

Maintenance and rehabilitation works on Italian dams A classification procedure and a data collection

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Summary

A Working Group was activated by the ICOLD Italian National Committee, to collect information and data about maintenance and rehabilitation works carried out on Italian dams in the last four decades.

Information for a remarkable number of case histories were collected, reviewed and classified (according to the type of dam, type of problem, adopted technology for the work, etc.).

The main amount of data was provided by the largest Utilities, operating in the hydroelectric sector. A comparatively small contribution was obtained from smaller dam owners.

In Italy less than 10 dam owners manage about 50% of the Italian dams; the remaining 50% is shared among many different owners, managing very few dams each and not supported by internal permanent technical staff.

A final report was completed by the Group in 2012, reporting the collected data and the remarks and considerations derived from them.

The activity of the Group earned general appreciation, pointing out the widespread interest for sharing the knowledge on this topic derived from actual experiences and results.

A second phase of the activity of the Group is going to be started, looking for the involvement of most dam owners to extend the data collection and the dissemination of the results.

The procedure to monitor and to improve the information on existing dams and on the rehabilitation interventions executed is drafted.

The perspective is to compare and to correlate this information management with initiatives developed on similar aspects by other members of ICOLD.

Foreword

The rehabilitation of existing dam is presently the main concern in Europe, where the most important and feasible projects have been already implemented, and where the present capital in terms of infrastructure

requires sometimes important interventions for rehabilitation.

Dams aged more than 60 years, in Italy, are over 320 on a total of 533.

In general the behavior of the structures is satisfactory, and their performance exceeds the expected lifetime.

Nevertheless several dams and manmade lakes show their age.

Reservoirs are silted, electromechanical equipment requires updating or exceptional maintenance, in some cases requires the revamping of the imperviousness of the structure or in the foundations.

Frequent seismic events have not provoked damages to dams, that's an important issue, but monitoring of movements and cracks or precautionary strengthening interventions are recommended and foreseen.

Hydrologic trends and hydraulic design practices induce a more careful dimensioning of spillways and bottom outlets. Several structures have been revised or are planned to be resized.

Monitoring of dams behavior or hydraulic events affecting the structure and the reservoir was highly developed and almost all the plants are controlled by new efficient systems, substituting the visual control performed locally by the old fashioned watchmen.

Rehabilitation of plants is generally accompanied by a modification of the purpose of the dam and reservoir.

The water and energy demand is affected by economical changes produced by the globalization, and several plants have been modified to meet a new pattern of production.

The increasing cost of energy and the development of alternative sources of energy (solar, wind) pushes to develop hydroelectric potentialities for a better balancing of the electric network. Plants once considered not economical are now financed.

The contribution of dams to flood management is increasing, as a consequence of the climatologic change. Information, first, and standards have to be focused on this aspect, becoming a priority in European countries.

As a consequence, the designers and the operators are more concerned of the rehabilitation, recovery or conversion of plants then to build new structures.

Maintenance and revamping are now more important activities than new developments. New projects are built in the emerging countries, as China, Brazil, Turkey, India, etc) or in the third world countries to assure energy and water supply or irrigation.

The activity of the Group

The **Gruppo di Lavoro Riabilitazione Dighe** (Working Group on Dam Rehabilitation) produced information on 176 interventions of rehabilitation on dams, performed between 1980 and 2011.

The intervention are split in the table according to the type of problem to be solved and in function of the date of execution.

Types of intervention are:

