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Hydraulic structures. Dams and reservoirs

Elements of dam engineering -3

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Strengthening of master curricula in water resources management for the Western Balkans HEIs and stakeholders
Project number: 597888-EPP-1-2018-1-RS-EPPKA2-CBHE-JP

HYDROENGINEERING STRUCTURES-1

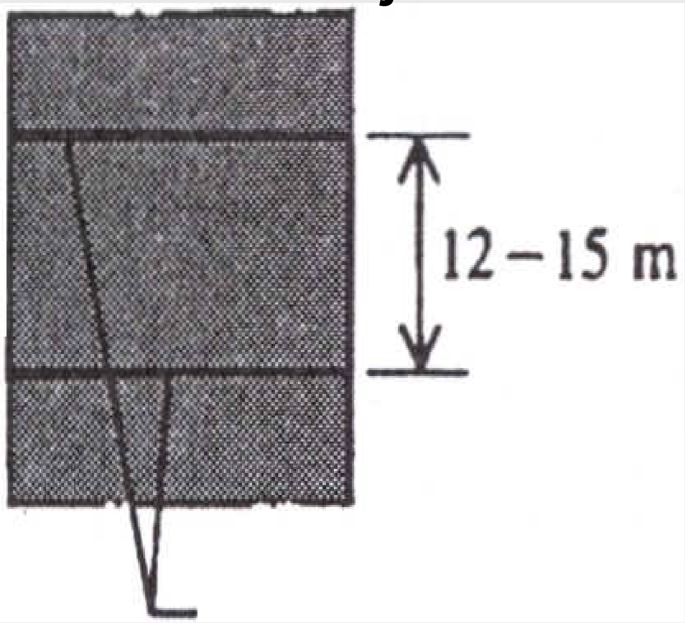
Q1: Elements of dam engineering

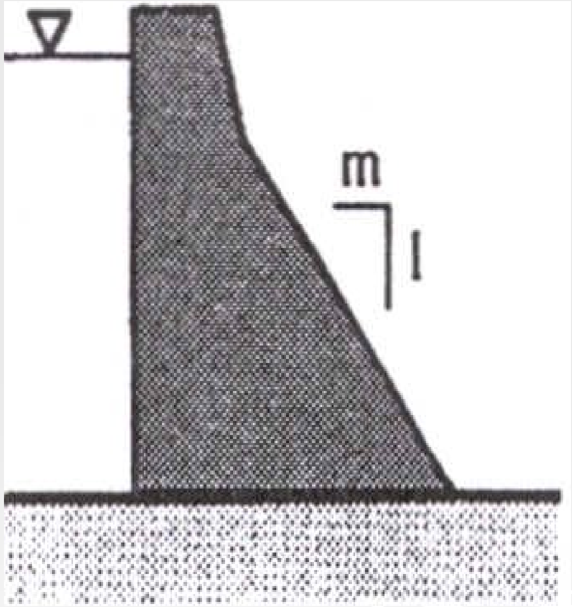
1. Historical perspective
2. Embankment dam types and characteristics
3. **Concrete dam types and characteristics**
4. Spillways, outlets and ancillary works
5. Site assessment and selection of type of dam

Principal variants of concrete dams

Horizontal section at base   Cross section

contraction joints





(a) Gravity dam $m = 0.75 \pm$

Table 16.1 Concrete gravity dams higher than 200 m.

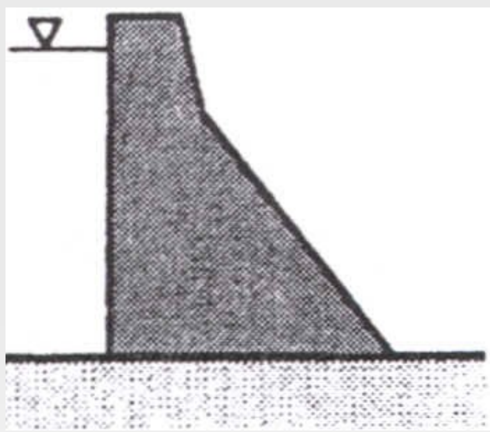
Dam	*Country*	*Built (year)*	*High (m)*	*Volume of dam* ($m^3 \times 10^3$)	*Volume of reservoir* ($m^3 \times 10^6$)
1. Grande Dixens	Switzerland	1961	285	6000	401
2. Sayano-Shushenska	Russia	1990	242	8435	31,300
3. Bhakra	India	1963	226	4130	9621
4. Hoover	USA	1936	223	2845	34,852
5. Dworshak	USA	1973	219	4931	4278
6. Longtan*	China	2009	217	7458	27,270
7. Toktogul	Kyrgyzstan	1978	215	3345	19,500
8. Guangzhao*	China	2008	201	2870	3245

