SOCIALIST REPUBLIC OF VIETNAM
Ministry of Construction (MOC)

Technical Regulation on Hydropower Civil Works

Design, Construction and Completion Inspection of Civil Works and Hydromechanical Equipment

Final Draft

June 2013

Japan International Cooperation Agency

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IL
CR(2)
13-102

SOCIALIST REPUBLIC OF VIETNAM

QCVN xxx : 2013/BXD-BCT-BNNPTNT

NATIONAL TECHNICAL REGULATION
ON HYDROPOWER CIVIL WORKS

Quy chuẩn kỹ thuật quốc gia

về công trình xây dựng thủy điện

HA NOI - 2013

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Foreword

QCVN xxx : 2013/BXD-BCT-BNNPTNT : The national technical regulation on hydropower civil works is compiled regarding to the stipulation in the paragraph 2 and paragraph 4 of the article 30 in the Law of technical Regulation and Standard as well as the paragraph 1 of the article 9 in the decree number 127/2007/NĐ-CP dated 01 August 2007 by the Government detail prescribing the implementations of some provisions in the Law of technical Regulation and Standard.

QCVN xxx : 2013/BXD-BCT-BNNPTNT is compiled by the JICA in co-operation with the Center for Water Research and Engineering Application - Water Resources University, appraised by the Ministry of Science and Technology and promulgated by the Ministry of Construction regarding to the Circular No /2013/TT-BXD-BCT-BNNPTNT day/month/2013

NATIONAL TECHNICAL REGULATION QCVN xxx : 2013/BXD-BCT-BNNPTNT

National technical regulation on hydropower civil works

Quy chuẩn kỹ thuật quốc gia về công trình xây dựng thủy điện

1. Scope of application

1.1. This technical regulation stipulates mandatory technical requirements being obeyed in the activities relating to the construction of hydropower works, regardless of sources of investment including new construction, modification, upgrading or extension of hydropower civil works.

1.2. This technical regulation is applied for hydropower plants forming reservoirs and other types of hydropower plants with installed capacity equal to or greater than 30 MW. However, it is allowed to apply this technical regulation for hydropower civil works which do not create reservoirs and with installed capacity less than 30 MW depending on the investor's judgment.

2. Reference documents

The following reference document is necessary and required for applying this technical regulation:

QCVN 02 : 2009/BXD: National technical regulation - Natural physical and climatic data for construction;

QCVN 04 - 04 : 2012/BNNPTNT: National technical regulation on Hydraulic Works - Drilling blast holes - Technical requirements;

QCVN 04 - 05 : 2012/BNNPTNT: National technical regulation on Hydraulic Works - Basic stipulations for design.

3. Nomenclatures and definitions

3.1. Authority

Government management organizations which are entitled to decide activities relating to each specific hydropower project.

3.2. Inspector

Individuals or organizations that are entitled by jurisdiction authorities to inspect activities relating to hydropower projects according to the provisions of laws.

3.3. Completion Inspection

Inspection to be done on completion of one sub-stage or whole of the work in the investment stage of the project and on completion of constructing whole of the works or work item to verify qualities of the investment stage and qualities of constructing whole of the works or work-item before implementing next stages of a project or putting the works (or work-item) into operation.

3.4. Hydropower project

The project which includes the purpose of power generation utilizing water resources.

3.5. Hydropower works

A hydraulic works which has the function of using the energy of water resources to generate electricity.

3.6. Permanent work

The work which is used permanently or periodically during the operation period.

3.7 Temporary work

Works are only used during the constructional phase or are used temporarily in order to repair permanent works in the exploiting phase.

3.8. Pressure line

The alignment which is arranged for impounding works in order to form a reservoir, or the combination of works bearing water pressure directly from a reservoir such as dam, spillway, intake and power plant in a river.

3.9. Hydropower reservoir

The work which is used to store and regulate river runoff in order to provide water for purposes of electric power generation and other water requirements. Hydropower reservoir includes the following work items:

a) Reservoir foundation;

b) Dam: having the functions of rising water level to form a reservoir and store water for power generation;

c) Spillway: having the functions of discharging excess water out of a reservoir in order to regulate floods and guarantee the safety condition for the dam;

d) Water intake: having the functions of providing water for the electric power generation and other water requirements;

e) Works for management and operation;

f) Some reservoirs can have additional works, such as sediment flushing work, low level outlet work, navigation work (navigation lock, harbor, etc.), traffic roads, fish-way work and hydropower work in the pressure line, etc.

3.10. Waterway system of a power plant

A combination of work items being located downstream of the headwork which has a function of conveying water from the headwork to the outlet of hydropower works in order to use the water energy for power generation.

3.11. Dam

The barrage across the flow of river and stream or encloses lowland in order to retain water and rise water elevation before dam and form a reservoir. Dams are divided into types as bellowing:

a) Classification basing on the construction materials:

1) Earth dams: mainly constructed from soil material or strong weathered rock and totally weather rock;
2) Rock dams: mainly constructed from rock material;
3) Concrete dams: mainly constructed from concrete or reinforced concrete materials;
4) Multi-blocked dams: dams are constructed from many types of materials, which do not have the same sources of originate and physico-mechanical properties as well as are arranged into many blocks in dam body;
5) Homogeneous dams: dams are constructed mainly from one type of material (earth, rock, concrete, etc) having the same sources of originate and similar physico-mechanical properties;

b) Classification basing on the features of foundation:

1) Dams are constructed on rock foundation;
2) Dams are constructed on non-rock foundation (soil, sand, gravel, etc.);

c) Classification basing on the permeability properties of soil foundation:

1) Dams are constructed on the pervious foundation;
2) Dams are constructed on impervious foundation (or less pervious foundation);

3.12. Non-overflow section

A part of dam or other work items which is contacted with water but does not allow overtopping.

3.13. Spillway dam

Dams are constructed from materials that allow water to overflow

3.14. Dam body height

The maximum vertical distance between the lowest part of the dam-body foundation and the highest section of the dam body. It is defined as below:

- Regarding the dams using earth and earth-rock materials: the height is determined as the vertical distance from the lowest ground surface of dam foundation after clearing (regardless the height of cut-off trench) to the dam crest;
- Regarding the concrete dams of all types: the height is determined as the vertical distance from the bottom of the lowest cut-off to the dam crest.

3.15. Design flood

A flood event which is expected to occur at the dam site in correspondence with the designated frequency.

3.16. Check flood

A flood event which is expected to occur at the dam site in correspondence with the designated frequency or extreme flood.

3.17. Freeboard

The minimum height between the maximum check-water level and the dam crest elevation to be secured in order to assure that water in a reservoir shall not overflow the dam under all expected circumstances.

3.18. Maximum credible earthquake (MCE)

The greatest earthquake which can possibly occur at the construction site by a specific source along the existing fault or other seismic source. MCE is estimated by a deterministic analysis or probabilistic analysis (in correspondence with the occurence frequency (or return period) of earthquake and in accordance with the construction grade) based on the tectonic characteristics, seismic and geologic indication as well as information relating to earthquakes in the past.

3.19. Operating basis earthquake (OBE)

The greatest earthquake which can possibly occur within the service life of the work in accordance with the frequency, that does not exceed 50 % of exceedance probability during the service life of that work. The work shall be designed so that the structure is not damaged or is slightly damaged and operates normally in case OBE occurs.

3.20. Concrete strength

The ability in bearing the maximum pressure of the concrete sample at twenty-eight days that is casted and maintained in the standard condition. Regarding this pressure, the concrete sample shall not be cracked. The unit of concrete strength is MPa. The strength of concrete is divided into two types: compressive strength and tensile strength.

3.21. Target strength of concrete

The required strength of the chosen concrete mixture shall meet requirements of the design strength considering the dispersion level of concrete strength at construction site. Basing on the value of target strength to design gradation and concrete test.

3.22. Concrete grade

The compressive strength of the concrete sample at twenty-eight days that is casted and maintained in the standard condition. Concrete is divided into grades M10; M15; M20; M25, M30; M40, M45 and higher. The unit of concrete grade is MPa.

