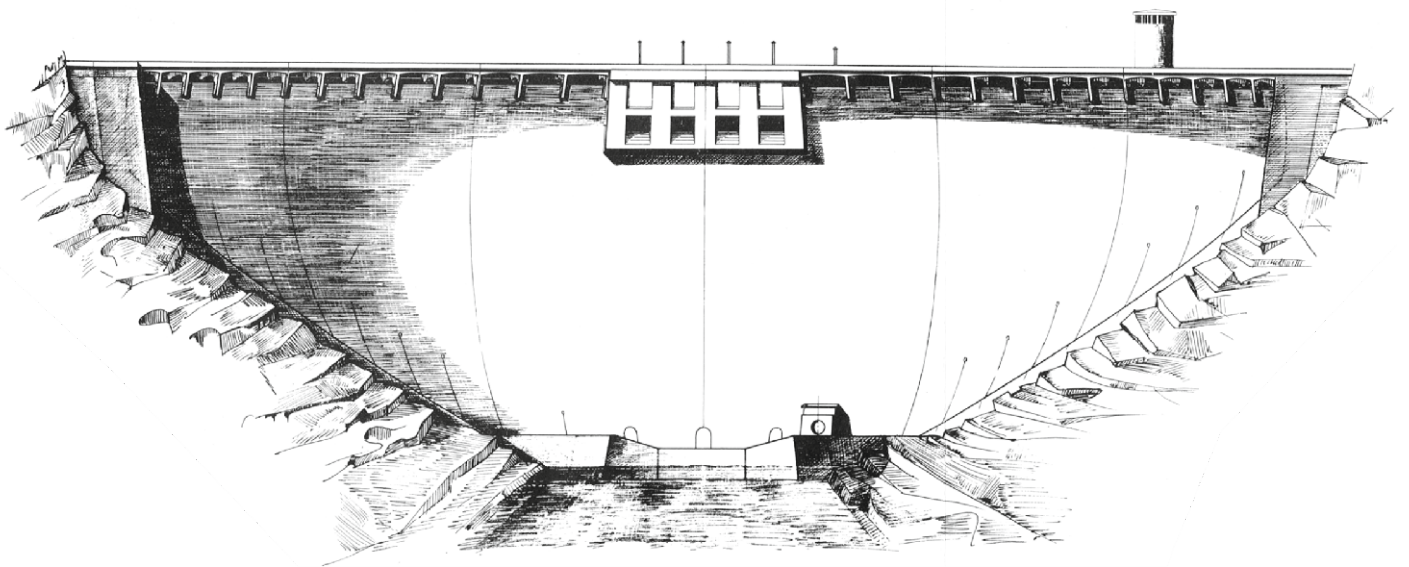


Dams Safety



coba
GROUP

ENGINEERING AND ENVIRONMENTAL CONSULTANTS



ENGINEERING AND ENVIRONMENTAL CONSULTANTS

PRESENTATION

COBA is a multinational and multidisciplinary group of Engineering and Environmental Consultants, founded in 1962.

The Group provides engineering consultancy services ranging from basic and planning studies, technical, environmental and economic feasibility studies, design and construction design as well as project management and works supervision, to operation follow-up and behaviour monitoring.

The Group has offices/subsidiaries in three continents and experience in sixty countries and encompasses several companies in accordance with functional specializations or geographical areas.

The competences acquired along the last six decades, together with the state-of-the-art employee expertise, the stability of its permanent staff and the comprehensive international experience allow to find out the best solutions for the full satisfaction of public and private Clients' needs and expectations.

During its existence, the Group has participated together with public authorities or private developers, in the feasibility of multidimensional projects, some of them being structuring projects and with major impacts on the improvement of peoples' life conditions in the several countries where it worked.

At present, the Group has a wide number of competences and technical areas that allow the composition of multidisciplinary teams who share knowledge and experiences in the execution of projects.

FIELDS OF ACTIVITY

HYDRAULIC UNDERTAKINGS

Concrete, Earth-fill and Rock-fill Dams. Weirs and Reservoirs Water Conveyance Systems. Hydraulic Structures.

POWER GENERATION AND TRANSMISSION

Hydroelectric Power Plants. Photovoltaic power plants and wind farms. Small Hydropower Plants. Power Plants Rehabilitation and Modernization. Substations High Voltage Transmission Lines. Cooling Water Systems for Thermoelectric Plants.

WATER SUPPLY AND WASTEWATER SYSTEMS

Catchment, Transport and Distribution of Potable Water. Water Treatment Plants. Drainage Systems. Wastewater Treatment Stations. Pumping Stations.