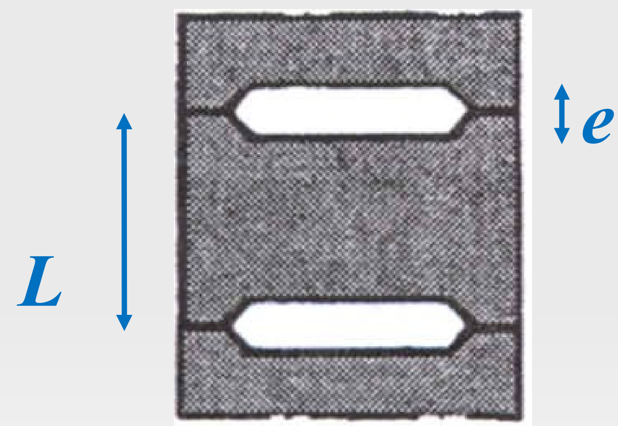
Further variants of concrete dams

Cross sections

Horizontal section at base

contraction joints





(a) Hollow gravity

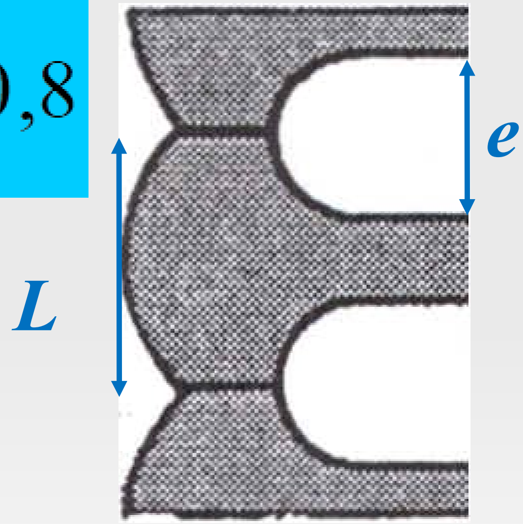
$$\frac{e}{L} = 0{,}15 - 0{,}4$$

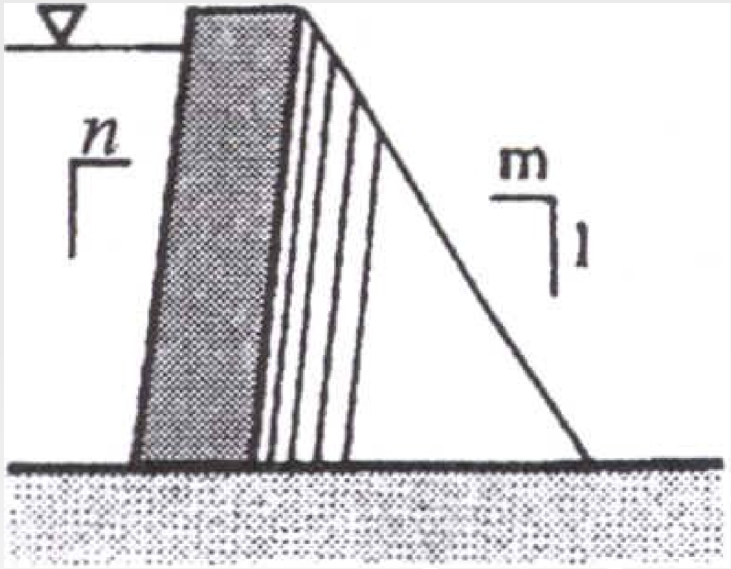
Principal variants of concrete dams

Horizontal section at base — Cross section

contraction joints

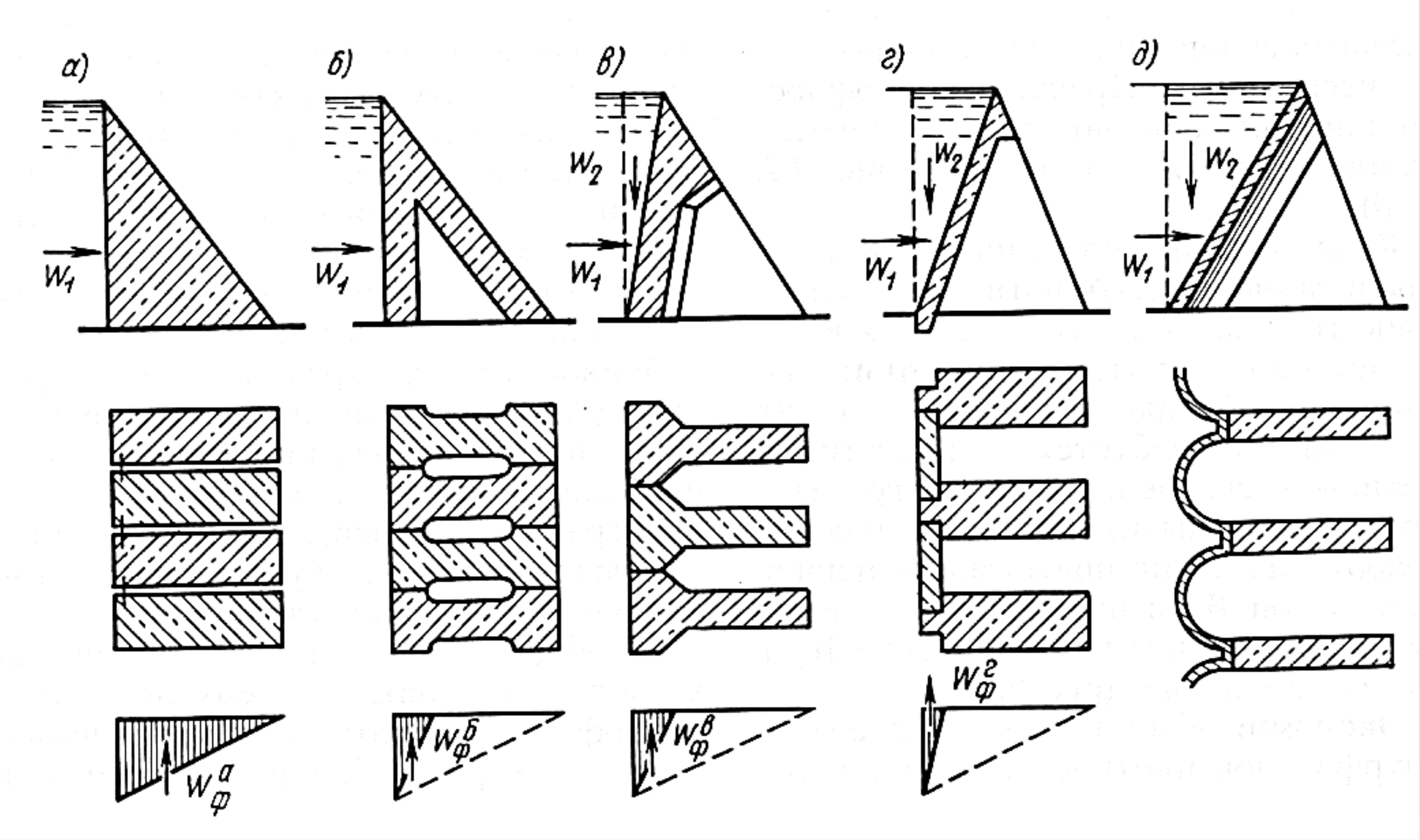
$$\frac{e}{L} = 0{,}5 - 0{,}8$$





(b) Massive buttress -roundhead

***m* = 0.8-1.0; *n* = 0.1 - 0.3**


а)
б)
