Placement of Concrete in Hydropower Structures According To Climatic Conditions in Albania

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Abstract

Concrete – 100 years ago a new building material and today regarded as indispensable – came just in time to be used from the very beginning of the hydropower era in the World, around the turn of the century. It soon became the preferred material for construction of dams and power-houses, although the performance with regard to durability proved to be poor in many cases, giving rise for concern. Most prone to damage were dams at mountain sites, exposed to harsh climatic conditions. The problem was obviously one of lack of know-how in the field of concrete technology. An important factor in mix design is the ratio between water and binder. As long as only binder is cement, the term w/c ratio cannot be misunder-stood. With the increasing use of pozzolana as binder in addition to the cement, the term w/b ration is now widely used. The term w/c ration as used in literature shall be interpreted to include pozzolana.

Keywords: *Concrete,pozzolana,Durability,permeability,water tightness*

INTRODUCTION

The type of structure may influence mix design. Large massive structures pose other requirements than slender ones; mixes for heavily reinforced structures will be different from sparsely reinforced ones. Examples are:

Massive Structures

Too high temperature gradients and shrinkage, both resulting in cracks, are problems associated with massive structures. Internal temperature rises due to the heat developed during hydration of the cement. As a rule of thumb, temperature gradients larger than 20°C over a distance of 300mm or less may result in cracks. The maximum temperature should also be kept below a certain limit, often set to around 65°C.

Measures to reduce these problems are:

- keeping contents of cement paste as low as possible. Result – stricter requirements for proper composition of the aggregate.
- Using a low heat cement or replacing part of the cement with pozzolanic materials, normally pulverized fly ash. Silica fume is less efficient as temperature reducer, since the associated chemical reactions start early and develop heat. If a certain amount of cement is replaced by a smaller amount of silica, however, the total result is reduced heat development.

- Cooling the mixing water with ise. This operation requires proper equipment and procedures to ensure that all ice is converted to evenly distributed water before concreting.

For structure where temperature development must be controlled, test measurements should be made. Massive structure will not be heavily reinforced, hence larger stone sizes and stiff consistency may be used (see below).
Slender, Heavily Reinforced Structures. The mix for slender structures with dense reinforcement requires smaller stone sizes, and a plastic or flowing consistency to allow proper filling of the form.
Early form removal is often requiring for such structural. This need requires rapid strength development, and rapid hardening cement, reduced w/c ratio, or higher cement contents may be considered.

GENERAL REQUIREMENTS TO CONCRETE PROPERTIES

Concrete dams are formed of cement-concrete placed in the dam body (Figure. 1.0). Concrete dam section designed such that the loading produces compression stress only and no tension are induced anywhere.

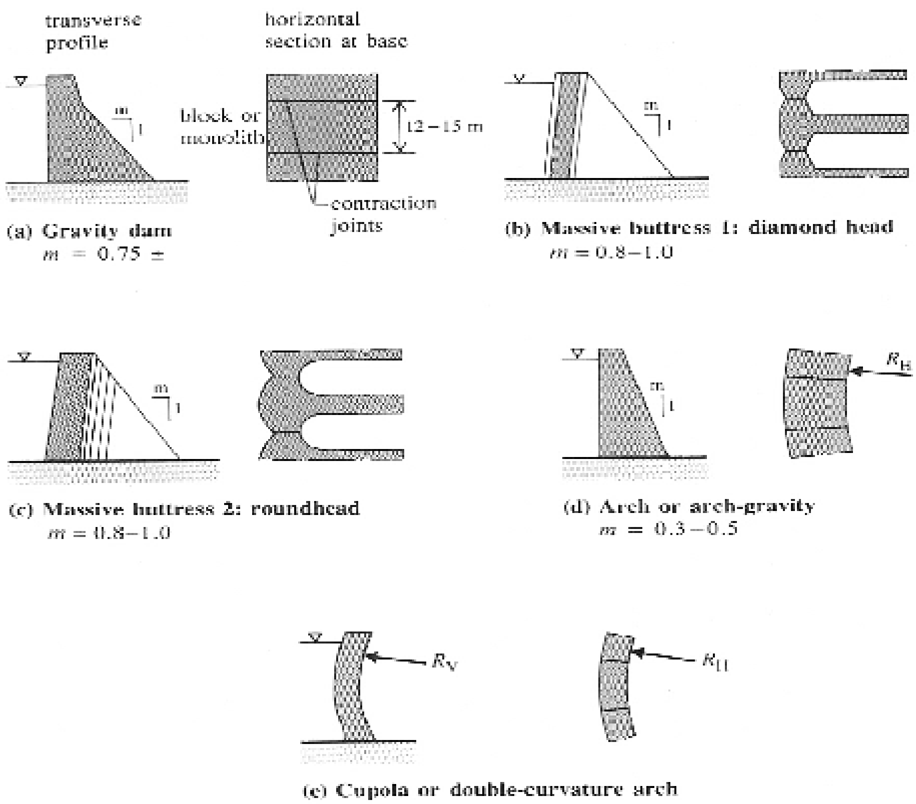

Figure. 1.0 Type of Concrete Dam

The reinforcement is minimum mainly as temperature control. Concrete is placed in two ways: Reinforced concrete dam (RC dam) or Roller compacted concrete (RCC) dams. The variations of concrete dam include:

1. Concrete gravity dam,
2. Concrete arch dam and arch-gravity dam

3. Multiple arch dam
4. Double curvature or dome/cupola dam
5. Buttress dam (head as diamond, roundhead, massive, decked etc)
6. Hollow gravity dam
7. Brick or rock masonry gravity dam

Rubble/random/stone masonry to fill dam section. Concrete / mass concrete as bulk material in dam section with steeper side slope. RCC section to take loadings, thus decrease section.
Gravity dam: Stability due to its mass. Dam straight or slightly curved u/s in plan (no arch action). The u/s face is vertical or nearly vertical, d/s sloping.
Consistency corresponding to the transport and casting methods used, and to the possibilities and methods of compacting. Concrete in dams can be placed by cranes – as opposed to concrete in tunnels which is usually pumped and therefore requires high binder content for good pump ability. For the slender slab and buttress dams, which are also heavily reinforced, consistency must be adjusted correspondingly.

CRITERIA FOR SPECIFYING PROPERTIES

Concrete strength class, as determined from requirements resulting from structural analysis, has been the predominant criterion for specifying concrete quality even when other properties, such as water tightness, are greater interest. This criterion may lead to disputes in practice, when the specified strength is incompatible with other requirements to the concrete.
The situation has now changer, with growing awareness that long term durability should receive greater attention. The first steps should be to establish what kind of deteriorating forces or mechanisms can be expected in the accrual environment for the structure. Such phenomena may be deterioration of the concrete by aggressive agents, or deterioration of the structure due to corrosion of the reinforcement. The investigation will translate into basic minimum requirements for the cement, for the w/c ratio and for the concrete, which will often render a strength class which is higher than the one initially required or deemed necessary from the structural analysis.
Low permeability is a prerequisite for durability, w/c ratio; compaction and curing determine permeability and also strength. Check of concrete strength can therefore continue to be a good of concrete quality, once there is awareness of what really matters.

CLASSIFICATION OF ENVIRONMENT

The Norwegian standards operate with four classes of environment based on expected degree of aggressiveness and specify a maximum w/c ratio and recommended minimum cement content for each. The necessary and advisability of specifying minimum cement contents are disputed. For ordinary structures, cement contents will as a rule is higher than the recommended minimum. For mass concrete such as gravity and arch dams, large foundations etc…, lower cement contents are used in order to reduce temperature rise.
The w/c ratio, however, is a direct indicator of the potential permeability of the cement paste and of the concrete, and a key factor for durability.
The four on environment are defined as follows:
Mildly aggressive environment –LA
In practice, the LA class refers to indoor structures in a dry, non-aggressive atmosphere – offices, industry that emit no aggressive gases or aggressive liquid spill, dwellings etc.
Moderately Aggressive Environment –NA

The NA class refers to ordinary, outdoor structures subject to normal levels of carbon dioxide and other gases in the atmosphere, normal acidic or contaminated precipitation, and structures in fresh water non subject to freezing, indoor structures in a humid atmosphere.
Severely Aggressive Environment – MA
Structures subject to salts, chlorides, other aggressive agents, freezing thawing in fresh or saline water, high levels of carbon dioxide or highly contaminated atmosphere.
Especially Aggressive Environment –SA
This class refers to especially aggressive environment involving severe exposure to acids or other aggressive agents. Membranes to protect the concrete surface will be necessary.
The requirements according to Norwegian standards are as shown in **Table 1.0**

Table 1.0 Requirement according to Norwegian standards

Class	Maximum ratio $w/(c+\Sigma k^*p)$1	Recommended minimum Binder contents $C+\Sigma k^*p$ [1] kg/m^3
Mildly aggressive , LA	0.922	225
Moderately aggressive, NA	0.60	250
Severely Aggressive, Ma	0.45	300
Specially Aggressive, Sa	Special	Treatment

p= weight of pozzolana if used. k= efficiency factor, with respect to the property in question. this figure is given in the NS 3420[1]. It could probably have been set lower. In practice, at least, the w/c ratio should never come close to this value structural concrete.
As mentioned above, massive structure often contain substantially less cement per m^3 in order to reduce temperature rise. Binder contents as low as 170 kg/m3 are therefore acceptable for mass concrete under certain conditions, e.g for the interior of mass structures, while the exposed surface concrete of the same structure may have higher binder content.