AGRICULTURES AND RURAL DEVELOPMENT

Irrigation and Drainage Systems. Rural Roads. Production Systems. Mapping and Basic Information.

TRANSPORTATION INFRASTRUCTURES

Roads and highways. Railways. Passenger and Freight Railway Stations. Metro and Light Rail. Airports. Bridges and other engineering structures.

ENVIRONMENT

Environmental Impact Assessment. Environmental Management, Monitoring and Auditing. Pollution Control. Landscaping. Land Management. Recovery of Degraded Areas. Waste Landfills.

GEOTECHNICAL STRUCTURES

Tunnels and Caverns. Slopes in Fill and Cut Section. Special Foundations Breakwaters. Embankment Works.

MARITIME AND FLUVIAL WORKS

Wharfs. River Training. Quay Rehabilitation. Flood and Flow Control.

MINING INDUSTRY

Environmental Studies. Design of Tailings Dams and Related Structures. Safety Assessment of Tailings Dams. Design Review of Tailings Dam Closure. Operations Maintenance and Monitoring Manual for Tailings Dams. Risk Analysis. Mine Closure Plan. Training.

BUILDINGS

Residential and Services Buildings. Industrial Buildings. Steel and Mixed Industrial Structures. Rehabilitation and Restoration of Ancient Buildings.

CARTOGRAPHY AND CADASTRE

Geographic Information Systems (GIS). Digital Cartography. Thematic Cartography. Thematic Cadastres. Land Acquisition.

SAFETY CONTROL AND REHABILITATION

Expertise, Monitoring. Inspection and Reinforcement of Dams and Transportation Infrastructures. Works Instrumentation. Project Maintenance and Operation.

PROJECT MANAGEMENT AND CONSTRUCTION SUPERVISION

Project Management. Cost Management. Site Supervision. Quality Assurance/Quality Control.

DAM ENGINEERING

COBA's activity associated to dam design dates back to its foundation and represents the field in which COBA is internationally renowned, having designed and provided technical assistance to dams in Europe (Portugal, Spain, Greece and Turkey), Africa (Angola, Algeria, Cape Verde, Guinea-Bissau, Guinea-Conakry, Mozambique, Senegal and Tunisia), America (Brazil, Costa Rica, Dominican Republic and Venezuela) and Asia (Vietnam).

COBA began its activity with the design of concrete dams, having contributed to the evolution of knowledge of science and technique of arch dams. Reference is made to the trial load method, totally conceived by the firm's experts in the 60's. Later on, COBA's experience extended to the design and construction of earthfill dams and, more recently, to RCC (roller compacted concrete) dams.

Within its several Departments, besides the design of the dam itself, COBA also undertakes all associated activities, such as hydrological studies, geological and geotechnical studies, hydraulic structures designs, design and specifications for hydro and electromechanical equipment, power generation and distribution and environmental studies.

Furthermore, COBA's experts have frequently participated in expertise missions and Consulting Panels for international financing agencies and other organizations, in a large number of countries.

Dam Safety

In engineering works absolute safety conditions cannot be guaranteed, as they are always subject to construction and operation risks. Thus, the risk of dam failure must, at all times, be present in all concerned entities responsible for their construction and operation - Entrepreneur, Design Engineer, Contractor and Supervision Organisations. All them shall act towards the minimization of such risks.

Dam safety is of vital importance to society and its monitoring, throughout time, demands the intervention of experts in several engineering fields, namely geology, seismology, hydraulics, geotechnics, structures, hydromechanical equipment, electrical equipment and environment.

Minimization of risks associated to dams shall start during the phase of the basic studies and extends throughout the design, construction, first and controlled filling and operation phases.

It is important to note that each dam is a unique case and due consideration must be taken into account regarding all constraints that based its design, the calculation methods used, the singularities identified or that occurred during the construction and, later on, during the first and controlled filling and dam operation.

The identification of typical scenarios of incidents and accidents specific to each dam is thus essential for adequate follow-up and monitoring in order to allow for timely detection of potential deficient operation and/or deterioration and thus allow for the implementation of the necessary rehabilitation measures.

The principal typical incident and/or accident scenarios related to dam safety may be grouped into three areas, namely to the dam's body and foundation, to the hydraulic devices and equipment and to the reservoir.

From the phenomena that most contribute to incidents and/or accidents, emphasis is placed upon the following: internal erosion, slope instability, cracking, settlements, problematic interfaces of the embankment with large concrete structures, structural deficiencies that affect concrete, undersizing, design or construction problems,

cavities and the deficient operation of hydromechanical equipment. In the case of earthfill dams, most accidents are due to overtopping resulting from unforeseen floods.