3.23. Antiseepage grade of concrete

The ability in bearing the maximum water pressure of the hydraulic concrete sample at the age of 28 days, which is poured and maintained in the standard condition. At this pressure, the concrete sample is not penetrated through by water. The antiseepage ability of hydraulic concrete is divided into grades such as CT2, CT4, CT6, CT8, CT10 and CT12. The unit of antiseepage grade is MPa.

3.24. Hydromechanical equipment

Mechanical equipment which is installed in hydraulic projects and hydropower projects to regulate water flow and guarantee safety for works such as gates, valves, trash racks and penstocks but not including electro-mechanical and hydro-mechanical equipments which are installed inside the power house.

3.25. Gate

A type of hydromechanical equipment which is used for retaining and regulating water flow.

3.26. Trash rack

A type of hydromechanical equipment which is arranged at upstream of intake gate in order to prevent debris and water leafs from inflowing into the waterway.

3.27. Penstock

A pipeline which has internal water pressure acting continuously along the length of pipe.

3.28. Headrace

A part of waterway structure which leads water from intake to a head tank or surge tank or turbine of electrical generator. Headraces are usually open channels or tunnels or pipe conduits or combination thereof.

3.29. Tailrace

A part of waterway structure which leads water from draft tube or rear turbine of electrical generator to the water receiving area (reservoir or river). Tailraces are usually open channels, tunnels, pipe conduits, or combination thereof.

3.30. Inlet

A type of structure which is located in the upstream of the waterway and allows water in source to flow into it in order to generate electricity.

3.31. Outlet

A type of structure which is located at the downstream end of the waterway and allows free discharge of water after power generation to the water receiving area.

3.32. Deformation joint

The narrow gap which divides the work into separated parts so that the work operates safely, to prevent and limit the fracture and failure situation when the work or its foundation is deformed due to uneven settlement or the changes in the environmental temperature. Deformation joints, which contact with water, must be designed to assure that water shall not penetrate. The deformation joint includes three types: settlement joint, thermal joint and anti-vibration joint:

a) Settlement joint: deformation joint which is used to prevent and limit the fracture situation of the work caused by uneven settlement. Uneven settlement is formed by the differences in the applied loads acting on the ground as well as the differences in the load-bearing strength of the foundation. Transversal joints of settlement joint must assure safety when the work sections are deformed by uneven settlement or changes in the temperature and not allow the penetrating of water;

b) Thermal joint: deformation joint deals with the phenomenon that the structures are deformed under the influences of the environmental temperature;

c) Anti-vibration joint: deformation joints used to limit the influences of earthquake acting on the work.

3.33. Construction joint

The gap divides the work into small blocks to serve the construction work and deal with the thermal stress being generated during the construction period. The construction joints must be treated by filling jointing-materials before putting the work into operation.

3.34. Hydraulic concrete

Concrete is used for the structures placing in the inundated areas and the areas being affected by the changes of water level.

3.35. Common concrete

Concrete is used for the structures on land and does not regularly contact with water.

3.36. Guarantee of serving level of hydropower work

The number of years that the work assures to generate electricity with the capacity and production of electricity according to the design function during the string of 100 years of continuous exploitation, is computed by percentage.

3.37. Safety coefficient

The ratio of the general calculated resistance, deformation or other parameter of the considering object to the general calculated loads acting on it (force, moment and stress), deformation or other parameters. The safety coefficient is used to evaluate the level of general and local stability, durability, stress and deformation for each work item and its foundation.

4. Classification of works

4.1. General stipulation

4.1.1. The grade of works is a foundation to determine mandatory technical requirements in accordance with different levels and in coherence with the scale and importance of the works. The design class of a work refers to a grade of works.

4.1.2. The hydropower works are divided into five classes (special class, class I, class II, class III and class IV) depending on its scale and importance. The works of different classes shall comply with various technical requirements. The works of special class have the highest technical requirements. These requirements for the works are decreased from the higher to the lower classes.

4.2. Principles for the classification of hydropower works

4.2.1. Work grade must be determined based on each criterion: service capacity, water storage ability and technical characteristics of constructions in the headwork unit (referring to stipulation in the table 1). Class of a hydropower works is the highest grade of the grades which are determined according to each above criterion.

Table 1 Classification of hydropower works

Name of works (or work items) are considered for classification	Type of founda-tion soil	Class				
		Special	I	II	III	IV
1. Hydropower plant having capacity of, MW		>1 000	300 ÷1 000	100 ÷<300	50 ÷<100	<50
2. Reservoir volume regarding to the retention water level, 10^6 m^3		>1 000	>200÷1 000	>20 ÷ 200	≥3 ÷ 20	< 3
3. Earth or earth and rockfill dams, obtaining the maximum height of, m	A	> 100	>70 ÷ 100	>25 ÷ 70	>10 ÷ 25	≤ 10
	B	-	> 35 ÷ 75	>15 ÷ 35	>8 ÷ 15	≤ 8
	C	-	-	>15 ÷ 25	>5 ÷ 15	≤ 5
4. Concrete or reinforced concrete dams obtaining the height of, m	A	> 100	>60 ÷ 100	>25 ÷ 60	>10 ÷ 25	≤ 10
	B	-	>25 ÷ 50	>10 ÷ 25	>5 ÷ 10	≤ 5
	C	-	-	>10 ÷ 20	>5 ÷ 10	≤ 5
5. Retaining wall with the height of, m	A	-	>25 ÷ 40	>15 ÷ 25	>8 ÷ 15	≤ 8
	B	-	-	>12 ÷ 20	>5 ÷ 12	≤ 5
	C	-	-	>10 ÷ 15	>4 ÷ 10	≤ 4

NOTE:

1) There are three typical groups of foundation soil:
   - Group A: the foundation is rock ;
   - Group B: the foundation is sandy soil, coarse-grained soil, clay at the hard and semi-hard state;
   - Group C: the foundation is water saturated clay at the plastic state;
2) The height of a structure is estimated as defined in 3.14. The height of retaining wall is the maximum vertical distance between the lower face of the bottom slab and the wall crest.

4.2.2. The headwork class is equal to the grade of the hydropower works. The class of the water conveyance and transfer system located downstream of the head work will be equal or smaller than the class of the headwork and become smaller according to decrease of the service scale.

4.2.3. The class of the hydropower works determined according to the table 1 will be considered degradation by one grade (exclude the class IV work) regarding to the following circumstances:

a) In case that the grade of a work determined in a relation with the dam height is lower than the grade determined according to the reservoir volume in a correspondence with the retention water level;

b) The work items of the special class and class I work which are not placed in the pressure alignment such as administration building, control building, service road, etc.

(exclude power house, pressure water pipeline as well as water-line used to conduct water to the turbine, head tank and surge tank);

c) Structures which have the exploitation time less than 10 years;

d) Hydraulic works belonging to the energy line, in case of rehabilitation and renovation will not affect significantly on the normal operation of the hydropower plant.

4.2.4. Classes of hydropower works defined in the Table 1 will be considered to increase one level (excluding the special class work) if one of the major work-items have failures or risks which can lead to significant damage for the socio-economic and environmental conditions downstream.

4.2.5. In the diagram of the cascade exploitation, if the class of a hydropower reservoir, which is being considered for investment of construction, is smaller than that of the operating work in upstream, the design calculation shall assure that the ability of flood discharge of the work in lower stage equals to the design flood discharge (discharge of design and check flood) of the work in upper stage plus the flood discharge of the middle area regarding the grade of the work in lower stage.

4.2.6. The grade of hydropower works belonging to other industries, being presented in parts of hydropower projects or hydropower works which are designed to cross current constructions (road, railway, etc.), will be correlation with the class of relevant works and the higher grade shall be chosen for design.

4.2.7. The class of hydropower works crossing flood protection dike are determined as the grade of the pressure works and shall not be lower than the design level as well as the safety standard of that protection dike.