The standards are aimed primarily at structural, reinforced concrete, and cannot be applied too rigidly to all hydropower structures. Hydropower structures will normally be in environments classified as moderately aggressive, NA, or severely aggressive if subject to freezing when wet. Concrete for buildings and structures exposed to no particular wear, without special requirements, might be specified with w/c ratio up to the maximum permissible for the NA class, 0.60.
According to the recommendations in the standards, all structures subject to freezing when wet, e.g. all Norwegian concrete dams should be classified for Severely Aggressive environment, with w/c ratio ≤ 0.45. This requirement has been modified in practice. Slender, reinforced dams, walls or watertight structures are classified as MA, while the w/c ratio for more massive structures may be in the range 0.55-0.45; this is accepted by the Norwegian public controlling body, the Safety and Emergency Planning Department of the NVE.

[1]Civil engineering Standard collection for concrete structure

AMBIENT TEMPERATURE

Both high and low ambient temperature will affect concreting and design of the mix.
When concreting is cold weather (below freezing) it must be ensured that:
- The fresh concrete will not freeze
- The internal temperature will be high enough to allow hydration to start
- The strength development will be sufficiently rapid to make the concrete frost resistant before internal temperature falls below freezing.

Part of measure will coincide with those necessary for early form removal – rapid hardening cement, low w/c ratio and high cement content. Hot mixing water and heating of aggregate may be required to get a sufficiently high temperature of the fresh concrete. In addition, insulation of the form to prevent freezing in the early stages may be required.
When concreting in hot weather (tropical zones, or hot summer days in temperate zones), it must be ensured that the fresh concrete temperature is so low that the maximum concrete temperature during hydration will not rise above 65°C. Cooling of the mixing water and of the aggregate may then be necessary. Aggregate storage piles should be shielded against sunlight, and also sprayed with water if there is risk o their completely drying out. The site of concreting must be shielded against direct sunlight. When casting massive structures for which temperature rise may be a problem, concreting should be limited to periods of the day/night when the temperature is below 20-30°C.
Hot weather and high temperature of the fresh concrete will accelerate setting. This must be considered when determining consistency, use of admixtures and available time for transporting, casting and compacting the concrete. The properties of fresh concrete with silica are notably affected by the temperature. The effect of admixtures will also vary with the temperature.

LARGE GRAVITY DAMS

While the majority of large gravity dams in Albania as built after 1950 have suffered from the lack of concrete technology know-how at the time and have performed poorly, there are some exceptions from the rule. Ulza dam as shown in figure (1.1) a 50 m high gravity structure on river Mati, is perhaps the most conspicuous example of a professional concrete job from this early age. Another concrete gravity dam constructed on early age in Albania is also shkopeti dam. Shkopeti Dam as shown in figure (1.2) was built from 1958 to 1963 on the Mati River downstream of the Ulze project and about 25km from the mouth of the Mati at the Adriatic Sea. It is a concrete gravity dam reaching a maximum height of 52m with a crest length of 89m. The powerhouse is 250m downstream of the dam. It was rehabilitated during the 1990s. A project is underway to equip Shkopeti with a dam monitoring and alarm system while preparing an emergency action plan.

Fig. 1.1 Ulza concrete gravity dam

Fig. 1.2 Shkopeti concrete gravity dam

For today's large gravity dam's strong efforts are made to keep down the curing temperature of the mass concrete through measures such as:

- Use of a special low-heat, slow–curing cement type – the so-called" Dam cement"
- Mixes that are lean in cement (150-200 kg/m^3) and rich in silica fume (10-15 kg/m^3).
- Zoning of the dam cross section, with a core that is extra lean in cement between the surface zones.
- Use of cool aggregates and cold water, or ice, in the mix.

For the all – important compaction process bulldozers with vibrator attachment are used. This procedure requires concrete of very stiff consistency.
Normal height between concreting joints is 3 and the distance between vertical joints approximately 15 m. All horizontal joints are washed before setting – using air/water jets to remove cement laitance.

Design conditions and stability requirements, vertical joints etc, deviate very little from what is used for small structures.

CONLUSION

Related to albania climate condictions also acording to long masurements of hydrological parameters like:humidity,wind speed,tension of evaporation and temperature that the most important climate parameter for to define desing criteria for hydraulics structure in generaly,there are not such extremaly figure masure until nowadays.Minimum and maximu temperature achived are aproximatly -24 to 41,that means in albania and aspecialy in those site where are cunstructed or are planed to construct different hydraulic structures no special cement and others aditive are required to use in concrete mix desing to improve or to increase and decrease temperature of reaction between gradients of concrete when we place it on structure.

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