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Public Meeting with the U.S. Nuclear Regulatory Commission License Amendment Request (LAR) for Class I Structures

April 23, 2015

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Agenda

- History
- Overall Goal
- 4 Elements
- Closing Remarks

History

- The CIS project started in 2012 where the investigation of the structure for a pipe support resulted in a self identified corrective action and complete structural re-evaluation of Class I Structures.

FCS License Basis

- FCS USAR (Section 5.11) License Basis:
  - Allowable Stress Design (ASD) for Normal operations.
  - Ultimate Strength Design (USD) for faulted conditions.

- Operability Analysis Completed in 2012
  - It was noted that the current License Basis is conservative.

Options to License Basis

- Many options to change the FCS license basis were evaluated.
  - ACI 318-63 is the code of construction (Design Basis).

- ACI 318-71 is one of the updated codes that was evaluated carefully as a replacement to the 1963 code. But was finally rejected because of the exhaustive evaluations required to address all the new detailing in the code.

- Best option is to revise License Basis using the current code of record.

Overall Goal of the LAR

- Change License Basis
  - Replace Working stress with Ultimate Strength. This is a license basis change.
- Change Design Basis
  - Replace Design Basis Concrete Design Strength (f_c) in specification (4000 psi) with 28 day break strength.
- Adopt methods that are not in the1963 code
  - Use Finite Element Analysis for more accurate results.
  - Credit Dynamic Increase Factors to increase capacity.
- This applies to all Class I Structures other than Containment shell.

LAR has 4 Elements

Elements of the LAR

1. Replace Allowable Stress Design (ASD) with Ultimate Strength Design (USD) for normal operating/service conditions.
2. Use of 28 day test strength of concrete (not age hardening) for Class I Structures other than Containment Shell.
3. Use of “Ductility” (finite element analysis) as defined in ACI 349-01 Appendix C.
4. Use of Dynamic Increase Factors (DIF) for impulse loads as defined in ACI 349-01 Appendix C.

FCS LAR: Element 1

- ACI 318-63 Replace ASD with USD for normal/service operating conditions.
  - Allowable stress design (ASD) commonly known as working stress design has four equations. Four USD equations will be developed that are analogous to the ASD Design Basis.
  - The USD equations will be developed from codes and License Basis.

- For faulted, the approach remains unchanged.

Element 1: ASD vs. USD Eqns.

- Final Load Combinations for Normal/Service Operating Conditions.

Working Stress Design (WSD) Current License Basis	Replacement Ultimate Strength Design (USD) Load Combination Equations
S = D + L	U = 1/ϕ (1.4 D + 1.7 L)
S = D + L + W	U = 1/ϕ (1.0 D ± 0.05 D + 1.25 L + 1.25 W)
S = D + L + E	U = 1/ϕ (1.0 D ± 0.05 D + 1.25 L + 1.25 E)
S = D + F	U = 1/ϕ (1.4 D + 1.4 F)

Element 1: Develop USD 1st Eqn.

- ASD basic equation is S = D + L
- Equivalent Ultimate Strength Design to the basic eqn.:

  [ACI 318-63 Equation 15-1] U = 1.5D + 1.8L

- ACI 318-71 and beyond uses a different basic equation.

  [ACI 318-71 Equation 9-1] U = 1.4D + 1.7L

FCS is proposing to use the updated version with 1.4 factor

S = Required section capacity for WSD
U = Required ultimate strength capacity
D = Dead load, including hydrostatic load
L = Live load

W = Wind load
E = Design earthquake (OBE)
F = External hydrostatic load
ϕ = Capacity strength reduction factor

Element 1: Develop USD 2nd/3rd Eqn.

- USD method for normal service conditions needs to address the following: Wind, Earthquake, and Hydrostatic loads.
- FCS UFSAR currently utilizes USD factored loads for SSE and OBE:

U = 1/ϕ (1.0D ± 0.05D + 1.5Pc + 1.0Tc)

U= 1/ ϕ (1.0D ± 0.05D + 1.25Pc + 1.25E + 1.0Tc) for OBE case

U = 1/ ϕ (1.0D ± 0.05D + 1.0Pc + 1.0E' + 1.0Tc) for SSE case

- Second equation is used to develop the USD equations for the optional normal service conditions and implement the earthquake and wind load factors.

Element 1: Develop USD 2nd/3rd Eqn.

- From the USAR Section 5.11 (Current License Basis):
  - U= 1/ ϕ (1.0D ± 0.05D + 1.25Pc + 1.25E + 1.0Tc) for OBE case
- The resulting USD load combinations for wind and earthquake are as follows:

U = 1/ϕ (1.0D ± 0.05D + 1.25 L + 1.25 W)

U = 1/ ϕ (1.0D ± 0.05D + 1.25 L + 1.25 E)

Note: This is similar to the ACI 318-71 code Equation 9-2: U = 0.75(1.4D + 1.7L + 1.7W)

Element 1: Develop USD 4th Eqn.

- The USD load combination for Hydrostatic loads is a simple conversion of the ASD equation plus the phi factor.

ASD $U = D + F$

Use the 1.4 factor to convert ASD to USD

USD $U = 1/\phi\ (1.4\ D + 1.4F)$

Element 1: ASD vs. USD Eqns.

- Final Load Combinations for Normal/Service Operating Conditions.

Working Stress Design (WSD) Current License Basis	Replacement Ultimate Strength Design (USD) Load Combination Equations
S = D + L	U = 1/ϕ (1.4 D + 1.7 L)
S = D + L + W	U = 1/ϕ (1.0 D ± 0.05 D + 1.25 L + 1.25 W)
S = D + L + E	U = 1/ϕ (1.0 D ± 0.05 D + 1.25 L + 1.25 E)
S = D + F	U = 1/ϕ (1.4 D + 1.4 F)

FCS LAR: Element 2

- Use of 28 day test strength of concrete for Class I Structures.
  - This is NOT age hardening as discussed in NRC Information Notice 2012-17.
  - 28-day concrete break strength information was documented.
  - Actual 28-day strength ranges are approximately 4700 psi to 5500 psi.

FCS LAR: Element 3

- Allow the use of “Ductility” (Finite Element Analysis) to bridge generation gap of concrete analysis.
  - There is a difference with conventional analysis and finite element (FE) analysis. We can now model shapes with small increments to come closer to actual values.
  - This is not a margin issue but improves accuracy. There is no impact on margin.
  - Ductility methodology is defined in ACI 349-01 Appendix C.

FCS LAR: Element 4

- Allow for use of dynamic increase factors (DIF) using ACI 349-01 Appendix C for impulse effects.
  - Impulsive loads are time-dependent loads which are not associated with collision of solid masses. The pressure raises quickly and then stabilizes. The pressure difference across walls equalize quickly.
  - Appropriate dynamic increase factors (DIF) address changing strain rates applied to a static analysis. Material strengths are increased to appropriately reflect the response of concrete to the dynamic condition.
  - This is not a margin issue but improves accuracy. There is no impact on margin.
  - “DIF” methodology is defined in ACI 349-01 Appendix C.

FCS LAR: Schedule

- LAR Submittal: 2nd Quarter 2015
- Requested Approval: 2nd Quarter 2016
- Design Correction and Install Columns (RF028):
  3rd Quarter 2016

Closing Remarks

- History
- Overall Goal
- 4 Elements
  - ASD v. USD
    (License Basis Change)
  - 28 day break strength (Capacity)
  - Finite Element Analysis (Accuracy)
  - Dynamic Increase Factors (Capacity)