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W1
W1
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W1
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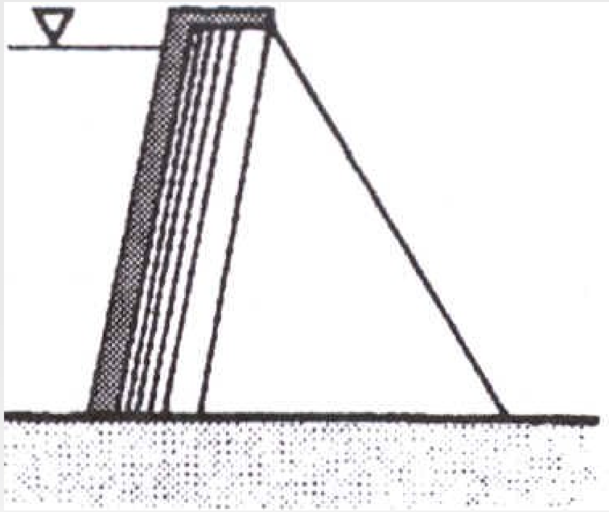
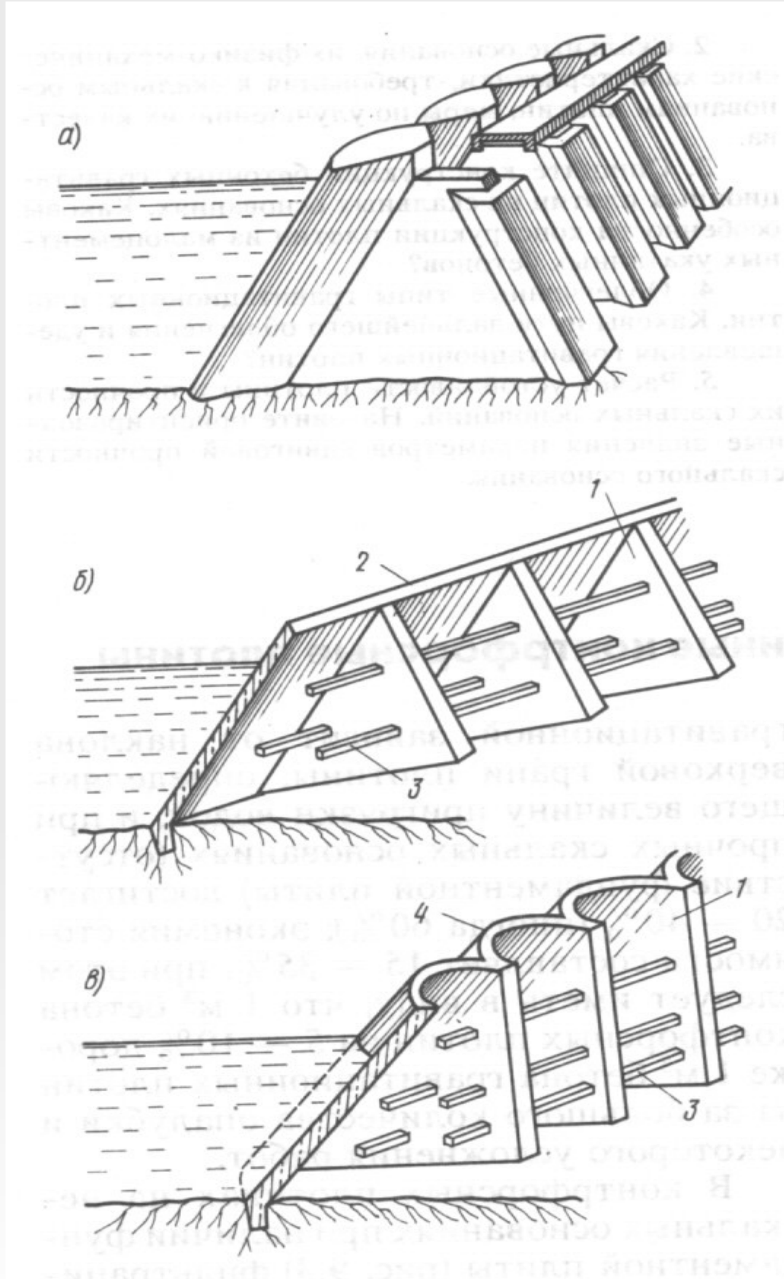
Further variants of concrete dams

Cross sections



Horizontal section

(b) Multiple arch (multiple cupola similar)


а)
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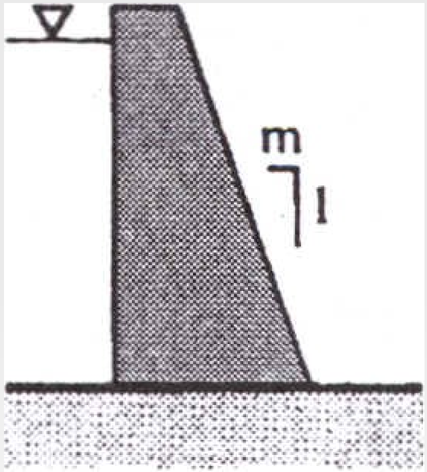
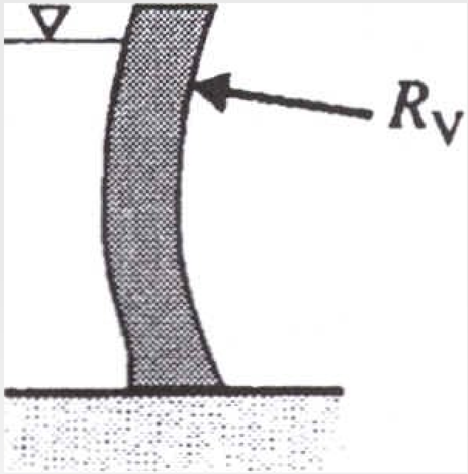
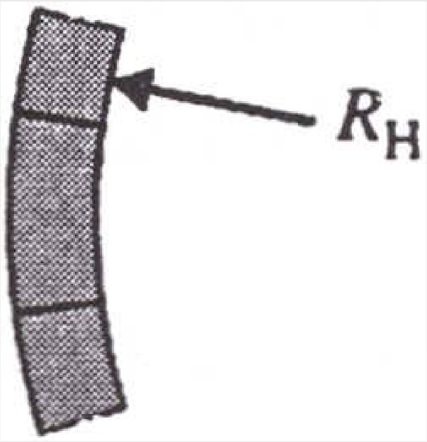
Principal variants of concrete dams

