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PORTLAND CEMENT ASSOCIATION

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U.S. Atomic Energy Commission
Advisory Committee on Reactor Safeguards
Washington, D.C. 20545

August 8, 1967

Attn.: Mr. Marvin C. Gaske

Subject: Preliminary Draft Technical Safety Guide (Sept. 28, '66) on Concrete Containment Structures, by F. P. Schauer

Dear Mr. Gaske:

Reference is made to your Memorandum of July 20, 1967, and the forthcoming meeting on August 17, 1967, in Washington, D.C.

I reviewed the subject report by F. P. Schauer and it appears to be an excellent basis for the design of secondary containments for nuclear pressure vessels. My following comments are meant primarily to condense this document in order to facilitate its use by the designing engineer. I am mentioning a few points on which I have a slightly different point of view than the author. I hope my following comments will contribute to the discussion at our forthcoming meeting.

(1) Page 9: Why is it necessary to specify Type II Portland Cement?

The wall thickness of secondary containment vessels usually does not exceed 3.5 ft. Heat of hydration, therefore, is no real construction problem.

GA used ice to control the max temp.

The improved resistance of Type II Portland Cement with respect to sulfate attack is no asset for these structures either.

On the other hand, the ASTM Specifications for Portland Cement (ASTM C150-65) specify a maximum C_3A content of 8 percent (Tricalcium aluminate) for Type II, whereas the C_3A content for Type I usually ranges above

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11 percent. C_3A is a desirable corrosion inhibitor due to its alkalinity. Therefore, Type I Portland Cement might offer more beneficial features for the construction of secondary containments than Type II.

(2) Page 9: Why is the chloride content limited to 100 p.p.m. for the mixing water for concrete and grout? = 0.01%

Reference is made to Research Department Bulletin No. 168 of the Portland Cement Association, entitled "Influence of the Cement on the Corrosion Behavior of Steel in Concrete." I am citing from page 4:

> "It is rather generally agreed, however, that when the amount of commercial calcium chloride is restricted to two percent by weight of cement, the degree of corrosion in ordinary reinforced concrete is insignificant.
>
> The use of calcium chloride or other chloride in concrete that contacts prestressing wires, however, is now generally considered inadvisable or is actually forbidden."

In other words, the suggested 100 p.p.m. for the mixing water appear to be a little too restrictive for reinforced concrete construction, but are too liberal for prestressed concrete construction.

For example, a 6-bag mix contains 564 lb. cement/cu. yd. of concrete. Two percent of calcium chloride would be 11.3 lb./cu. yd. This concrete, mixed with 6 gal. of water per bag of cement would contain 6x6x8.33 = 300 lb. of water/cu. yd. Using the suggested ratio of 100 p.p.m., the allowable chloride content would be only 0.03 lb./cu. yd.

One can see that some adjustment or clarification of the above limit is necessary. Unless dissimilar metals or prestressing steel are in direct contact with the concrete (or grout), the conventional limit of two percent by weight of cement appears to be more appropriate.

(3) Page 12: The dynamic test of 500,000 cycles appears to be too severe in view of the fact that secondary containments are essentially not subject to dynamic loads.

The "Tentative Recommendations for Concrete Members Prestressed with Unbonded Tendons" (unpublished report by ACI Committee 423) call for a dynamic test of 500,000 cycles from 60 to 66 percent of the ultimate strength of the prestressing steel. This represents a stress variation of 10 percent at the sustained stress level.

The suggested dynamic test on page 12 of the subject document calls for a stress variation from 0.9 to 1.1, i.e., 20 percent of the sustained stress level. It is possible that some commonly used prestressing tendons can not meet these requirements.

(4) Pages 28 through 43:
The load factors, load combinations, allowable stresses and structural distinctions could, perhaps, be simplified as outlined below.

It should be possible to design secondary containments by either one of two methods:

1. Working Stress Design
2. Limit Design (or Ultimate Strength Design).

The capacity equation for Method No. 1 should read approximately:

$$C_1 = D + P + T + E$$

The corresponding equations for Method No. 2 should read:

$$C_2 = D + 1.5P + T\ (1.5P)$$

$$\text{or } C_2 = D + 1.25P + T\ (1.25P) + 1.25E$$

$$\text{or } C_2 = D + P + T + 2E$$

The load factors in the latter method appear applicable, no matter whether the structure is prestressed or not. In terms of the subject document, this means combining Sections 6.3.3.4 (pages 28-32) and 6.3.3.6 (pages 40-42).

Concerning the allowable stresses, a similar combination of Sections 6.3.3.5 (pages 33-39) and 6.3.3.7 (page 43) should be possible.

For Working Stress Design, for example, the following values appear appropriate:

Flexural compression at transfer of prestress (if any),	$0.60\ f'_{ci}$
Membrane compression at transfer of prestress (if any), etc.,	$0.50\ f'_{ci}$
Flexural compression under design load,	$0.50\ f'_c$
Membrane compression under design load,	$0.40\ f'_c$

etc.

For Ultimate Strength Design or Limit Design, the above values should be about 50 percent higher, i.e., they should be close to the ultimate flexural capacity of concrete, $0.85\ f'_c$, times a capacity reduction factor, $\phi = 0.9$.

Similar principles can be followed in establishing the allowable steel stresses.

Looking at the suggested stress limits, it appears somewhat inconsistent to allow a flexural compression stress of $0.6\ f'_c$ under Working Stress Conditions (Section 6.3.3.5.3 on page 35) and a value of only $0.75\ f'_c$ under Cracking Stress Loading (Section 6.3.3.5.4 on page 36), i.e., under loads which are about 50 percent higher. Under no loading condition should one allow a concrete compression stress of 1.0 f_c' (Sections 6.3.3.5.5, page 37, and 6.3.3.7.2, page 43), because a stress intensity of 0.85 f_c' is commonly accepted as the ultimate capacity of concrete in flexure.

(5) Page 41: Reference is made to Section 6.3.3.4.4. Where is this Section 6.3.3.4.4.?

(6) Page 53: The test requirements for prestressing steel described on this page differ from the ones called for on page 12.

While the requirements for the static test (page 53, (a)) are the same as the ones on page 12, the requirements for the Cyclic Tests (page 54, (b)) and for the Rapid Loading Test (page 54, (c)) are different from the ones in Section 6.3.2.4. (b) (page 12). Are these tests required in addition to the ones described on page 12?

I hope the above comments will be of interest at the forthcoming discussion of the subject document.

Very truly yours,

Paul E. Mast

Senior Structural Engineer

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