Material Characteristics and Construction Methods for a Typical Research Reactor Concrete Containment in Iran

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1. Introduction

Generally selecting an appropriate material and also construction style for a concrete containment due to its function and special geometry play an important role in applicability and also construction cost and duration decrease in a research reactor (RR) project.

The reactor containment enclosing the reactor vessel comprises physical barriers reflecting the safety design and construction codes, regulations and standards so as to prevent the community and the environment from uncontrolled release of radioactive materials. It is the third and the last barrier against radioactivity release. It protects the reactor vessel from such external events as earthquake and aircraft crash as well [1-4]. Thus, it should be designed and constructed in such a manner as to withstand dead and live loads, ground and seismic loads, missiles and aircraft loads, and thermal and shrinkage loads [5].

This study aims to present a construction method for concrete containment of a typical RR in Iran. The work also presents an acceptable characteristic for concrete and reinforcing rebar of a typical concrete containment. The current study has evaluated the various types of the RR containments. The most proper type was selected in accordance with the current knowledge and technology of Iran.

2. Methods and Results

2.1 Concrete Containment

A typical containment as shown in Fig. 1 consists of a cylindrical wall, a hemispherical or elliptical dome and a flat base slab. These sections can be made by reinforced or pre-stressed concrete [6-8]. The preferred material for the base slab is a reinforced concrete while both types can be used for dome and wall.

Notice that safety and economic issues shall not be underestimated. A steel liner is used in this typical RR. The liner is an airtight structure with large ductility and encloses the reactor from the outside atmosphere and is connected to the concrete containment by steel connectors. Thus, the current containment is a concrete type with steel liner [6,9].

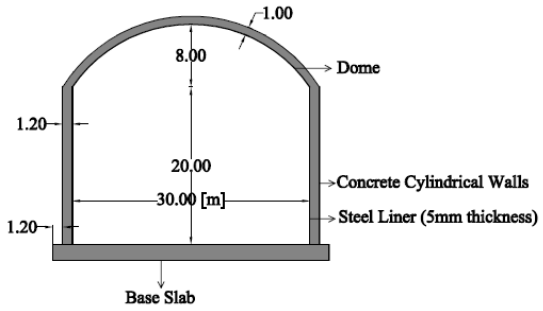

Fig.1. Schematics of RR concrete containment

The codes and standards for concrete structures of a RR in Iran consist of ACI 318, 349 and 359, UBC Uniform Building Code, Iranian Code for Seismic Loads 2800 and Iranian National Building Codes Discourse of Concrete Structures.

2.2 Construction Methods

Among three different methods for construction of the concrete wall including the conventional method, slip forming and jump forming, the third was selected for a typical RR in Iran. It is a lengthy duration method calling for a lot of labor. Slip forming is a time saver needing a specific calculation and continuous hydraulic lifting and consequently special facilities. This method has been used for numerous containments without steel liner and there are not enough experience in the case of steel-lined structures. The jump forming is a method which has been used for many steel lined containments. It is faster than the conventional method and needs less human resources. Bette yet, it does not need scaffolding from the base slab. The jump forming is chosen for the concrete containment wall on account of all the afore-mentioned reasons and applicable technology in line with the Iranian construction industry.

The conventional method was decided on for the containment dome since the advanced methods require special facilities such as very heavy load crane to lift the steel plate formwork. Note also that the advanced methods are more complicated and thus require more specialists [6].

2.3 Material Selection

There are numerous vital indicators which affect such materials selection as seismic loads, vibrations, temperature transients, internal and external missiles and atmospheric conditions [2]. Materials of a concrete containment may as well be grouped into concrete, steel reinforcing ribbed bars or pre-stressed tendons and carbon steel liner [4, 9].

The containment building can be constructed by such compositions as pre-stressed concrete with bonded tendons, pre-stressed concrete with unbonded tendons which are simpler for in-service inspection and tests, and reinforced concrete by usage of concrete and deformed reinforcing steel bars (mild carbon steel) which has simpler technology [2,3,9]. The reinforced concrete is selected for a typical RR containment in because of more accessible technology and acceptable characters in accordance with project purposes for all parts of the containment. The material properties for the reinforced concrete are presented in Table I. The concrete of Portland cement has strength of 30 MPa for the base slab.

Table I: Characteristics of Concrete and Reinforced Bars

Concrete (High-density Concrete)	
Specified compressive strength of concrete	25.8 MPa
Modulus of elasticity of concrete	27 000 MPa
Poisson's ratio of concrete	0.17
Density	2,400 kg/m³
Reinforcing Steel (Hot Rolled Ribbed Bars)	
Specified yield strength of reinforcement	500 MPa
Modulus of elasticity of reinforcement	200 000 MPa
Density	7800 kg/m³

3. Conclusions

The current material selection was compatible with codes and standards as well as earlier studies. The construction methods of jump forming for the wall and conventional forming for the dome were adapted to Iranian technology and engineering knowledge. Future work includes ANSYS and ABAQUS analyses for the effect of different internal and external hazards such as aircraft crash, earthquake, tornado and loss of coolant accident on the concrete containment.

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