Cross sections

Horizontal section

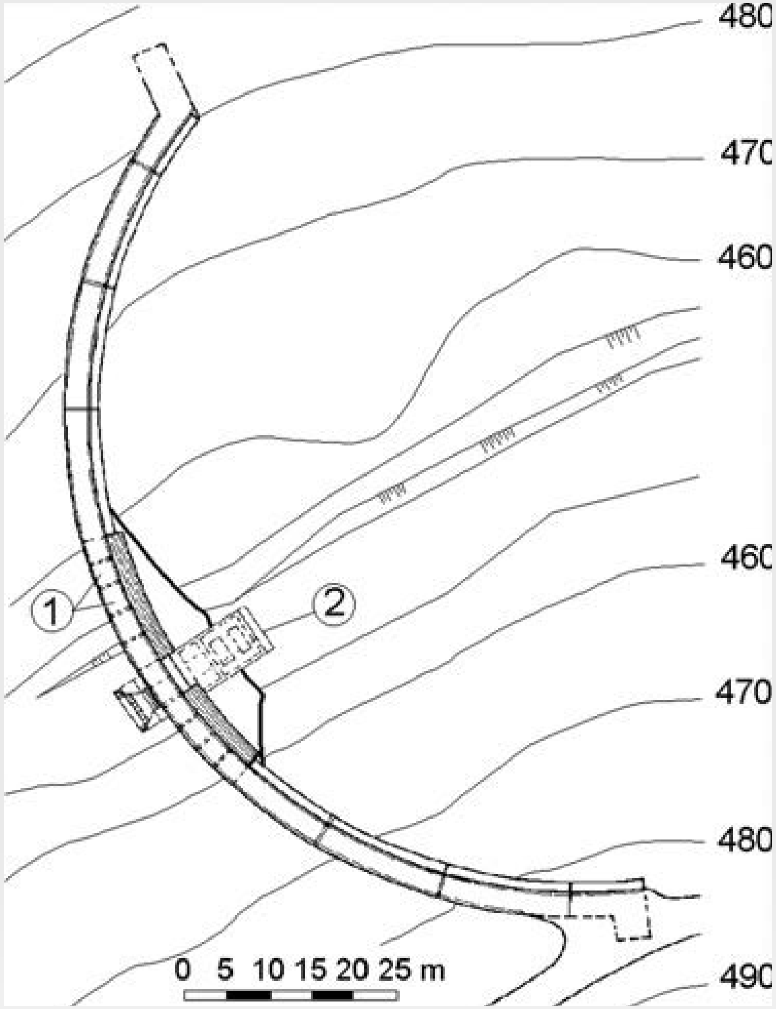


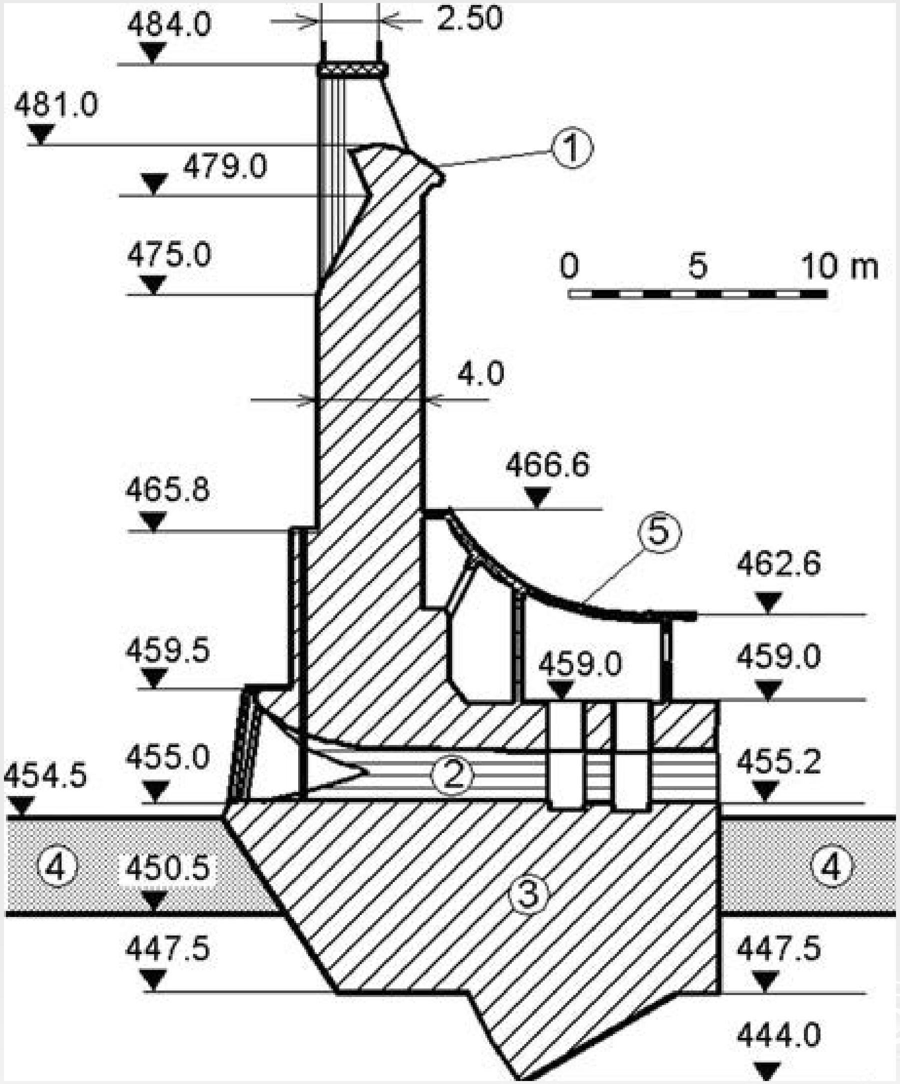




(c) Arch and Cupola or double-curvature arch

Abutment stability !