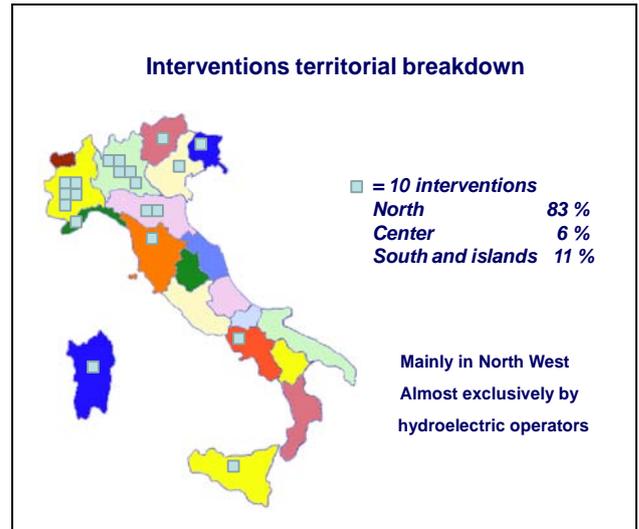
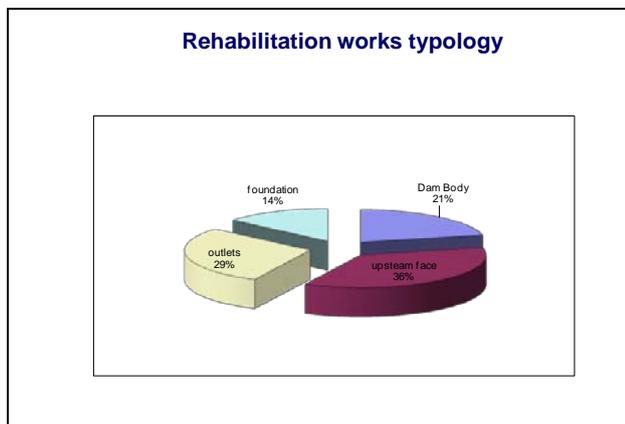
1. Works on the body of the dam;
2. Repairs on the upstream facing of the dam to improve water tightness;
3. Rehabilitation or modernization of the outlets and of the spillways;
4. Interventions on foundations.

Period	1	2	3	4	TOT
before 1970	1	2		1	4
1970-79	1	4	4	0	9
1980-89	1	11	6	1	19
1990-99	7	18	4	4	33
2000-2009	16	17	26	13	72
after 2009	3	4	2	4	13
Not dated	9	4	8	5	26
Tot	38	60	50	28	176

The relevant report was completed in 2012.

Comments on results of the analysis

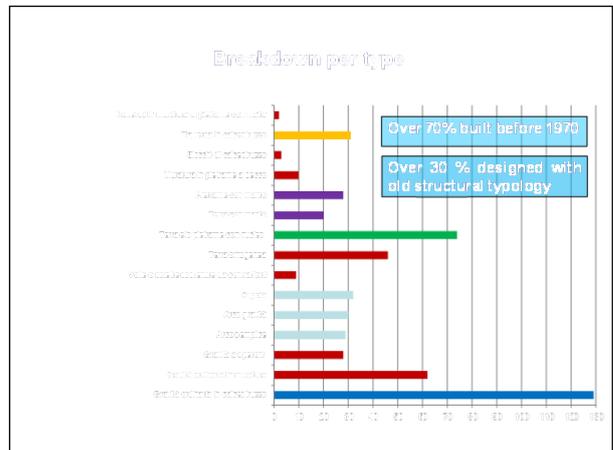
The interventions of rehabilitation are increasing. Main reasons are supposed to be the increasing aging of dams and more severe prescriptions by authorities.



Activities are more frequent on plants operated by industrial companies who have more technical and financial resources

About 40% of dams are operated for irrigation and drinking water by little organizations that only recently are started a process of integration

About 30 % of dams are built adopting structures now anymore used. On this environment the incidence of interventions and modification is quite high. have a structural scheme nowadays abandoned, on that population there is an high incidence of rehabilitation interventions



There is an important number of plants not completed or underutilized for financing problems. The relatively small amount required for maintenance (possibly 1-2% of the investment cost) limits the performance of expensive and strategic infrastructures reducing the effective output.

For 76 cases it was possible to prepare work schedules reporting essentials of several interventions of rehabilitation.

Intervention schedule

Data of the dam.

ITCOLD - Interventi di riabilitazione dighe

Diga di SAN GIACOMO (SO)

Regione:	LOMBARDIA
Quota max regolazione:	1949 m s.m.
Corso d'acqua:	ADDA
Utilizzazione:	IDROELETTRICO
Anno ultimazione:	1950
Concessionario/Gestore:	A2A S.P.A.
Tipologia:	GRAVITA' A SPERONI A VANI INTERNI
Volume invaso:	64 Mm ³
Altezza:	83,5 m