4.2.8. The class of the temporary works serving in the construction phase of hydropower works is permitted to increase to the higher class, which is stipulated in the table 1, if there will be failures which can lead to following consequences but shall not be higher than the class of major work:

a) Lose the safety condition of the permanent structures which is still uncompleted;

b) Can result in significant damages in the economy, society and environment downstream. Physical damages, in case of occurring, will be dramatically larger than the additional investment for the temporary works;

c) Delay of the commissioning date and decline the investment effectiveness.

4.2.9. The relationship of class of each work item in one unit of headwork of hydropower work is stipulated in the table 2:

4.2.10. The determination of work class, which is stipulated from 4.2.1 to 4.2.9, is proposed by the design consultant and accepted by jurisdiction authorities.

Table 2 Relationship between hydropower works and the class of major, secondary or temporary constructions at the same unit of headwork of hydropower work

Class of work	Special	I	II	III	IV
Class of major work	Special	I	II	III	IV
Class of secondary work	I	II	III	IV	IV
Class of temporary work	II	III	IV	IV	IV

5. Guarantee of serving level of hydropower works

5.1. The guarantee of serving level for hydropower works shall not be lower than values stipulating in the Table 3.

5.2. Regarding the multipurpose-hydropower works, apart from requirements about guarantee level for power generation, the guarantee level of serving for other demands other than hydropower shall obey provision in the Table 3 of the QCVN 04 - 05 : 2012/BNNPTNT.

5.3. The reduction of the guarantee level for the serving of work is only permitted if there is reliable evaluation, which is accepted by the jurisdiction authorities.

Table 3 Guarantee level for service of hydropower works

Objects are served by works	Guarantee level upon class of works, %					Other requirements
	Spe.	I	II	III	IV	
1. Independent power generation	90	90	85	80	80	The investors stipulate the reduction level of power output, electricity output and affected time in a year (or season) when water deficiency problem occurs depending on the task taken by the hydropower plant in the power system and provide those criteria to the design agency.
2. Using irrigation water for power generation	Upon regime of irrigation					If there are differences in water used for electric power generation and irrigation during a day, a daily regulated reservoir will be used to re-regulate.

6. Safety coefficient of hydropower civil works

6.1. Loads, impacts and load combinations acting on the hydropower works shall follow the article 6 of the QCVN 04 - 05 : 2012/BNNPTNT.

6.2. Data on natural conditions relating to the features of topography, geology, hydrological geology and flow that are used to calculate loads acting on the hydropower work and construct hydropower works obey current stipulations. Other natural data refers to the QCVN 02:2009/BXD.

6.3. Calculation in determining the safety coefficient K of hydropower civil works follows the limit state method, in which input data about engineering geology and construction material shall be processed by the statistic method with the confidential probability in relation to loading deviation and over load ratio, material error coefficient, working condition factor and constructional factor, obeying the stipulations in the Appendix B. The safety coefficient (K) of each construction or work-item must guarantee the below requirements:

a) The safety factor for the stability of work-items and the construction-base system:

1) Not smaller than values stipulating in the table 4 with regards to the normal working condition;

2) Not lower than 90 % and 95 % of the stipulated values in the table 4 regarding to the abnormal working condition (special) and during amendment construction, respectively;

Table 4 The minimum safety coefficient on the stability of work-items and the construction-base system in the normal working condition

Type of construction and work-item	Safety coefficient according to the construction class			
	Special	I	II	III, IV
1. Concrete and reinforced concrete works on the earth and semi-hard rock foundation	1,25	1,20	1,15	1,15
2. Concrete and reinforced concrete works on the rock foundation:				
- Sliding surface passes through cracks in the rock foundation	1,25	1,20	1,15	1,15
- Sliding surface passes through the contact surface between concrete and rock or goes through the rock foundation, which partly passes cracks and partly passes through the monolith	1,35	1,30	1,25	1,25
3. Arch dams as well as other preventing and supporting works on the rock foundation	1,70	1,60	1,55	1,55
4. Man-made backfill slope	1,50	1,35	1,30	1,25
5. Natural slope, rock slope	1,25	1,20	1,15	1,15

b) The safety factor for the durability of concrete and reinforced concrete works:

1) Not lower than value stipulating in the table 5 and not lower than 90 % of the values in the table 5 in accordance with to the normal and abnormal (special) working condition, respectively with regards to concrete and reinforced concrete dams;

2) Not lower than values stipulated in the table 5 regarding to the reinforced-concrete structure in all working conditions;

Table 5 The minimum safety factor for the durability of concrete and reinforced concrete works in the hydropower civil works

Type of construction and work-item	Safety coefficient according to the construction class			
	Special	I	II	III, IV
1. Concrete and reinforced concrete dams	1,40	1,35	1,30	1,30
2. Reinforced concrete structure regarding to the laminar and flank type in all working conditions	1,25	1,20	1,15	1,15

c) The safety factor for the deformation regarding to each type of works in the hydropower project and in all working conditions is not lower than below values:

1) K > 1.0 regarding to concrete and reinforced concrete works on the earth or semi-hard rock foundation;

2) With regards to the concrete and reinforced concrete works on the rock foundation:

- If the sliding surface passes cracks in rock base, K>1.0;
- If the sliding surface passes the contact surface between concrete and rock or goes inside the rock foundation, which partly passes cracks and partly passes monolith, K > 1,10;

3) Arch dams as well as other preventing and supporting works on the rock foundation, K >1.35;

4) Natural or man-made slope, K > 1.0;

d) The application of other calculating method to determine the safety coefficient must obtain the results that are not lower than required calculation regarding the above limit state method.

7. Construction hydropower civil works

7.1. General requirements

7.1.1. The safety condition of durability and stability in the design circumstance and check circumstance in correlation with the grade of work shall be assured. The general and local safety coefficients of durability, stability and deformation in all working conditions shall not be smaller than values being stipulated in 6.2

7.1.2. The operation and maintenance activities shall be in favorable condition. There are appropriate responses to specifically deal with each circumstance to mitigate negative impacts, which could be occurred for the work itself and other influenced objects in case of failure in works.

7.1.3. Flow rate and flow regime of discharge to downstream shall be determined according to requirements of environment protection and activated water consumers including scheduled objects in near future of construction such as the replenishment for works in downstream and navigation requirements during the dry season. If there are not any specific water consumption requirements in downstream during dry season, the downstream should receive the minimum volume of water equal to 0~30% of the average flow in the year with the frequency of 95% (0~30%$Q_{95\%}$) so as to preserve the ecological environment.

7.1.4. Guarantee the architectural and aesthetic harmony of each work in the headwork unit and its integration with the surrounding scenery. In all design instances, the following conditions should ensure to be maintained: the protection of nature and ecological environmental sanitation as well as the ability of combination with tourist and convalescence of sites.

7.1.5. Combine with the highest level between requirements of constructing the hydropower work and the requirements of traffic development in the project area. Hydropower works, in case of building on the rivers or streams, which have a function of navigation, it is assured that in necessary conditions, such navigation transportation can pass through. If it is constructed in the area with high value of aquatic products, fish-ways and aquatic protection works must be proposed to arrange and build. Those works must conform to requirements and stipulations of aquatic sources protection and assure that such protected aquatic species can regularly or seasonally pass through the works depending on its biological features.

7.1.6. With regards to the special and class I construction, the design and building should be based on experiments on foundation, constructional materials, hydraulic regime, infiltration, working conditions of complex structures, temperature state in concrete and operating condition of equipments and the effectiveness in applying advance science and

technology. Objective and scope of experiments shall be based on specific conditions of each work, which are proposed in the beginning period of the project. This task is also applied in the other work-items of lower class if there is not any similar sample (or constructional example).

7.1.7. During the repair, rehabilitation, upgrading or extension of existing work, the influences to the electricity generation and water-consuming sectors shall not be over-disadvantages.

7.1.8. Major design criteria of flow shall obey stipulations in 5.2 of the QCVN 04 - 05 : 2012/BNNPTNT. If there is not any or not enough reliable flow measurement data for determining inflow of a reservoirs, it is allowed to use the rainfall data obtaining the calculated frequency equivalent with the guarantee level stipulated in the Table 3 in order to estimate the inflow from the rainfall – runoff relationship of the project basin or similar adjacent basin.