Notwithstanding the different types of deterioration liable to occur and the different ways of evidencing, associated to the specific characteristics of each anomaly and each dam, it is possible to systemize a certain quantity of actions that, jointly, enable their detection and characterization.

a) Visual Inspection

Visual inspection of dams should be undertaken during all phases of their life-spans and is probably the most efficient method to detecting deterioration. Visual inspections may be classified according to three types:

- Routine inspections, undertaken by the staff responsible for the monitoring system;
- Special inspections, undertaken by experts responsible for the preparation of reports about dam behaviour;
- Exceptional inspections, carried out by the abovementioned experts, eventually with the cooperation of other experts.

b) Monitoring

The implementation of a monitoring plan essentially envisages control of the structural, hydraulic, operational and environmental safety conditions during the several phases of a dam's life span.

The magnitudes subject to monitoring, the type of equipment and erection specifications, erection sites as well as the reading frequencies and consequent validation, interpretation and dam behaviour assessment activities shall be analysed in light of the constraints and potential risk scenarios of each dam and of the recommendations made in the dam design.

The joint analysis of data gathered in periodic inspections to dams in conjunction with monitoring data shall be a continuous and integrated task that enables a periodic assessment of dams' safety conditions. This activity is carried out by a team specialized in several scientific areas, who shall be responsible for the validation of the data gathered.

COBA has wide experience in dam inspection and monitoring, in the definition of inspection standards and their interpretation, as well as in the recommendation of remedial measures and in the design aiming dam rehabilitation and safety. Its experience in this specific field encompasses 150 dams in six countries as shown in this leaflet.

In addition, its experience also covers the preparation of rules and standards to be adopted by safety supervision organisations and by Owners.

In this respect, emphasis is made on the consultancy services provided to the World Bank and the ANA (Agência Nacional de Águas), through the contract signed with the World Bank, further to an international call for tenders launched in 2012, COBA having been the winner. The contract lasted between January 2013 and January 2015.

GOVE DAM REHABILITATION

Client: GABHIC – Gabinete Administrativo da Bacia Hidrográfica do Rio Cunene

Date: 2003/05

Dam	Type	height (m)	Crest Length (m)
Gove. Dam repair	Earthfill	58	1 112



CAMBAMBE DAM REHABILITATION

Client: Ministério da Energia

Date: 1983

Dam	Type	height (m)	Crest Length (m)
Cambambe (Rehabilitation)	Arch	88	380



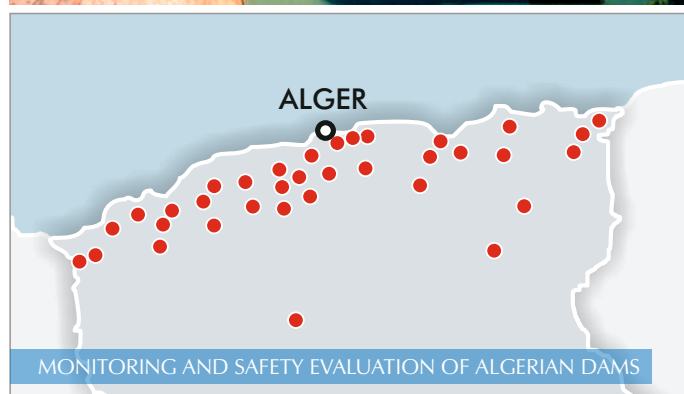
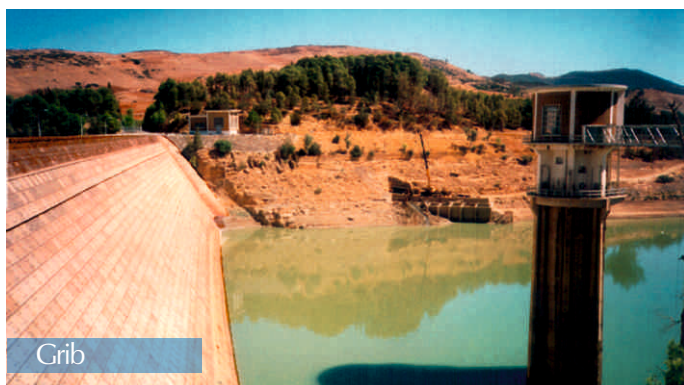
ALGERIA

INSPECTION AND STRENGTHENING OF OPERATING LARGE DAMS

Client: Agence Nationale des Barrages et Transferts

Date: 2005/08

Dam	Type	height (m)	Crest Length (m)
Grib	CFRD	65	270
Bakkadda	Rockfill	45	220
Oued Fodda	Gravity	100	170
Boughzoul	Gravity	13,5	580



