4 to 6, two are closed, and from 7 to 9, three are closed.
Moreover if there are spillways with gates, one of them must be calculated as closed (its mechanism could be broken or blocked). For these assumptions minimal required freeboard is checked (Table 4) .
In France; this is calculated differently in each dam. Generally minimal freeboard for design flood with and without waving is checked.
● In Poland; checking of conditions for exceptional dam's maintenance (for control flood). All spillways and outflows are calculated as opened. The minimal required freeboard is taken from the Table 4.
In France; conditions of safety flood discharge are found for each dam by individual analysis.
● There are also some important and interesting constructional and dimensional structural conditions in Poland and guidelines in France for spillways and outlets.
One of the most important rule for design floods discharge calculation in Poland is that a spillway must discharge at least 80% of the base flood. Another one is that if water lifting is higher than 2m and capacity of reservoir > 200 000 cubic meters, the bottom outlet must have two pipes at least, with possibility of repairing one of them without influence on the other one's efficiency. There is no similar obligatory rule in France, and some higher dams have only one bottom outlet. In both countries bottom outlets are considered as necessary for emptying reservoir's dams. The upstream-downstream bottom outlet slope in France should be ≥ 1% while in Poland ≥ 0,2%.

5.4 Stability analysis in Poland and France

In Poland as in France there are various methods used for stability analysis. But as it was already mentioned Polish technical rules concerning stability analysis are characterized by norms and ministerial decree, while in France there is no official rules for them.

For smaller embankment dams in Poland as well as in France older methods of Bishop, Fellenius or limit state are used. In Poland the limit state method is well developed and defined by law. More precise coefficients are used, which in detail allow to calculate different cases of stability analysis. For example, among other ones are used special coefficient consequences of hydraulic structure destroying γ_n, and coefficient loads configuration γ_{Lc}.

A very important aspect of stability calculation is the problem of an inaccuracy in measurements and error propagation which does not depend on design engineer, but which are able to cause that the structure can be unstable , although fulfilling the inequality of state's method. Therefore in Poland this error is estimated essentially for dams I and II class.

As regards the stability of gravity dams all necessary cases for sliding, stability against overturning and internal stability are calculated in both countries. For the higher gravity dam as well as fill dams finite elements method is used. In Poland there are no arch dams, while in France there is a large amount of them and their stability is usually calculated by finite elements method.

The main difference in calculating a dam's stability between Poland and France is that in France the earthquake influence is additionally taken into consideration.

6 Conclusion

There are different classifications of dams and dikes in both countries. In France classifying into a group interesting public safety provides the owner and the control service with organizational rules concerning structure control, at the time of its building and during its maintenance. A very interesting idea is the control of every dam project higher than 20 m by a special committee of specialists: CTPB. It gives the maximum possible control for the dam project. In France there are no official rules concerning technical designing for dams and dikes. This is why the responsibility of the design engineer and control service seems to be higher than in Poland where law, simultaneously with classification of dam or dike, defines rules concerning organization of control but also technical rules. They guarantee structure's safety because minimum technical parameters of safety for each class of structure is imposed. But at the same time it restricts the engineer's designing freedom, as well as the possibility of introducing improvements to design methods. There are also different organizations (as for exemple control service) concerning dams and dikes in both countries. Notwithstanding these differences, all stages of dams' "life" are well controlled in Poland and France. In the case of dikes, in Poland control is already ongoing while in France a law from August 2003 is a new base to organize a good dikes control system.

References:

Degoutte G. et al., 2002, *Small dams,* first publishing on digital disc only, Cemagref and Engref edition, 173 p.
Lino M., Mériaux P., Royet.P., 1999, Méthodologie de diagnostic des digues, Cemagref, 223 p.
Poupart M., Royet P., 2001, *La surveillance des barrages,* CFGB Technical symposium 10 to 11 may 2001
Royet P., mai 2002, *Sécurité des barrages autorisés aspects réglementaires et administratifs ,* Cemagref, 17p.
Ministère de l'Agriculture, 1977, *Technique des barrages en aménagement rural*, Paris, 325 p.
Małopolski Zarząd Melioracji i Urządzeń Wodnych, *Wytyczne przeprowadzania przeglądów stanu technicznego wałów przeciwpowodziowych i sposobu ich dokumentowania,* internal papers, 10 p.
Centralny Urząd Gospodarki Wodnej, 1969, *Wytyczne opracowywania instrukcji utrzymania budowli pietrzących wodę oraz eksploatacji mającej wpływ na ich bezpieczeństwo*, Warszawa, internal papers, 16p.
Centralny Urząd Gospodarki Wodnej, 1969, Wyposażenie budowli hydrotechnicznych w urządzenia kontrolno pomiarowe, Warszawa, Wydawnictwo Katalogów i Cenników, 61 p.

The main laws, circulars and decrees:

Arrêté from 13th of February 2002**,** *Fixant les prescriptions générales applicable aux installations, ouvrages, travaux ou activités soumis à déclaration en application des articles L.241-1 à L214-6 du code de l'environnement et relevant de la rubrique 2.5.2 (2º) de la nomenclature annexée au décret nº93-743 du mars 1997 modifié*

Circulare nº70-15 from 14th août 1970, *Relative a l'inspection et à la surveillance des barrages intéressant la sécurité publique*

Circulare nº75-65 from 27th of November 1975, *Relative au* Comité Technique Permanent des Barrages

Circulare from 24th of July 2002**,** *Mise en oeuvre du décret nº2002-202 du 13 février 2002 modifiant ou créant les rubriques 2.5.0, 2.5.2, 2.5.4 et 2.5.5 de la nomenclature «sur l'eau» et des trois arrêtés de prescriptions générales pour les opérations soumises à déclarations au titre de ses rubriques.*

Circulare from 6th of August 2003, *Organisation du contrôle des digues de protection contre les inondation fluviales intéressant la sécurité publique*

Code civil

Code rural

Décret from 17th June 1966, Instituant un Comité Technique Permanent des Barrages

Décret nº88-622 from 29th May of 1988 *Relatif aux Plans d'urgence, pris en application de la loi nº87-565 from 22 July of 1987*