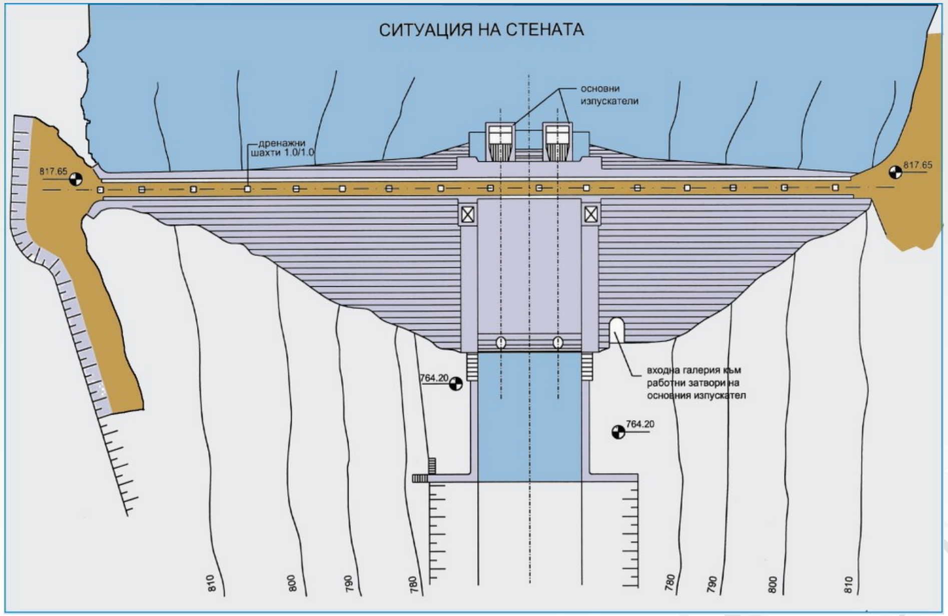
Structurally it functions primarily as a horizontal arch, transmitting the major portion of the water load to the abutments or valley sides rather than to the floor of the valley.

Dam	Country	Built (year)	Height [m]	Crest length [m]	Volume of the dam $m^3 \times 10^3$	Volume of the reservoir $m^3 \times 10^6$
1. Bakhtiari	Iran	U.C.	315		3100	4845
2. Jinping I	China	(2014)	305	569	7425	7760
3. Xiaowan	China	2010	292	902		15,043
4. Xiluodu	China	2013	278	700	13,055	12,670
5. Inguri	Georgia	1980	272	680	3960	1100
6. Vaiont	Italy	1960	262	190	360	150
7. Mauvoisin	Switzerland	1957	250	520	2030	211.5
8. Laxiwa	China	2009	250	460	3682	1079
9. Deriner	Turkey	2012	249	720	3400	1970
10. Ertan	China	1999	240	775	4138	6170
11. El Cajón	Honduras	1984	234	282	1600	7085
12. Chirkey	Russia	1978	233	338	13,580	2780
13. Goupitan	China	2009	232.5	557		6451
14. Karun 4	Iran	2010	230	440	1650	2190
15. Luzzone	Switzerland	1963	225	600	1330	108
16. Contra	Switzerland	1965	220	380	660	105
17. Mratinje	Montenegro	1976	220	268	742	880
18. Glen Canyon	USA	1966	216	475	3747	33,304
19. Ermenek	Turkey	2009	210	132		4582

Advantages of the concrete dams

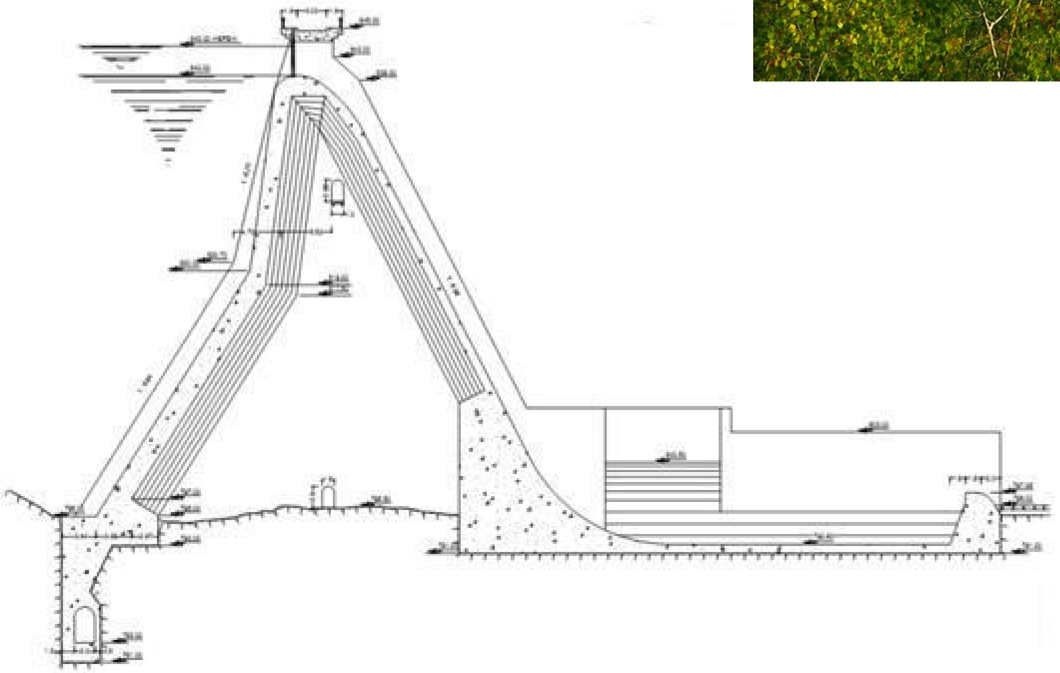
- concrete dams are suitable to the site topography of wide or narrow valleys alike, provided that a competent rock foundation is accessible at moderate depth «5 m.
- concrete dams are not sensitive to overtopping under extreme flood conditions
- concrete dams can accommodate a crest spillway, The cost of a separate spillway and channel are therefore avoided.
- Outlet pipes are safely housed in chambers or galleries within the dam.