7.1.9. Foundation and ground of works will be treated by appropriate methods before the construction if the following technical requirements are not met:

a) Having the compressive strength that is higher than the maximum pressure at the bottom of foundation, which can be generated in design calculating instances;

b) Having the modulus of deformation which is higher than deformation modulus of the work;

c) Foundation and ground of water-raising works, which are used to form a reservoir, have a infiltration coefficient lower than 0.01 m/24hours ($\approx 1.16 \times 10^{-5}$ cm/s), the unit water absorption below 0.01 l/(min.m^2).

7.1.10. Construction site of temporary works and constructional material mines, which are exploited for the construction, shall be reinstated after the termination of work.

7.1.11. If the unfinished main work is used as constructional diversion work, the diversion frequency shall refer to the grade of major work in accordance with the diversion period of time.

7.1.12. Execution of drilling of blast holes and rock excavation in the construction of hydropower work, referring to the QCVN 04-04 : 2012/BNNPTNT.

7.1.13. Operating and regulating procedures shall be established for all hydropower reservoirs and shall be approved by the jurisdiction authorities before or during the period of construction design stage. Content of the operating and regulating procedure (for one reservoir and inter-reservoir) shall meet the following requirements:

a) Works operate safely in all discharge levels including the design and check flood circumstances;

b) Provide water to assure harmony in benefits of water-consuming sectors in correspondence with high flow year, normal year and dry year;

c) Guarantee to regulate floods regarding the requirements of flood protection for reservoir and downstream:

- The flood releasing operation for the flood events lower than the design flood does not cause significant damages for downstream area;
- In case of flood releasing operation for the flood events higher than design flood, there shall be appropriate constructional solutions in order to assure safety for reservoir work, hydropower plant and minimize damages in downstream area;

d) There shall be adequate solutions to maintain necessary discharge for water consumption and protection of the river environment in downstream areas bearing impacts of dam and water intake works. Regulating discharge to downstream for maintaining the environmental flow shall follow the 7.1.3.

7.1.14. Concrete in the water contacting zone shall have the depth of impervious layer and anti-seepage grade in accordance with the water pressure acting on it and being stipulated in the table 6. Synthesis material which has high impervious and stability features against the fluctuated-water environment can be used as an impervious layer which covers the outside upstream face of a concrete dam or surface of water-contacting concrete structures in case of reliable technical solutions but must guarantee the conditions of safety and stability of the structure that are stipulated in the article 6 of this regulation.

Table 6 Requirements on the impervious grade of hydraulic concrete in underwater

Ratio between the maximum active water pressure and the thickness of structures or the thickness of the structural facing layer	**Minimum Impervious grade**	**Bearing the maximum water pressure** MPa
Less than 5	CT-4	≥ 0,4
From 5 to 10	CT-6	≥ 0,6
Higher than 10	≥ CT-8	≥ 0,8

7.1.15. Compressive strength (notation: R_n, unit: MPa) of normal concrete structure (excluding foundation lining concrete) in the construction of hydropower works depends on the characteristics of structures, working condition and loads combination acting on it but is not lower than 20 MPa.

7.1.16. Compressive strength of hydraulic concrete is not lower than values being stipulated in the table 7:

Table 7 The minimum compressive strength of hydraulic concrete in correspondence with the impervious grade regarding to maximum water pressure.

Impervious grade	CT-4	CT-6	CT-8	CT-10	CT-12	> CT12
R_n, MPa	20	25	30	35	40	50

7.1.17. Bending and tensile strength of the concrete structure should be determined considering the compressive strength of the concrete, characteristics of that structure, working conditions, load combination and ensuring the safety requirement in terms of durability.

7.2. Reservoir

7.2.1. Shall follow the 8.1 of the QCVN 04 - 05 : 2012/BNNPTNT.

7.2.2. Works to be done before the construction of dams and reservoir, referring to the 8.1.5 of the QCVN 04 – 05 : 2012/BNNPTNT.

7.2.3. If the dam is constructed in the area in which the activities of termites are expected, the existence of termite shall be investigated by appropriate devices. Before the commencement of construction, issues relating to termite shall be totally treated.

7.3. Dams

7.3.1. Earth dam

7.3.1.1. The earth dam must guarantee below basic technical requirements:

a) Having adequate safety height (include the settlement prevention depth of a foundation and dam) to ensure that a dam is not overflowed in all working circumstances;

b) The penetration, which crosses foundation, body and shoulders of a dam, the contact surface among dam and foundation, bank and bearing of constructions placing internal a dam, does not influence the volume of stored water in a reservoir. It will also not create piping, spoil dam and decline the service life;

c) If the discharge works and inlet are arranged in a dam body, they will be placed on the stable natural foundation, which obtains anti-seepage solutions along the contact surfaces between backfill soil of a dam and those structures, to ensure that a dam toe will not be eroded in case of flood discharge;

d) The interface between the two backfill blocks in a non homogeneous earth dam must guarantee that the following phenomenon will not arise: soil destruction through the over-movement of soil from this place to other place caused by the seepage flow, cracks as well as the creation of zones with stress variation and sudden deformation in a dam and foundation;

e) Constructional segmentation and stages must not create the backfill construction joint on the plane connected from upstream to downstream. The constructional loading block to increase the stability of foundation and downstream cut-off dike must consider that block as one part of a formal cross section of a dam. The crest of that loading block must be placed on the exit point of a saturated line of the constructional dam cross-section in the first constructional phase.

7.3.1.2. The overall stabilized settlement level of dam and foundation does not exceed the limit 1.0% and 1.5% of the dam height in case the dam height is from 15.0 m and above as well as below 15.0 m, respectively.

7.3.1.3. The shape and dimension of a dam cross section must satisfy the following requirements:

a) The crest elevation must follow regulation in the point a of the article 7.3.1.1;

b) The width of a dam crest depends on the class of a construction and conditions of transportation, construction, management and exploitation but is not lower than 10 m regarding to the dam of special class and class I and not lower than 5 m regarding to a dam of class II and below. If there is additional function for transportation route, the top of a dam must follow regulations of transportation, but is not lower than above regulations;

c) Dam slopes, dam body and dam toe are protected by adequate structures and materials to assure the stability under the destruction influences of wave and rain pressure as well as other destruction factors. It will also guarantee the stability in all working conditions of a dam;

d) Dams of the height above 15 m must have banquettes (berm). The elevation differences between the two continuous banquettes on the same dam face will not higher than 15 m. Width of a berm is not smaller than 3,0 m. If there is an additional task of transportation rout in downstream berms, the width of a berm must follow regulations of traffic way. The upstream face should be arranged with a berm at the lower limit of a major consolidation layer in order to form the necessary bearing.

7.3.1.4. A surface diaphragm type fill dam including reinforced concrete facing type, asphalt concrete facing type, and plastic membrane facing type shall satisfy the following requirements:

a) Not to have cracks which damage the sealing function of the diaphragm;

b) Impervious curtains shall be arranged in the dam foundation to the waterproofing layer (obtaining the infiltration coefficient less than 0,01 m/day) or to the depth from 0,5 H to 1,0 H, where H refers to the height of water column acting in front of the dam;

c) Appropriate measures shall be taken to prevent seepage at the contact between surface diaphragm and the foundation.

7.3.1.5. Soil used for forming impervious structure must obtain the filtration coefficient, which is not higher than 10^{-5} cm/s. Regarding the homogeneous dam, filled materials shall be soil of similar physical and mechanical properties. Swelling clay shall not be used for filling a dam.

7.3.1.6. The impervious layer on the top of the sand, crush stone, pebble and caves in the storage reservoir shall not be removed. Soil which has the ability of wave barrier as well as bank and dam protection from hills and mountains in upstream of dam for banking shall not be removed.

7.3.1.7. The compaction factor K of backfilled soil regarding to earth dam from grade II and above and dam being built in the area which has the earthquake intensity from class VII and above is not lower than 0.97 ($K \geq 0.97$); regarding to dam with works from grade III and below and other earth works, is not lower than 0.95 ($K \geq 0,95$).