DAM MONITORING AND SAFETY EVALUATION

Client: Agence Nationale des Barrages et Transferts

Date: 1992/97

Dam	Type	height (m)	Crest Length (m)
Zardezas	Concrete	64	242
Boukourdane	Earthfill	74	610
Hammam Grouz	Gravity	50	217
Beni-Amrane	Rockfill Gravity	39,5	145
Bouroumi	Earthfill	100	300
Deurdeur	Earthfill	56	380
Foum El Gherza	Arch	73	186
Ghrib	Rockfill	105	270
Boughzoul	Earthfill Gravity	14	580
Ladrat	Earthfill	44	660
Lekhal	Earthfill	43	600
Ain Zada	Rockfill	50	940
Keddara	Rockfill	108	486
Guenitra	Earthfill	69	515
Hammam Debagh	Earthfill	93	430
Ain-Dalia	Rockfill	64	220
Bakhadda	Rockfill	60	220
Colonel Boughara	Earthfill	17,5	580
Cheffia	Earthfill	50	650
Dahmouni	Earthfill	41	860
Foum El Gueiss	Rockfill	27	150
Ksob	Multiple Arch Dam	46	254
Sidi Mohamed Ben Aouda	Earthfill	64	890
Harreza	Earthfill	41	1 787

DAM BEHAVIOUR DIAGNOSTIC AND DAM SAFETY

Client: SANEPAR - Companhia de Saneamento do Paraná

Date: 2009/10

Dam	Type	height (m)	Crest Length (m)
Iraí	Earthfill	19	1 220
Passaúna	Earthfill	22	1 325
Piraquara I	Earthfill	30	280
Piraquara II	Earthfill	13	670



REHABILITATION OF JABURÚ I DAM

Client: Secretaria dos Recursos Hídricos (Ceará)

Date: 1998/00

Dam	Type	height (m)	Crest Length (m)
Jaburú I	Earthfill	47	770



FUNIL DAM

Client: FURNAS – Centrais Elétricas, SA

Dam seismic analysis (1998) and strengthening of foundation curtain and joints grouting (1991)

Dam	Type	height (m)	Crest Length (m)
Funil	Arch	85	360



MOZAMBIQUE

INSPECTION AND STRENGTHENING OF OPERATING LARGE DAMS

Client: ARA-Sul

Date: 2003

Dam	Type	height (m)	Crest Length (m)
Corumana	Earthfill	46	3 050
Macarretane	Barrage	4	650
Massingir	Earthfill	48	4 630
Pequenos Libombos	Earthfill	45	1 540



DOMINICAN REPUBLIC

MONITORING, INSPECTION AND STRENGTHNING OF ALL HYDROELECTRIC DAMS IN DOMINICAN REPUBLIC

Client: Corporación Dominicana de Electricidad (CDE)

Date: 1986

Dam	Type	height (m)	Crest Length (m)
Valdesia	Gravity	78	342
Sabana Yegua	Earthfill	90	1 190
Rincon	Gravity	52	176
Hatillo	Earthfill	52	1 800
Bao	Earthfill	112	425
Tavera	Gravity	82	405
Sabaneta	Earthfill	72	850
Las Barias	Gravity/Earthfill	15	664



SPECIAL PLAN FOR DAM INSPECTION 2001 - REGARDING 57 DAMS

Client: Instituto da Água (INAG)

Date: 2001/04

Dam	Type	height (m)	Crest Length (m)
Quinta da Serra	Earthfill	9,8	140
Vale dos Pereiros	Earthfill	12	132
Santo António	Earthfill	12	140
Várzea do Linhó	Earthfill	12,5	59,6
Vale do Juncal	Earthfill	13,5	75
Coalheira	Earthfill	12	89
Vergancinho	Earthfill	14,5	120
Pedra Alçada	Earthfill	11,5	94
Fonte	Earthfill	10	80
Amoreira	Masonry	8	47
Bacharel	Earthfill	10	68
Vila Chã	Earthfill	11,4	90
Retorta	Earthfill	10	164
Mingazes	Earthfill	11	130
Vale Raposeira	Earthfill	6	137
Vale do Pinhal	Earthfill	13	70
Copeiro	Earthfill	8	73
Valeira Alta	Earthfill	10	160
Vale Touriz	Earthfill	12	123
V. dos Gaios	Earthfill	5	70
Nova	Earthfill	9	85
Malhada Alta	Earthfill	9	205
Vale Pinheiro	Earthfill	7	110
Vale da Ursa	Earthfill	17	450
Vale Arca I	Earthfill	12	417
Vale Sanceiro	Earthfill	5	192
Charnequinha	Earthfill	8	520
Daroeira	Earthfill	16	500
Vale de Carneiros	Earthfill	10	160
Nabos	Earthfill	10	138
Monte dos Alhos	Earthfill	5	205
Monte da Fava	Earthfill	3,5	40
Sobrena	Earthfill	14	180
Cabeça de Cabra	Earthfill	6	120
Maroteiras	Earthfill	10	130
Terça	Earthfill	11	310