Iskar Dam



Type – concrete gravity dam
Year of building - 1956
Hight of the dam – 74 m
Length of the dam crest – 204 m
Total volume – $655,30*10^6$ m^3
Catchment area – 1046 km^2

Studena Dam

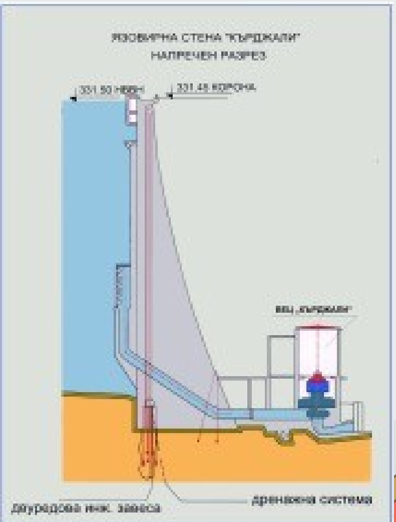


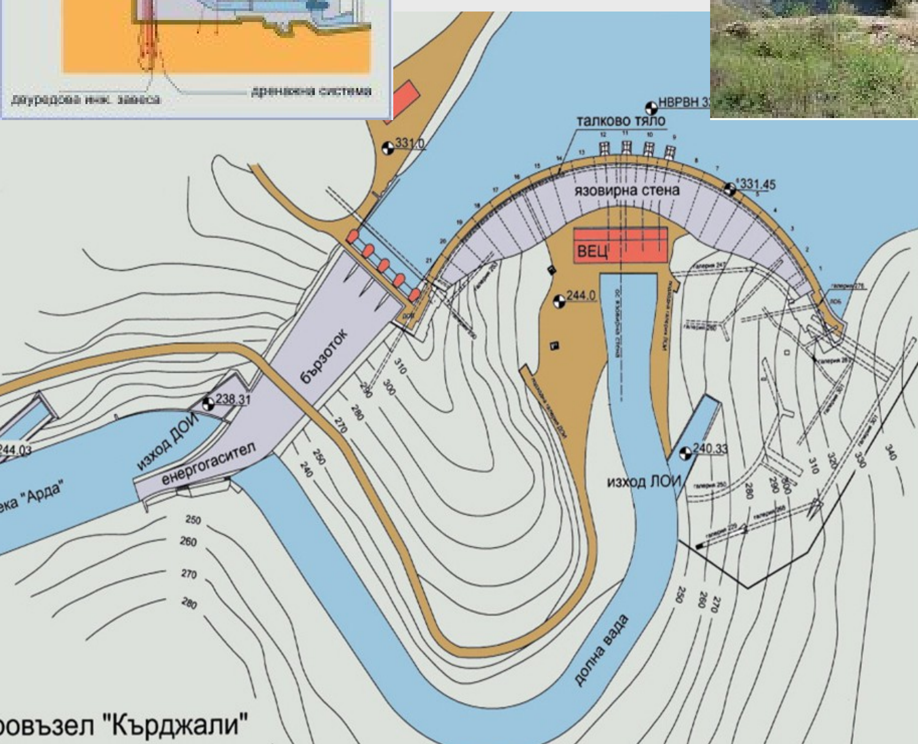
Type – concrete hollow dam
Year of building - 1953
Hight of the dam – 53 m
Length of the dam crest – 268 m
Total volume – $20{,}620 \times 10^6\ m^3$
Catchment area – $103{,}3\ km^2$

Studena Dam

Rehabilitated in the period 2017 – 2018.

Kardjali Dam





Type – concrete arch dam
Year of building - 1963
Hight of the dam – 103,5 m
Length of the dam crest – 403 m
Total volume – 539,9*10^6 m^3
Catchment area – 1882 km^2

Tsankov Kamak Dam

Type – concrete cupola dam
Year of building - 2010
Hight of the dam – 130,5 m
Length of the dam crest – 464 m
Total volume – $110{,}708 \cdot 10^6$ m^3