Description of the intervention

ITCOLD - Interventi di riabilitazione dighe

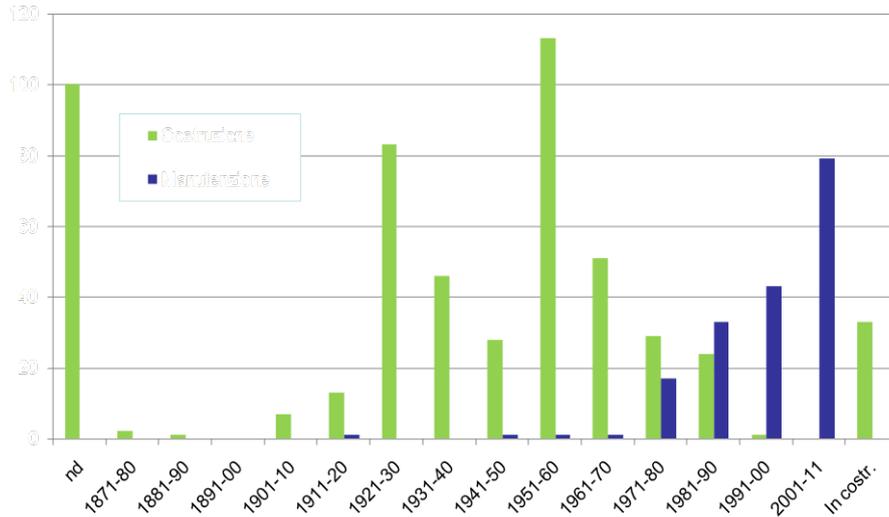
Diga di SAN GIACOMO (SO)

Tipologia intervento:	Fondazione
Periodo di esecuzione:	2003
Motivazione:	Realizzazione schermo impermeabile di valle
Breve descrizione:	Iniezioni di impermeabilizzazione nei calcestruzzi e nella roccia di fondazione mediante iniezioni di miscele cementizie
Progetto:	Studio Lombardi
Direzione lavori:	Geotecna Progetti
Impresa civile:	ATI Edilpinta S.r.l. - Palingeo S.r.l.
Impresa elettromecc.:	nn
Importo appalto:	0,84 M €
Fine lavori:	luglio-03
Riferimento:	P. Valgoi
Commento:	intervento efficace
Eventuali articoli inerenti:	L'acqua n. 4/2009



Building and rehabilitation periods

Several ongoing works not accounted for **Rehabilitation activities increasing**



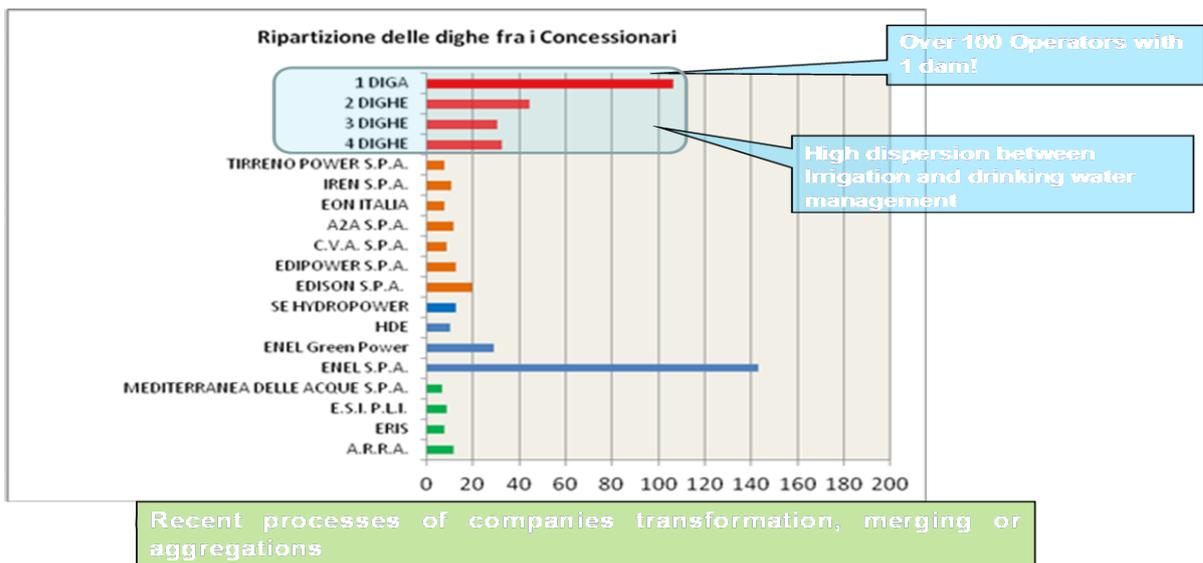
The schedule reports dam data and intervention essentials, as:

- Type of intervention
- Period of intervention
- Short description
- Designer and construction company

- Cost of intervention
- Performance of the intervention

These schedules offers a base information on the specific intervention, giving also the possibility to deepen the information asking to the Administrator of the Database.