Bacharel



Retorta



Vale Touriz



Cabeça de Cabra

PORTUGAL

Dam	Type	height (m)	Crest Length (m)
Vale da Torre	Earthfill	8	185
Maçanedo	Earthfill	7	350
Vale Cobrão	Earthfill	12	519
Michões	Earthfill	10	345
Soberanas de Baixo	Earthfill	12	345
Algalé I	Earthfill	12	100
Algalé II	Earthfill	11	135
Vale de Arca II	Earthfill	22	430
Porches	Earthfill	20,6	207
Vinte e Dois	Earthfill	7	170
Venda Velha	Earthfill	11	575
Carregal I	Earthfill	17	130
Vale dos Peixes	Earthfill	10	115
Negrelinhos / Mouriscas	Earthfill	16	700
Covões	Earthfill	16	114
Pias	Earthfill	15	120
Vale do Bebedouro	Earthfill	14,5	220
Fazenda Julieta	Earthfill	11	155
Abegoaria de Baixo	Earthfill	10	100
Muge	Earthfill	10	70
Abegoaria de Cima	Earthfill	12	110
Cadouços I	Earthfill	10	225
Cadouços II	Earthfill	15	160
Cadouços III	Earthfill	16	280



STRUCTURAL AND HYDRAULIC SAFETY

Dam	Client	Date	Type	height (m)	Crest Length (m)
Minutos. Dam Contingency Plan	DGADR - Direcção-Geral de Agricultura e Desenvolvimento Rural	2009/10	Earthfill	36	1 288
Cadouços I	INAG – Instituto da Água	2006	Earthfill	10	225
Cadouços III	INAG – Instituto da Água	2006	Earthfill	16	280
Lapão	DRABL - Direcção Regional de Agricultura da Beira Litoral	2005	Earthfill	39	97
Eightening os Cova do Viriato Dam in Penhas da Saúde	Câmara Municipal da Covilhã	2005/07	Concrete Gravity	26	201,6
Monte Branco. Plan of First Filling. Monitoring Program	EDIA – Instituto para o Desenvolvimento e Infra-estruturas do Alqueva	2003	Earthfill	9,5	253
Lagoa Vermelha. Plan of First Filling. Monitoring Program	EDIA – Instituto para o Desenvolvimento e Infra-estruturas do Alqueva	2003	Earthfill	12,2	340

STRUCTURAL AND HYDRAULIC SAFETY

Client: Instituto da Água (INAG)

Date: 1999/01

Dam	Type	height (m)	Crest Length (m)
Alfândega da Fé	Earthfill	25	750
Burga	Earthfill	35	353
Salgueiro	Earthfill	28	191
Peneireiro	Earthfill	14	693



STRUCTURAL AND HYDRAULIC SAFETY

Client: Instituto da Água (INAG)

Date: 1998/01

Dam	Type	height (m)	Crest Length (m)
Santa Clara	Earthfill	85	428
Roxo	Butress/Earthfill	49	847
Monte da Rocha	Earthfill	55	1 600
Maranhão	Earthfill	55	204
Gameiro	Gravity/Earthfill	20	293
Furadouro	Concrete	17	190



STRUCTURAL AND HYDRAULIC SAFETY

Dam	Client	Date	Type	height (m)	Crest Length (m)
Além da Fazenda	Electricidade dos Açores (EDA)	1994/97	Concrete	19	70
Aljustrel	Pirites Alentejanas	1998/89	Rockfill	16	300
Roxo	Direcção Geral dos Serviços Hidráulicos	1974	Butress/Earthfill	49	847
Ponte de Jugais	Emp. Hidr. Serra da Estrela (EHSE)	1972	Concrete Gravity	18	15
Covão do Curral	Emp. Hidr. Serra da Estrela (EHSE)	1971	Concrete Gravity	12	185
Covão do Ferro	Soc. Ind. Penteação, Energia, Fiação de Lãs	1964	Concrete Gravity	32	340



 JULY | 2023



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