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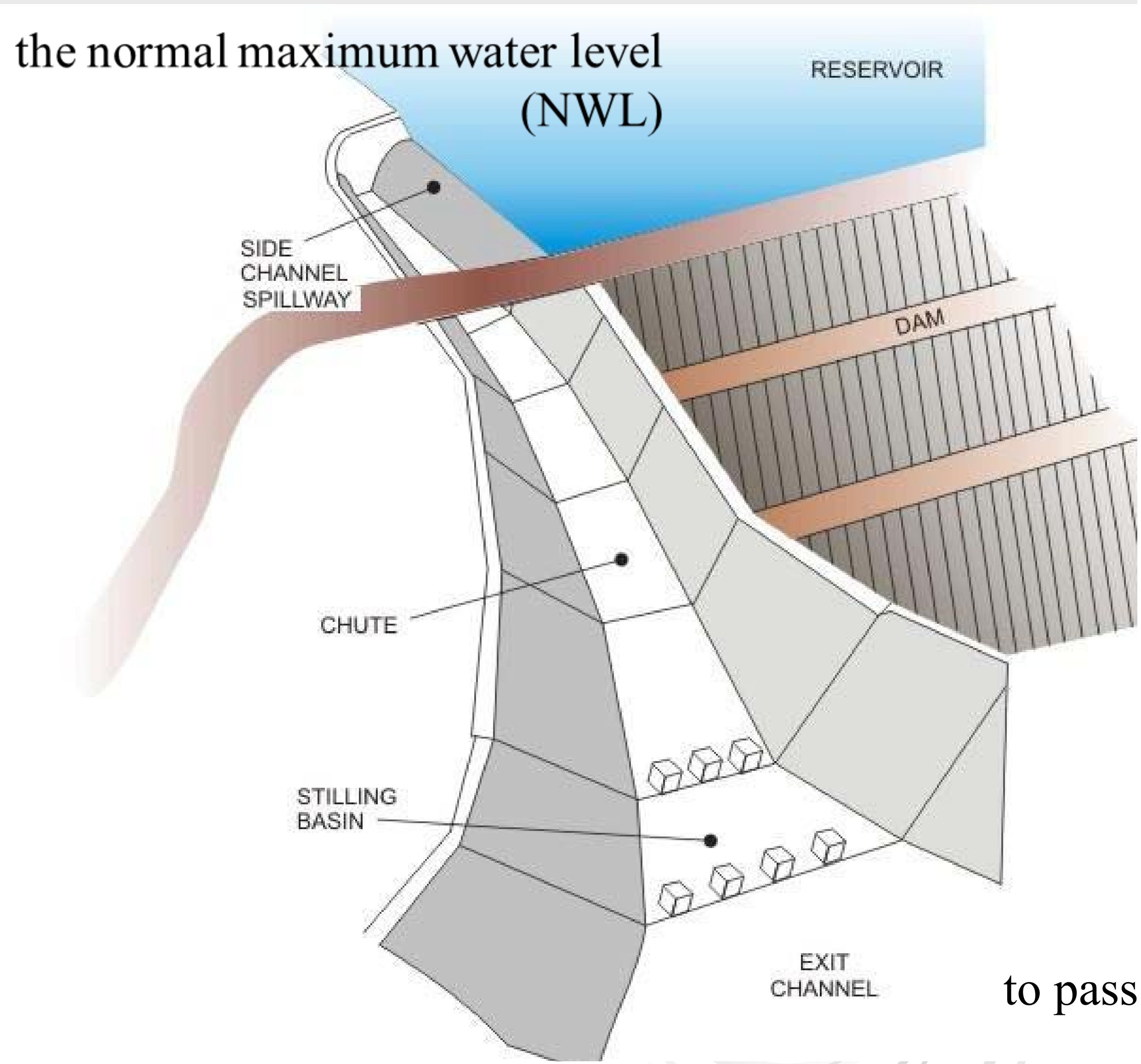
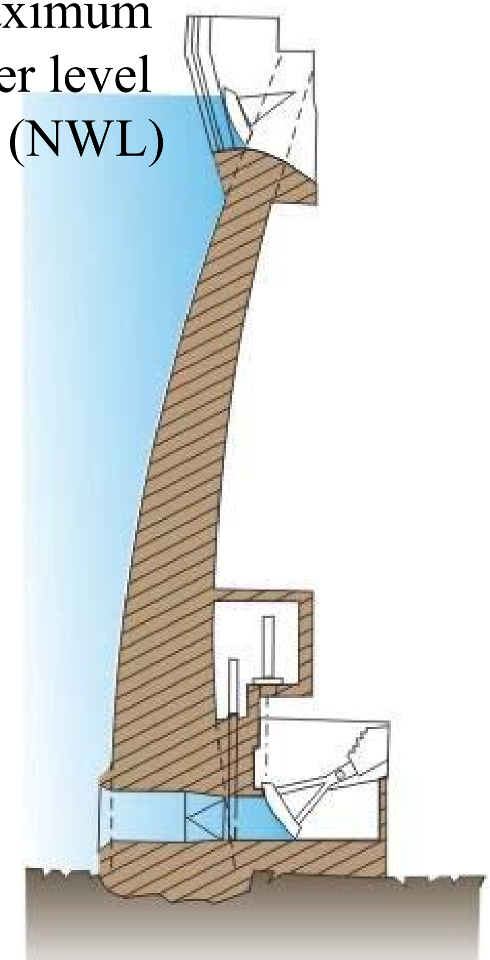
5. Site assessment and selection of type of dam
6. Loads on dams

Spillways

the normal maximum water level (NWL)



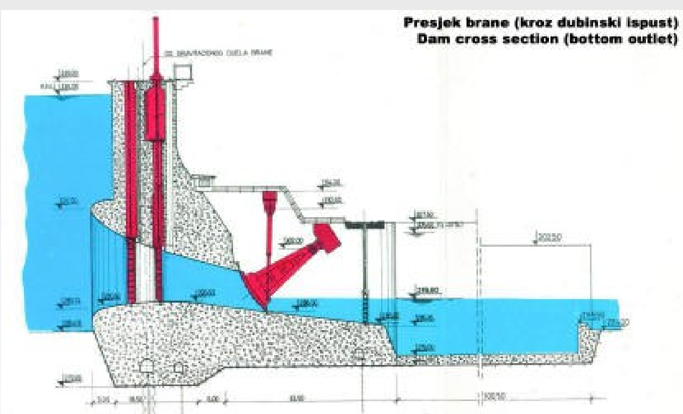
the normal maximum water level (NWL)