7.3.2. Rock-fill dam

7.3.2.1. Implement regulation in the articles from 7.3.1.1 to 7.3.1.4 .

7.3.2.2. The dam components relate to anti-seepage structure of dam such as core, abutment plane and core wall must be placed on the good foundation.

7.3.2.3. The foundation of rock zone must be the decomposed stone, which has the deformation module not lower than the deformation module of a backfill rock block. It is allowed to use a foundation of sand, broken stone and gravel when there are appropriate structural treatment and anti-seepage method as well as compacted and constructional solutions and it assures that the relative density ratio of sand, broken stone and gravel in a dam foundation is not lower than 75 %. The settlement, deformation must be control to prevent phenomenon such as separated crack and hanging core.

7.3.2.4. Filled rock shall not be mixed with other impurities and shall guarantee the continuous grading in order to obtain the required compaction factor and dry density regarding to the design. Diameter of the maximum grain will not larger that the depth of filled layer after compressing. The fraction of rock grains having the dimension $d \leq 0,075$ mm

does not exceed 5%; the grain fraction having d ≤ 5 mm does not exceed 20% in the rock-filled block after finishing the compacting task.

7.3.2.5. Rock used for fill dam must have the ability in weathering resistance and is not softened when contacting with water and surrounding environments with the softened coefficient $K_m \geq 0,90$. The quality of rock is specified by the immediate anti-compressive strength in one axis at the saturated state (R_n) and the softened coefficient (K_m):

a) Rock used for filling upstream zone at the foreground of impervious core, the upstream zone determined from the dam axis of the rock-filled dam, concrete facing slab dam and the area under the downstream level of downstream zone, shall have R_n not less than 30 MPa (not less than 40 MPa regarding to the class I and Special class of filled rock dams)

b) Rock used for filling the area above the downstream level of the downstream zone shall have R_n not less than 20 Mpa.

Note: The soften factor K_m refers to the ratio between the immediate anti-compressive strength in one axis at the saturated state and the immediate anti-compressive strength in one axis at the air-dried condition

7.3.2.6. The temporary spillway is permitted to be placed to discharge flood across a body of the un-finished rock-filled dam but there are constructional solutions to guarantee the safety condition for dam and reservoir.

7.3.3. Earth and rock fill dam

Regarding a dam having a mixture of many types of soil and rock, the backfilled blocks in dam body are arranged appropriately. The interface area between two backfilled blocks must assure not to arise the following phenomenon: soil destruction through the over-movement of soil from this place to other place caused by the seepage flow, cracks as well as the creation of zones with stress variation and sudden deformation in a dam and foundation. The dam part which is filled by earthen materials and rock materials refers to 7.3.1 and 7.3.2 respectively.

7.3.4. Gravity concrete dams

7.3.4.1. A crest of a dam, not used to overflow, must have adequate safety height comparing to the maximum water level in front of a dam and not allow the overflow of wave. Width of crest should meet requirements of construction, management, exploitation, transportation and other requirements (if existed). If there is additional task of traffic way, the dimensions and structure of crest must follow regulations of transportation. If there is not any requirement for transportation, the width of crest must not smaller than 3,0 m.

7.3.4.2. Longitudinal and transversal galleries are placed inside dam body. These galleries meet below requirements:

a) The distance between floors of a gallery is not over 20 m in height and floors are connected together by passages running around the floor. The lowest longitudinal gallery must assure the requirement of emptying infiltration water;

b) The distance between the upstream dam face and upstream face of longitudinal gallery must be larger than 1/20 of the water height, which is measured at the bottom elevation of a gallery but is not smaller than 2.0 m;

c) Gallery for water concentration, check and installing measurement devices and pipeline has a width of not lower than 1.2 m and the height not lower than 2.0 m. The grouting gallery near the foundation has a dimension that depends on the working condition of the grouting machine but not lower than 2.0 m and 3.0 regarding the width and height, respectively.

d) The area surrounding the openings in the dam body, such as galleries, water discharge equipment or penstocks installed inside the dam body, shall be structurally safe against stress concentration and thermal stress.

7.3.4.3. Settlement joints shall be arranged at locations with alteration in foundation geology and dam height. The distance between settlement joints must assure that dam shall operate safely and does not crack. The width of a settlement joint shall not be over 30 mm. The width of a thermal joint shall not be over 10 mm and 3 mm at the position at which the distance to the upstream bearing surface does not exceed 5 m and inside the dam body, respectively.

7.3.4.4. All settlement joints and thermal - settlement combination joints shall be sealed and filled (grouted) by impervious materials (called as water barrier), except for the thermal joints in dam body. Water barriers shall meet requirements of imperviousness and have adequate ductility as well as durability, that is not lower than the durability of concrete material being used for dam.

7.3.4.5. Impervious curtains and drainage holes shall be arranged to reduce uplift. The unit rate of water absorption, infiltration factor and gradient of water column in an impervious curtain in a rock base does not exceed values in the table 9.

7.3.4.6. Concrete at the water contacting surface must meet requirements being stipulated in 7.1.14. The thickness of the external layer of the structure shall be determined based on the type and style of dam, the height of acting water column, climatic condition of the construction site as well as the dimension of dam body item and structure, but not less than 2,0 m.

Table 8 Values of permitted infiltration gradient [J_{cp}] in an impervious curtain in a rock base

Dam height H m	**Water proof characteristic of the impervious curtain body**		**[J_{cp}]**
	The unit rate of water absorption l/(min.m^2)	**Infiltration factor** cm/s	
< 60	≤ 0,05	≤ $1x10^{-4}$	15
From 60 to 100	≤ 0,03	≤ $6x10^{-5}$	20
> 100	≤ 0,01	≤ $1x10^{-5}$	30

7.3.5. Other types of dam

When the jurisdiction authorities allow to apply technical regulations or standards for dam construction being applied in the world to specific works in Vietnam, it must assure that the design criteria and technical requirements shall conform with provisions in this regulation.

7.4. Spillways

Refer to the 8.3 in the QCVN 04 - 05 : 2012/BNNPTNT and 7.3.4 of this regulation.

7.5. Waterway

7.5.1. The construction of waterway of hydropower plant shall meet below requirements:

a) Waterway shall be operated safely and stably in all design circumstances assuring the ability in conveying and controlling required discharge in all exploiting states being proposed in the design;

b) Sand, dust, driftwood or any other substances shall not be allowed to damage waterway and hydraulic turbine;

c) Waterway shall have regulating works to empty excess volume of water;

d) Waterway shall assure the ability in bearing the loads or pressure caused by water hummer for the following conditions during the operating periods:

- Sudden rejection of full load at the power plant;
- Full load acceptance;

e) The crown of the pressure pipeline must be placed below the minimum hydraulic gradient line, which can be occurred.

7.5.2. The construction of waterway and channels of power house refers to the article 8.7, 8.8 and 8.10 of the QCVN 04 - 05 : 2012/BNNPTNT.

7.5.3. The construction of hydraulic tunnel refers to the 8.9 of the QCVN 04 - 05 : 2012/ BNNPTNT.

7.5.4. Application of new structures, material and construction technologies, which are applied in developed nations for specific works shall guarantee safety in operation, stability (stability in strength, anti-sliding and collapsing as well as anti-seepage) in designing and examining circumstances.

7.6. Intakes

7.6.1. The implementation refers to the article 8.4 of the QCVN 04 - 05 : 2012/BNNPTNT to assure stability in water supply and safety in all operating states of the hydropower plant.

7.6.2. The intake work shall not be built on the foundation which is partly rock and partly soil or on a ground soil of semi-hard and semi-soft or on non-cohesive soil. If it is hard to avoid these conditions, appropriate treatment methods must be carried out.

7.7. Settling basins

Referring to the article 8.5 in the QCVN 04 - 05 : 2012/BNNPTNT.