Breakdown per operator



Expected action

The activity of the Group continues with an Observatory, appointed to improve the work performed, completing and updating the information on rehabilitations executed, their typology and impact, and constituting a better database accessible by the operators of the specific sector.

The perspective is also to interconnect the database and its specifications with the similar work performed by other ICOLD Groups.

The database is structured in the easiest way to be practical and accessible to the non specialists. It is possible a more structured software and a more efficient interface, but The Group selected the easiest solution to have immediate results.

A more complex and expensive project may be conceived in the future, possibly with other national Committees.

The database we are building now will be easily integrated in the new shiny one.

The database

The database is built according to simple but precise rules.

The simplicity and the uprightness of the procedure is necessary because the access to the database and its updating is carried out by different operators contributing to a single informatics structure.

Therefore it is important to establish simple and precise rules of management and updating of the database.

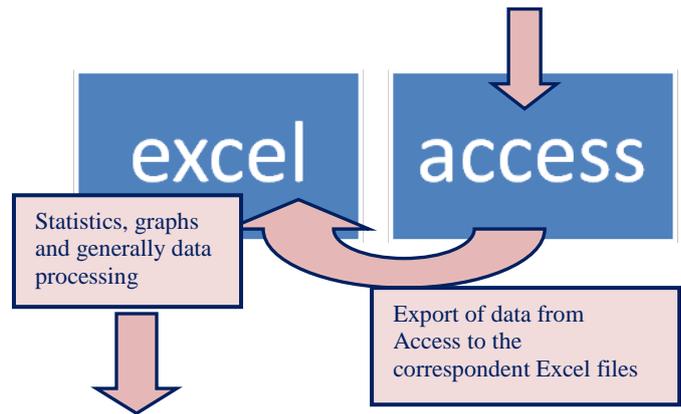
To this purpose the role of an Administrator managing database and accesses is vital. The Administrator is an appointed member of the Working Group, assisted by an IT expert.

Software

The environment chosen is Microsoft Office. The database of the Office suite is not the best, but it is widely know. Additionally the Access program is integrated by the use of Excel, well known by engineers and useful to process data and to develop graphs.

Access, on the contrary, is safer for the conservation of data. On Access is possible to produce queries and to build new files avoiding the risk to corrupt the database.

Transferring data from Excel to Access and back is easy and safe.



Database map

The database is constituted by:

Three **base tables** containing different categories of data. The three tables are linked by the DAM CODE.



Tables are:

- DBdighe,
- DBripristini
- Allegati.

DBdighe (DBdams) keeps the fundamental data of the 533 dams in Italy.

DBripristini (DBrehabilitations) lists the rehabilitation interventions (it is possible to have several interventions for the same dam).

Allegati (Annexes) contains notes, pictures, reports, miscellanea.

Four **Tabelle di Servizio** (Utility tables) list the standard terms to be adopted within the database. In fact key words have to be exactly spelled to allow efficient data retrieval. Tables are related to terms concerning

- Stato (State),
- Tipo (Type),
- Tipointervento (Type of intervention) and
- Uso (Use).



Tabelle di servizio

- Stato
- Tipo
- Tipointervento
- Uso

Three **Interface masks** are used to insert new data or to modify the existing ones. Interface masks are set one for each base table.



Reports may be produced to match the actual analyses. Reports may be produced without any corruption of the database.

Queries and reports may be performed in Access environment, or transfer ring data to Excel, adopting formulas or filters for data processing and then edit reports by using World.



Management rules

In order to properly manage the database, by excel or access, it is essential to rigorously follow some rules. If data are not well managed they are no longer reliable.