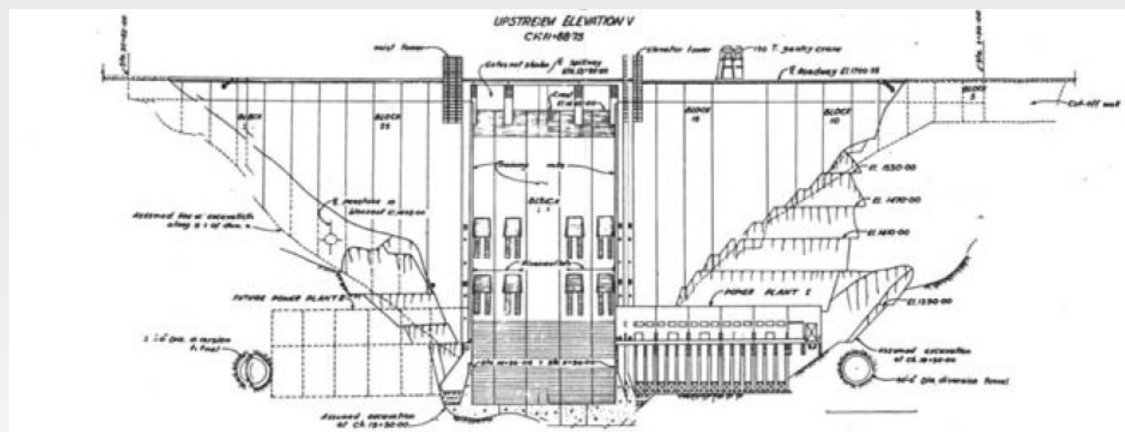


to pass flood water downstream

Outlets

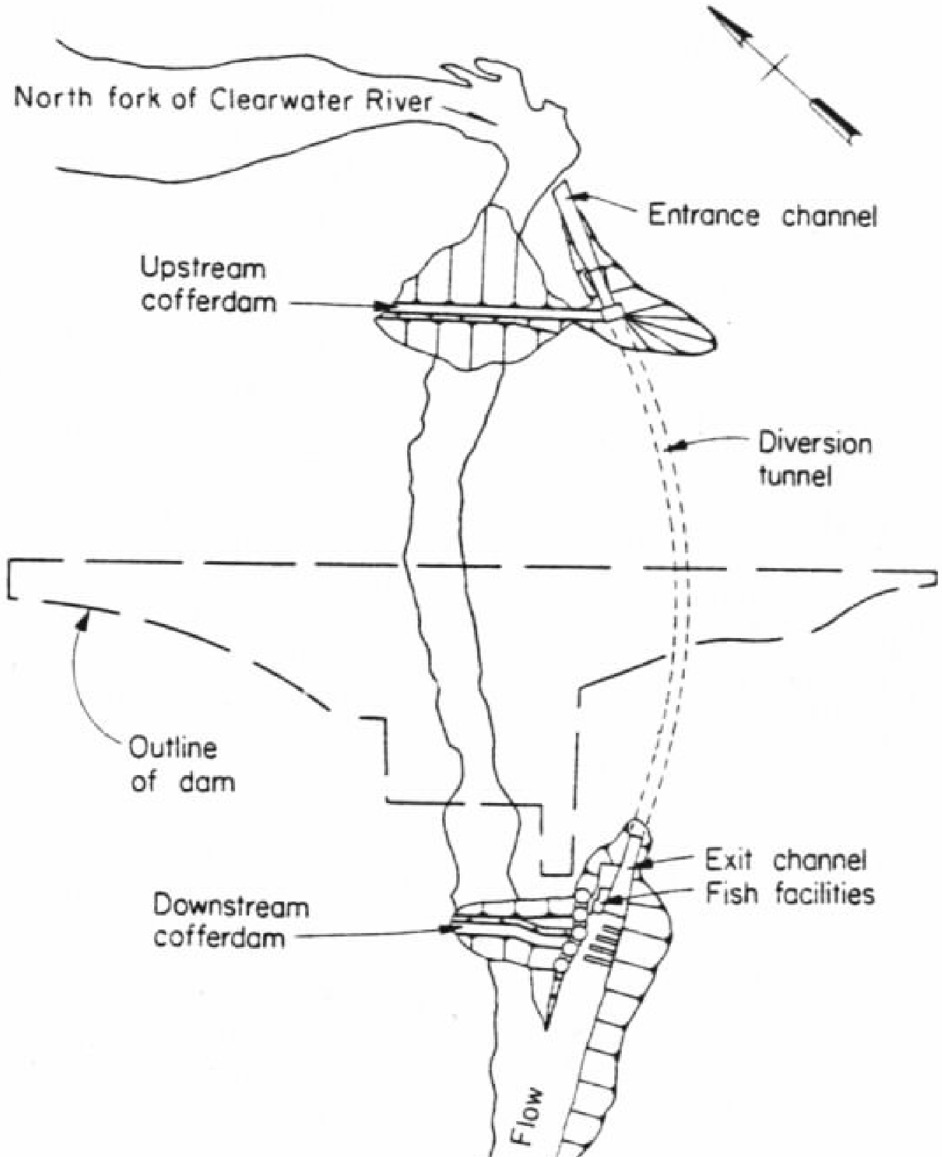
A bottom discharge facility (bottom outlet) is provided in most dams to allow emptying of the reservoir.





River diversion

TUNNELS



Site assessment and selection of type of dam

Advantages of Gravity Dam:

1) Strong & Stable
2) Overflow spillway, Pass flood
3) Any height
4) Not sudden failure
5) Suitable at heavy downpore
6) Less maintenance cost

Disadvantages of Gravity Dam:

1) Sound rock foundation
2) Higher cost
3) Skill labour & Mechanics
4) Diff. to rise the height latter
5) More time to construction

Advantages of Arc Dam:

1) Suitable deep gorges & Length small
2) Built on moderate/weak foundation
3) Thickness less than height
4) Less cost compare gravity dam

Disadvantages of Arc Dam:

1) Skill labour & Mechanics cost
2) Construction time large
3) Strong abutment
4) Not Suit if solid rock not available

Advantages of Buttress Dam:

1) Less materials
2) Week foundation
3) Buttress support again overturning & sliding

Disadvantages of Buttress Dam:

1) More form work
2) Constant maintenance and supervision
3) Life less

Selection of site for a Dam

1) Foundation
2) Topography
3) Reservoir
4) Catchment Area
5) Spillway
6) Construction Material
7) Communication
8) Environmental Condition

Factor governing the selection of type of dam

1) Topography
   - V Shape
   - U Shape
2) Geology and Foundation Condition
   -Solid Rock
   -Gravel
   - Silt & Fine Sand
   - Clay
   - Non-Uniform
3) Availability of materials for Construction
4) Spillway size and location
5) Roadway
6)Length and height of dam
7) Life of the dam
8) Earthquake

Earthfill	Rock or compressible soil foundation... Can accept limited differential settlement /plastic core/. Cut-off to less permeable horizons required. Low contact stresses. Requires range of materials-core, shoulders, internal filters
Rockfill	Rock foundation preferable; can accept variable quality and limited weathering. Cut-off to less permeable horizons required. Rockfill suitable for all weather placing.
Gravity	Wide valleys, excavation to rock is less than c. 5 m. Limited weathering of rock acceptable. Check discontinuities in rock with regard to sliding. Moderate contact stress. Requires imported cement.
Buttress	As gravity dam, but higher contact stresses require sound rock. Concrete saved relative to gravity dam 30-60%.
Arch and cupola	Suited to narrow gorges, uniform sound rock of high strength and limited deformability in foundation and most particularly in abutments. High abutment loading. Concrete saving relative to gravity dam is 50-85%.

Day 06: #2

Read, Write, Pair, Share			
Read the following text:	What is my response to the text?	What does my partner think?	What will we share?