7.8. Head tanks and surge tanks

7.8.1. For head tanks should have solutions, which meet below requirements:

a) Assuring stability and safety in operation in all calculated design circumstances;

b) Water flows into the penstocks shall not attract air and shall have small head-loss;

c) A head tank shall have an adequate size in order to assure acceptance and safe operation in case of bearing impacts of water hammer caused by the full load rejection and full load acceptance at the power plant;

d) A head tank shall have a spillway or flow-regulation works to control the maximum designed discharge safely when the full load is shut off;

e) Discharge from the spillway shall not cause damage to surrounding facilities or a river course;

f) The structures of a head tank shall be designed in order that garbage or sand does not flow into penstocks and turbines, and the accumulated sediment can be flushed easily;

g) Arrange adequate equipments in order to provide enough air into the conduit in case of emptying and to remove air in the conduit when it is full of water.

7.8.2. Necessity of surge tank shall be examined in order to guarantee the safe working condition of a generating unit in all design circumstances. The fluctuation of the water level

in the surge tank shall not be accelerated and shall return to equilibrium point in a short period in accordance with the characteristics of load of the power system and turbine control system.

7.8.3. Application of head tank and surge tank of new style with high technologies, which is applied in developed nations, to specific works in Vietnam must assure technical requirements in accordance with provisions in this regulation.

7.9. Penstocks

The penstocks shall satisfy the following requirements:

a) Stable operation in all working conditions and ability in bearing against expected loads in each type of penstock such as exposed type, rock-embedded type and earth-embedded type;

b) In all working instances, water in penstock will not infiltrate or flow out;

c) The crown of a penstock shall be placed below the lowest hydraulic gradient line, which can be occurred;

d) Exposed type penstocks shall be installed with anchor blocks or saddles. The anchor or saddle structure shall assure stable operation against expected loads. The supporting parts shall assure that a pipe cannot be horizontally displaced but it shall allow a pipe shell to move toward the longitudinal direction when a pipe contracts and expands as a result of environmental temperature.

7.10. Tailraces

Tailraces shall satisfy the following requirements:

a) Safety and stability in all operation states of hydropower plant operation

b) Any leakage from inside tailrace shall not cause damages to the surrounding ground or other structures;

c) Shall not significantly cause damage to the downstream waterways due to collapse of the waterways.

7.11. Outlets

The outlets shall assure the stable and safe operation in all working conditions of the hydropower plant. Connection with downstream channel flow shall be in stable and favorable condition. There shall be appropriate solutions to guarantee that river bed, river bank and constructed works on the channel flow in downstream of a hydropower plant will be operated safely and stably in design circumstances.

7.12. Hydropower plants (Powerhouse)

7.12.1. The hydropower plants (powerhouse) shall meet the general requirements as below:

a) A construction and equipments will operate safely, stably and conveniently in all exploiting and operating circumstances regarding the design calculation with high effectiveness;

b) The general layout of a headwork unit and the style of a construction are appropriate and in coherence with general landscape;

c) Influenced of hydrostatic pressure acting on a structure and hydromechanical and electromechanical equipment such as gates, valves, water turbines, etc. is within the design calculation;

d) Appropriate with the geologic characteristics of the foundation;

e) Shall not be inundated in all expected circumstances;

f) Having drainage pit, water-collecting well and adequate pumping system in order to drain water for the power house all well as in case of emergency inundated situation in a plant;

g) There are erecting and repairing floor as well as floor used to install devices that serve management tasks with appropriate plane area;

h) Having adequate ventilation and lighting systems;

i) Having galleries and stairs to connect floors of a plant;

j) Having appropriate solution in transport machines and devices;

k) Connection with downstream channel flow is stable and favourable. There are appropriate solutions to guarantee that a river bed, river bank and constructed works on the channel flow in downstream of a hydropower plant will operate safely and stably;

7.12.2. Under-water parts of the powerhouse should have solutions in dividing an installation house into sections. Dimension of each section depends on dimension of machine assemblies, foundation geology, structural solutions of constructional parts and allowance deformation. If there are adequate evaluations, a monolithic structure (no separation) can be used for the whole under-water parts of the installation house.

7.12.3. Galleries and wells of the powerhouse should meet the following requirements:

a) A gallery should have a width of 1.2 m or larger, a height of 2.0 m or higher and the exit ways of at least 2 gates. Emergency exits from longitudinal tunnel in case of

emergency must have separated stair insolating with arranged rooms inside a station;

b) Top of the well or entrance should be at least 0.5 m higher than the maximum water level in downstream. There is a water-tight cap (or gate) to prevent the inundated situation of the gallery

7.12.4. The lining (coating) of powerhouse must obey requirements being stipulated in relevant standards in constructing hydraulic tunnel.

7.13. Daily storage reservoir

7.13.1. The construction of daily regulated reservoir for a hydropower plant, working pursue the top-covering state, should specially consider the stability and durability of the earth water barrage as well as protective coating in case of high fluctuation of water level in a reservoir.

7.14. Bottom discharge

7.14.1. Bottom discharge or bottom outlet includes elementary types as below:

a) Blind drain placed directly on the parent rock ground, below earth dam, rock dam or earth-soil dam;

b) Pipeline placed inside concrete dam, reinforced concrete dam or concrete-rubble dam;

7.14.2. Apart from technical requirements applied for water inlet from reservoir, which is stipulated in 7.6, depending on specific condition, additional requirements shall be met as below:

a) Control discharge to downstream to maintain flow in order to meet requirement of environmental protection;

b) Assure to empty water to dredge reservoir foundation, repair some work items which are regularly submerged under water, anti-seepage for reservoir and some work items, or research for measurement, investigation and evaluation current situation of headwork items, etc;

c) Release sediment in a reservoir regarding to requirements of operating and managing procedure;

d) During construction phase, it meets requirements of constructional diversion;

e) Combine with flood discharge work to release partly volume of flood volume.

7.14.3. Bottom discharge, type hydraulic meets requirements being stipulated in 8.9 of QCVN 04-05:2012/BNNPTNT.

7.14.4. All hydropower works from grade II and above must build bottom outlet work. Bottom outlet work for lower grade works may be constructed if there is adequate evaluation of being accepted by investor.

7.15. Protective works of reservoirs, headwork area and downstream of headwork

7.15.1. Referring to the article 8.11 of the QCVN 04 - 05 : 2012/BNNPTNT.

7.15.2. Facilities to discharge water to downstream area to empty a reservoir, to maintain necessary amount of water for water utilization or environmental preservation shall be installed. Technical requirements for bottom outlet refer to 7.14.

7.15.3. If a serious negative environmental impacts or damages to production and life of people in downstream area due to the rapid water level changes (too high or too low) by the discharge from a hydropower plant are expected, appropriate measures shall mandatorily be taken to mitigate possible negative impacts or damages.

7.16. Observation device system of the work

7.16.1. Major constructions from class II and above will place the monitoring devices to observe the operation of the construction and foundation during the building and exploiting phases. The purposes of that is to evaluate the sustainable level of a construction, timely detect failures and defects, if existed, so as to obtain appropriate decision about methods of amendment, failure prevention and exploitation improvement.

7.16.2. The construction of observation system must meet bellowing requirements:

a) Provide immediate and precise data about the status quo in the operation of work. The observing data must be uninterrupted. Duration and the number of time in observation, the degree of detail and preciseness of observed data regarding stipulations of consultant authorities and owner;

b) Phenomena having relationship with each other must be observed concurrently. For example in order to evaluate the stability and durability of earth dam, rock dam or earth-rock dam the following observations must be done concurrently: filtration, stress and deformation at points in dam body;

c) Measurement results must be adjusted, tabulated and established data for analysis, evaluation and conclusion.

7.16.3. Regarding reservoirs, bellowing contents must be observed:

a) Inflow of the reservoir;

b) Time and spatial allocation of suspended loads and bed load flowing into the reservoir;

c) Time and spatial allocation of sedimentation in the reservoir;

d) Collapsing and regenerating conditions of the reservoir bank;

e) The changes of water level in the reservoir;

f) The changes of water flow withdrawing from the reservoir.