Each record corresponds to a fixed and permanent ID, which must be evermore respected.

Data flow must be filtered by an Administrator who oversees the correctness of their form and the input mode.

The Administrator informs collaborators and who contributes to the information system

About standards and procedures to be followed. These procedures must be simple and intuitive. Models and examples are useful.

For each data entry the database must be updated with a new name which includes the updating date.

Old files should be preserved to retrospective researches or data recovery in case of drawbacks.

File name includes:

Identification Title	Date in format yy/mm/dd	Verifier's signature
DBD	111220	LS

The hypothesized file name is DBD111220LS. In this format the file is automatically recorded in date order.

The version number is no more necessary unless there are two versions on the same day, negligible hypothesis.

It's not necessary to specify if it's an excel or an access file, it's understandable through the file extension.

The backup procedure must be regular and reliable.

It would be a good idea to prepare a complete printed copy at fixed dates, for instance every three months, or every series of substantial updates, otherwise if there aren't updates it is not necessary to reprint.

For each printed copy it would be preferable to associate a complete one recorded on a CD.

Base tables

DBdighe		
N°	TYPE	Notes on the field
1	ID	Base code of the dam (generated to the specific purpose, it is not the official code of the dam selected by the Dam Register in Italy)
2	Codice Diga	Code formally adopted by the official register of Italian dams
3	Nome	Name of the dam
4	Data ultimazione 1	Completion date (generally different from the commissionino date)
5	Data ultimazione 2	Completion date of one substantial modification of the dam, involving essential parameter qualifying the structure (as a superelevation)
6	Regione	Region of Italy
7	Coordinate N	North coordinate
8	Coordinate E	East coordinate
9	Fiume	River
10	Bacino imbrifero	Catchment basin (River reaching the sea)
11	Tipo	Type of dam, based on keywords.
12	Altezza	Height of the dam Italian law 584/1994
13	Volume	Reservoir volume on the Italian law 584/1994
14	Quota coronamento	Crest elevation in m a.s.l.
15	Qmaxregolaz	Normal reservoir level in m a.s.l.
16	Concessionario alla costruzione	Name of the Concessionary at the moment of the completion of construction.
17	Pubblicazioni	References of the paper available on the dam
18	Uso	Present use of the reservoir
19	Stato attuale	Present state of the dam
20	Qautorizz	Authorized normal level in case of limitation imposed by the Authorities
21	Vautorizz	Maximum reservoir volume admitted in case of limitation imposed by Authorities.
22	Concessionario attuale	Name of The present Concessionary
23	Riferimento	Reference person, with mail, being informed on the specific dam
24	Commenti e note	Notes and comments
25	Allegati ed immagini	Reference to paper or electronic documents available
26	Test	Restricted area to be used by the Administrator of the database
	Fields related to infos on the dam	
	Fields related to info on the dam, affected by variation and needing regular updating	
	Service fields of the database	

DBripristini

N°	TYPE	Notes on the field
1	ID	Fixed Code of each rehabilitation intervention.
2	Codice Diga	Code of the dam where the intervention took place, This code must correspond to the corresponding code in DBdighe.
3	Numero scheda	Numero f the schedule processed by the GdL (Working Group) on the specific intervention of rehabilitation
4	Topologia intervento	Type of intervention, based on specified keyword
5	Data inizio	Starting year of the rehabilitation works
6	Data fine	Ending year of the rehabilitation work
7	Finalità	Reason of the rehabilitation works (as leak, concrete weakening, Authorities order)
8	Descrizione	Short description of the intervention
9	Concessionario gestore dell'intervento	Concessionary in force at the moment of the intervention
10	Progetto	Designer of the intervention
11	Direzione lavori	Engineer in phase of execution of rehabilitation works
12	Impresa Opere Civili	Main Contractor or specialized contractors involved in the execution of the rehabilitation
13	Impresa ELMEC	Supplier appointed for supplì or installation of electromechanical equipment
14	Importo consuntivo dei lavori	Total cost of the intervention at the end of works, in Meuro
15	Pubblicazioni	Available publications on the rehabilitation
16	Riferimento	Reference person, with mail, being informed on the specific rehabilitation
17	Commenti e note	Notes and comments
15	Allegati ed immagini	Reference to paper or electronic documents available
19	Test	Restricted area to be used by the Administrator of the database

Utility tables

N°	Stato	State
1	Costruzione	Construction
2	Esercizio normale	Normal exercise
3	Fuori esercizio temporaneo	Temporary out of service
4	Invaso limitato	Limitation imposed to the reservoir
5	Invaso sperimentale	Experimental phase
6	Dismesso	Dismissed dam
ID	Uso	Use
1	Idroelettrico	Hydroelectric
2	Industriale	Industria
3	Irriguo	Irrigation
4	Laminazione	Routing
5	Multiplo	Multiple
6	Temporaneamente sospeso	Temporarily suspended
7	Dismesso	Dismissed
8	Altro	Other
N°	Tipo	Type
1	Arco gravità	Arch gravity
2	Arco semplice	Arch
3	Blocchi di calcestruzzo	Concrete blocks
4	Cupola	Dome, cupola
5	Gravità a speroni a vani interni	Buttress gravity, hollow
6	Gravità a speroni pieni	Buttress gravity, solid
7	Gravità curvilinea in calcestruzzo	Concrete gravity arch axis
8	Gravità ordinaria in calcestruzzo	Ordinary gravity, concrete
9	Gravità ordinaria in muratura	Ordinary gravity, masonry
10	Muratura in pietrame a secco	Ordinary gravity, masonry
11	Pietrame con manto	Rockfill with upstream impervious facing
12	Solette sostenute da contrafforti	Slabs supported by buttresses
13	Terra con manto	Earthfill with upstream impervious facing
14	Terra e/o pietrame con nucleo inclinato	Earthfill or rockfill with inclined impervious core
15	Terra e/o pietrame con nucleo verticale	Earthfill or rockfill with vertical impervious core
16	Terra omogenea	Homogeneous earthfill
17	Traversa in calcestruzzo	Concrete weir
18	Traversa in muratura di pietrame con malta	Weir in masonry of stones with mortar
19	Volte sostenute da contrafforti	Vaults supported by buttresses
code	Tipointervento	Type of intervention
1	Corpo diga	Dam body
2	Fondazione	Foundations
3	Paramento monte	Upstream facing
4	Scarichi superficie	Spillway(s)
5	Scarichi profondi	Bottom outlets
6	Sponde serbatoio	Reservoir banks
7	Altro	Other

Potential development

The natural projection is to progressively enriching the database with:

- Completion of missing data, or refinement of entered ones.
- Updating of data subject to change, such as limits of reservoir exploitation or change of Owners.
- Decommissioning of ancient dams and hydraulic structures.
- New construction projects.
- Completion of dams under construction.
- New rehabilitation interventions.
- Every additional documentation.

It should also be considered that this database refers to rehabilitation projects.

Furthermore it's not assumed to be the official register, but only a rational collection of data referred to these kind of works. As a matter of fact, the Italian Committee On Large Dams hasn't institutional tasks, even if it's a reference organization related to dams.

Dam database

Moreover the dams database, which constitutes the natural background of the rehabilitation interventions register, is not expected to be the Italian dams official database.

The organized list of Italian dams is institutionally managed. This contribution by Organization's dam experts could usefully be related to the official documentation.

The information systemic of dams is internationally developed by ICOLD and by the most organized National Committees.

A perspective of this unpretentious database is certainly a control about what is done at an international level in order to acquire methods and to create a profitable networking.

This advisable initiative stands in the widest topic of relationship management between the National Committees and the International Commission On Large Dams.

Web portal

One last consideration can be expressed about database visibility and its availability to ITCOLD members or to those working in the dams sector both in Italy and abroad.

In the future the database is expected to be a certified tool to be advertise with outlook and times decided by the ITCOLD Board.

Its prospective could be huge if supported by a proper web portal.

This topic about web visibility has its own value greater than the importance of the database itself,

although these two informative tools may strictly be connected to each other.

A web tool offers:

- Visibility, and then economic and functional contribution;
- chances to control the competence space and the reliability within the general context of interest of dams, otherwise in the hands of usually poorly informed journalists or isolated volunteers;
- availability of information contributions from Societies managing dams or from experts that worked on constructions and rehabilitations.

Such web portal must be well managed, following the Committee Board's management policies, controlled, and its information verified and filtered.