7.16.4. Regarding to earth dam and rock-filled dam, basic observations are implemented:

a) Vertical and horizontal displacement of dam face and major components of dam body;

b) Settlement of dam foundation and inside dam body;

c) Filtration (including filtration pressure, saturated filtration line and filtration rate) through the dam body, dam foundation, dam shoulder and the connecting components and filtrate through anti-seepage elements such as impervious curtain and water-proof pile;

d) Sedimentation in front of the dam;

e) The changes of water elevation in upstream and downstream towards time;

f) The stability of slope and bank: positions having cracks, settlement, collapse and extrusion springs, etc.

7.16.5. Regarding to concrete dam, reinforced concrete dam of all types and elements of toe plate and faceplate of rock-filled dam with concrete faceplate, the bellowing issues are observed:

a) Vertical, horizontal, bending and sloping displacement of concrete dam block and joint;

b) Filtration pressure acting on the dam bottom, energy dissipation basin, toe plate and in front of and behind impervious curtain;

c) Filtration in the dam shoulder;

d) Filtration rate;

e) Temperature of water in the reservoir, air, concrete and dam foundation;

f) Sedimentation in front of the dam;

g) Changes of downstream and upstream water elevation towards time.

7.16.6. Regarding hydropower plant, the bellowing factors are observed:

a) Vertical and horizontal displacement of powerhouse, turbine, electrical generator and major elements of the powerhouse;

b) Infiltration inside and outside the plant.

7.16.7. Apart from observation about the safety of dam and hydropower plant, principle observations are implemented as following:

a) Observe the changes of stress states including self stress of work, foundation stress and stresses among work and its foundation as well as important structures of dam such as stress in the impervious concrete slab including pore pressure in dam and foundation;

b) Observe soil pressure of dam acting on the contacting surface with hard works;

c) Observe deformable stress of non-soil anti-seepage wall;

d) Observe force of reinforcement of reinforced concrete structures;

e) Observe temperature and thermal stress inside the massive concrete works;

f) Observe behavior of underground water in downstream area of the dam;

g) Observe bank stability in the areas near the dam

h) Observe the earthquake in case of reservoir accumulating and seismic observation at the construction site, etc.

7.16.8. Based on specific condition of each work, the design consultant shall choose observing objectives, type of observed equipments and appropriate locations for installing observed measurements.

7.16.9. Regarding to the class III and IV construction, on the ground of specific circumstance of construction type and working condition of the work and its foundation, there are certain monitoring devices for some major work-items if there is appropriate evaluation, which is approved by the investor.

8. Hydromechanical equipments

8.1. General requirements

8.1.1. Hydromechanical equipments, which are installed in hydropower works, must safely and stably operate in expected circumstances and be convenience in management, exploitation and maintenance.

8.1.2. Depending on the type of hydromechanical equipments, working condition and its installing site in the work so as to determine types of loads and load combinations are chosen appropriately. The design calculation needs to apply load combinations in the most unfavorable operating-condition.

8.1.3. Items of valve gates, penstocks and hydromechanical equipments are confirmed to have sufficient stability, strength and stiffness by inspections of stress, deflection and deformation.

8.2. Valve gates

8.2.1. The design calculations of valve gates (including quick closing device at the intake of power house), valve clearance and accompanying devices shall satisfy the following basic requirements:

a) Have sufficient durability, water-tightness, strength, stiffness and stability regarding to requirements of the project;

b) To be efficient in operation, exploitation and maintenance;

c) Do not being vibrated and shaken during the operating and exploiting processes;

d) Having adequate solutions in protection and anti-corrosion regarding to working condition of devices;

e) Valve gate transfers forces to the valve clearance or anchors in accordance with the calculating diagram.

8.2.2. Apart from stipulations in the 8.2.1, regarding to each accompanying devices with the valve gates, the following requirements shall be satisfied:

a) Valve gate shall assure to transfer forces to the valve clearance or anchors in accordance with the calculating diagram;

b) Valve clearance and anchors shall conform with type of chosen valve and transfer the whole loads from the bearing parts of the gate to the concrete structure;

c) Hoisting device shall have the ability in operating the valve gate easily and actively as well as in holding the valve gate at the design locations so as to assure the solidity and safety. Depending on types of valve gates as well as conditions of managing, operating and exploiting, the structure of gate hoists shall be chosen appropriately;

d) Depending on the operating condition and the importance of valve gate in a relationship with the work, type of power supply device for valve gate shall be selected appropriately. The power supply device shall have a capacity to operate the gate certainly and easily;

e) A back-up power supply device or back-up generator shall be provided for a gate which is operated for flood discharge. A back-up power supply shall be capable to start gate operation quickly, certainly and easily, whenever ordinary power line shuts down.

8.3. Trash rack

Trash rack and supporting devices shall meet the fundamental requirements as below:

- Having enough durability, strength and stiffness in accordance with the design loads;
- Preventing floatage and damage garbage from flowing into the waterway and water intake in downstream of trash rack;
- Bar pitch of a trash rack shall be determined on the ground of determining the maximum dimension of the floatage which is allowed to flow into the waterway but will not influence the normal operation of turbine and pump, and the decrease in pressure caused by trash rack shall be minimized;
- Remove trash effectively;
- Materials of a trash rack shall be determined considering design load, water quality, type of floatage and maintenance condition

8.4. Steel penstock

The design of penstock shall meet the following basic requirements:

a) Operate safely and stably, do not vibrate, do not leak out, do not form vacuum during the processes of operating and exploiting, as well as bear design and check loads;

b) Easily handled in managing, operating and maintaining processes;

c) Holes on penstock being arranged (hole for installing maintenance manhole , drainage pipe and so on) shall be safe against stress concentration;

d) At the locations at which the center axis is changed, the penstock pipe shell shall be clamped by appropriate structures. The design calculation of those structures guarantee following requirements:

   - Stable against sliding and settlement regarding the most unfavorable calculating-load-combinations acting on pipelines.
   - Pipelines shall move toward longitudinal direction in case of changes in the air temperature, shall not allow the ability of horizontal movement and shall have a capableness in adjusting the height in case of installing;

e) The extension joints shall guarantee the sealed degree and the easiness of expansion of a pipe along its axis or toward the axis alignment and angle of rotation;

f) All of water in a penstock shall be drained completely in the pipe and the underwater as well as surface water shall be released from the pipe gallery;

g) In the plug position, there is valve gate or emergency valve, which is automatic operation;

h) Along the pipe alignment, “inspection” gates shall be arranged to periodically examine and maintain the inside;

i) All penstock alignments of hydropower works from grade III to grade special shall have the monitoring system to measure the displacement towards directions of anchors and intermediate supporting abutments as well as the pipe displacement. All observing marks of monitoring system shall be incorporated into the general controlling network of the work.

NOTE: Technical requirements for types of hydro-mechanical devices and electro-mechanical devices being installed inside the power house are not stipulated in this regulation (it is stipulated in the technical regulation of management, operation and exploitation of hydropower works).

9. Stipulation of management

This regulation is mandatorily applied by organizations and individuals relating to the construction activities of hydropower works in Vietnam.

10. Organization for implementation

Governmental managing authorities relating to the construction activities of hydropower works in central and local government must organize to disseminate and implement this regulation. During the implementation of this regulation, if there are any difficulties or proposals in supplementing and amending this regulation for the purpose of improving the quality in the construction activities of hydropower works, organizations and individuals shall actively propose to the Ministry of Construction for consideration and decision.

Appendix A

(Mandatory)

Major works and minor works

A.1 Major works

The following works are placed in a group of major works:

a) Dams of all types;

b) Boundary walls, retaining walls (bulkhead), fish way structures in the pressure line;

c) Water reception, intake, drainage, and discharge structures;

d) Canals of all types and on-canal works;

e) Hydropower plants, operation house, water pipes, and hydraulic tunnels;

f) Head tank and surge tank;

g) River bank-protection and channel training structures;

h) Ship-assistance works (navigation lock, lift lock, and control dam);

i) Hydro-engineering works in constructional complex of thermoelectricity plants.

A.2 Minor works

The following works are placed in a group of minor works:

a) Dividing wall;

b) Boundary and retaining walls outside the pressure line;

c) Backup discharge structures;

d) River bank-protection works outside the headwork complex;

e) Fish-protection works;

f) Drain ways for transferring forestry pallets and rough timber to downstream areas;

g) Management house.

NOTE:

Depending on damage level when occurring breakdown or if there is difficult to re-construct, some minor works in each particular state can be changed into major structures if there are enough reliable fact.

Appendix B

(Mandatory)

Calculation of general safety coefficient of works and work items

B.1 Calculation of durability, stability, stress, general and local deformation of hydropower works and their foundations shall follow the limit state method. The calculation shall be implemented regarding to the two limit states:

a) First limit state: works, structures and their foundations working in the most unfavorable condition including: assessment of general durability and stability of the work-foundation system; general infiltrative durability of foundation and earth embankment; durability of items of which damages can cause stops in the operation of works; stress and translocation of structural items on which durability and stability of work depend, etc.

b) Second limit state: works, structures and their foundations working unfavorably in normal operation condition including: assessment of local durability of the foundation, limit of translocation and deformation about the creation or expansion of crack and working joint; the destruction of local infiltrative durability or durability of items which are not considered in the first limit state.

B.2 To guarantee the safety of structures and their foundation, the following formulas (B.1) or (B.2) shall be followed in the calculations for assessment:

$$n_c.N_{tt} \leq \frac{m}{K_n}.R \qquad \text{(B.1)}$$

or:

$$K = \frac{R}{N_{tt}} \geq \frac{n_c.K_n}{m} \qquad \text{(B.2)}$$

Where:

n_c is load combination factor and shall be determined as follow:

- For the first limit state:

For the basic load combination: $n_c = 1.00$;
For the special load combination: nc = 0.90;
For the load combination during the construction and maintenance periods: nc = 0.95

– For the second limit state: n_c = 1.00;

K is the general safety coefficient of works;

N_{tt} is the calculated comprehensive loads (force, moment, stress), deformation or other factors which are bases for assessing the limit state;

R is the calculated general loading strength, deformation or other factors which are established based on the existing design standards and regulations;

m is the working conditional coefficient. Value of "m" is determined based on type of works, structures or their foundation; type of material; approximation of the calculated diagram; limit state group; and other factors stipulated in the existing design standards for each type of works as well as its structures and foundation. Working conditional coefficients of some typical works of hydropower projects are stipulated in table B.1:

Table B.1 Working conditional coefficient of some works of hydropower projects

Type of works and base	Working conditional coefficient (m)
1. Concrete and reinforced concrete structures on earth and semi-hard rock bases	1,00
2. Concrete and reinforced concrete on rock bases	
- If sliding face travels through fissures in the rock base.	1,00
- If sliding face travels through contact surfaces between concrete and rock or a part of its travel through fissures and others through monolith	0,95
3. Arch dams and other protection structures on rock base	0,75
4. Natural and artificial slope	1,00
NOTE: In some cases, if there are reliable facts besides using above coefficients, it is allowed to use additional working conditional coefficients to estimate particular features of structures and of their base.	

K_n is safety coefficient depending on size and function of structures:

– For calculations of the first limit state: K_n is determined based on structures' grade:

For Special Class structures: Kn = 1.25;
For Class I structures: Kn = 1.20;
For Class II, III, and IV structures: Kn = 1.15;

– For calculations of the second limit state: K_n = 1.00 ;

– For calculation of stability of natural slope or artificial slope next to other works with greater safety coefficient, safety coefficient of the slope shall be equal to safety coefficient of those works.

B.3 Error coefficients of material n_{vl} and of soil $n_đ$, which are used to determine calculated strength of the material and features of soil, shall be determined by the owner based on stipulations in private design standards for each work as well as its structure and foundations. If structures use a great amount of on-site material including filling materials, filling rock, etc., then calculated strength of material is determined based on statistical treatment for results of indoor and field experiments.

B.4 Calculations of the first limit state are implemented with calculated loads. A calculated load is equal to standard load multiplying load deviation coefficient n shown in table B.2. The standard load is in the standards of investigation and design, which are stipulated individually for each type of works as well as structures and their foundation, and is approved by the owner.

B.5 Calculations of the second limit state for works, structures as well as their foundation are implemented with load deviation coefficient n, error coefficients of material n_{vl} and of soil $n_đ$, which are all selected as 1.0 unless otherwise stipulated particularly in the private preliminary design standard.

B.6 Information which needs to be calculated, assumptions of calculation state, and calculation diagram for structures and their foundation shall be suitable for possible conditions which might occur and shall follow preliminary design standards approved by the owner as well as shall reflect the most unfavorable solution load combinations. Following factors would be considered if necessary:

a) Constructional order and load order of work items;

b) Influence from the impact of temperature, shrinkage, and surge infiltrative (seepage) pressure;

c) Non-linear elastic and plastic deformations as well as creeping properties of material used to build structures and of rock foundation;

d) Looseness of body structures and their foundation (cracking ratio, etc.); and

e) Heterogeneity of material of structures and rock foundation and their anisotropies.

B.7 When calculating sunken structures, internal force due to the deformation of foundation shall be considered. Sagging ratio and differential settlement shall be in allowable range and not cause any trouble for the operation, durability, and deformation of work and structure of each work item or among work items.

B.8 Water intake, drainage, and discharge facilities from class I and above shall be tested by hydraulic model to determine their capabilities of transferring and draining water as well as to check their hydraulic regimes, velocities and water pressures acting on them, and

to establish solutions for connecting them with downstream and upstream areas and to consider solutions to prevent erosion and abrasion, etc. This test is also used to determine shape and dimension of work items as well as to arrange the headwork complex efficiently and economically. This work is also applied for grade II structures with complicated shape of conveyance ways of which trust ratio cannot be obtained by using common hydraulic calculations and there is no existing similar model with enough reliable facts.

Table B.2 Load deviation coefficient n

Name of load and influence	Load deviation coefficient (n)
1. Self-weight of structures (excluding weights of soil and tunnel lining)	1,05 (0,95)
2. Self-weight of the tunnel lining	1,20 (0,80)
3. Vertical pressure caused by weight of soil	1,10 (0,90)
4. Lateral pressure of soil	1,20 (0,80)
5. Mud pressure	1,20
6. Rock pressure: - Weight of rock when constructing the arch	1,50
- Horizontal pressure of rock	1,20 (0,80)
7. Total weight of earth and rock layers above the tunnel or weight of the destructed zone, etc. (vertical pressure caused by weight of soil)	1,10 (0,90)
8. Hydrostatic pressure acting directly on the work surface and its base; wave pressure; return pressure as well as infiltration pressure and pore pressure.	1,00
9. Static pressure of subsurface water acting on the tunnel lining	1,10 (0,90)
10. Water pressure inside of the tunnel (including water hammer)	1,00
11. Pulsation pressure of water	1,20
12. Mortar pressure when injecting cement	1,20 (1,00)
13. Vertical and horizontal loads of lifting, transport, and unloading machines as well as loads of fixed technological machines.	1,20
14. Stowage loads (loads of temporary storage of material) in the range of unloading yard and operational range of the mobile crane	1,30
15. Wind loads	1,30
16. Ship loads	1,20
17. Impacts of temperature and humidity	1,10
18. Impact of earthquake	1,10
19. Loads when stowing blocks	1,30 (1,00)

NOTE:

1) Load deviation coefficient related to train on the railway, and vehicles on roadway shall be selected from bridge design standards
2) It is allowed to select load deviation coefficient equal to 1.00 for the cases: self-weight of structures and vertical pressure caused by weight of soil, if weight of that block is determined from calculation of soil characteristics (unit weight and durable characteristic) and concrete is determined based on material characteristics (unit weight of concrete and other characteristics) which follow suitably existing base test and design standards;
3) Only use load deviation coefficients inside the brackets if the calculation points out that structures are in unfavorable state.