Specification for Steel-Concrete Composite Structures for Safety-Related Nuclear Facilities: Development and Current Progress

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Presentation Outline

- SC construction, examples, and benefits
- Unique SC issues and overview of past standardization activities
- Similarities and differences with RC design practice
- AISC SC specification: background, supporting work, and outline

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Overview

- Nuclear structures involve heavy concrete construction to provide adequate radiation shielding
- This results in longer construction durations and large field labor force requirement
- Nuclear industry is looking for ways to minimize schedule and labor requirements to make nuclear power competitive and to complete projects faster
- Generic modular construction, and especially modular steel-plate composite (SC) construction is seen as being key to achieving these goals
- Steel plates on the exterior eliminate formwork and serve as equivalent reinforcement when shear connectors are used

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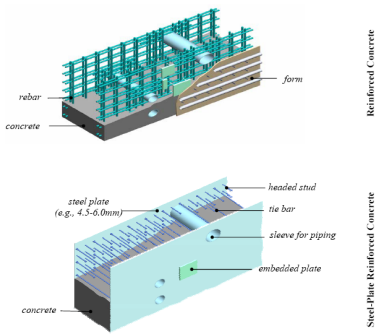
OVERVIEW



from MPR-2610, Report to DOE

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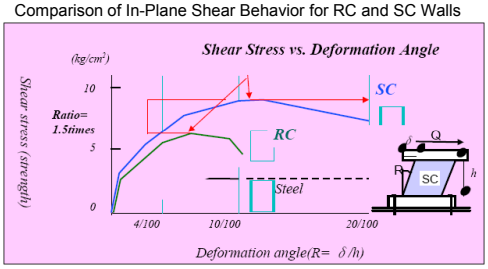
OVERVIEW

Comparison of In-Plane Shear Behavior for RC and SC Walls



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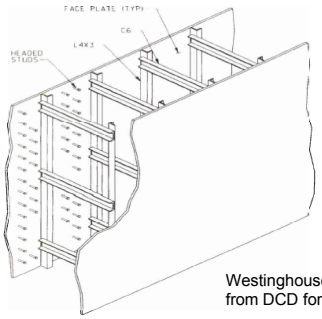
SC EXAMPLES



Westinghouse SC Wall
from DCD for AP1000

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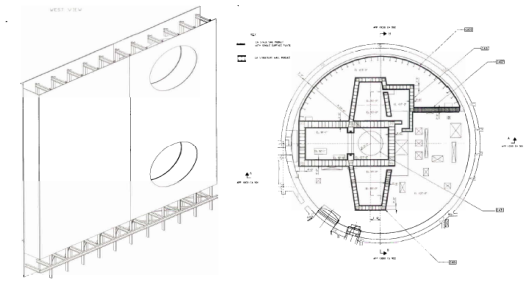
SC EXAMPLES



from Westinghouse's DCD for AP1000

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UNIQUE ISSUES ABOUT SC DESIGN

- Basic premise is simple – use steel faceplates as stay-in-place formwork with shear connectors and tie-bars to enable composite action and structural integrity (section acting as a single unit)
- SC modules can thus be made from a wide variety of steel faceplates, shear connectors, tie bars, or embedded shapes, and concrete
- Various vendors and designers have come up with their own schemes for SC section detailing
- The challenge has been to develop a standard that is general enough to cover SC designs with various types of shear connectors and tie bars

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CONSIDERATIONS FOR GOOD SC BEHAVIOR

- Maintain composite action
- Provide structural integrity
- Limit initial imperfection and locked-in stresses
- Prevent local buckling before yielding
- Control reinforcement ratio
- Prevent non-ductile failure modes (e.g., Out-of-plane shear)
- Strong connection performance, preferably stronger than that of the connected parts
- Limit too thin/thick faceplate and composite section thickness

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Major Challenges

- Lack of US-based design code or consensus standard
- More large-scale testing needed for interaction behavior under combined forces / loads, connection design
- Construction Issues – Availability of large fabrication shops, erection and fabrication tolerances, concrete inspection for voids, field welding techniques, etc
- Jointability – SC to SC and SC to RC Connections (at basemat, wall-to-wall and wall-to-slab interfaces) and associated rules for checking connection adequacy

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History of Standard Development

- In 1997, DOE's Brookhaven National Lab issued a report NUREG/CR-6486 for the US Nuclear Regulatory Commission
- ACI 349 committee did not address design of SC structures in 1997, 2001, and 2006 versions (and the latest being worked on)
- Outside the US, the Japanese introduced a guide document known as JEAG-4618 in 2005 (which is a guideline and issued as a Japanese code in 2009)
- Korean Society of Steel Construction launched its own research and standardization effort in 2005; KSSC's standard was issued in December 2009

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AISC Standard Development

- In 2005, we began canvassing ASCE and AISC to form standard committee for SC structures
- In 2006, AISC formed a subcommittee with Dr. Sanj Malushte, Bechtel Fellow, as chairman.
- Prof. Varma is vice-chair of the sub-committee.
- Several dedicated members from the industry, academic, and fabricator community.
- First ballot in 2011. Mostly positive.
- Second ballot in 2012.

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AISC Standard Development

- Appendix N9 to AISC N690. Structured like main body of N690, but in the appendix focusing on SC walls primarily.
- Appendix chapters are organized same as AISC 360, which is what is done for N690 as well (i.e., "dependent code" format)
- However, several chapters are very different in content because of the subject matter
- Special focus on general requirements with regard to local buckling, composite action, structural integrity, out-of-plane shear strength, etc
- Special focus on analytical requirements, incl. thermal
- Connection design requirements specified as performance requirements

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AISC Standard Addresses

- Loads and Load Combinations
- Local Buckling, Composite Action, and Structural Integrity
- Analysis Requirements, and Design Basis
- Design for Tension, Compression, Flexure, OOP Shear, IP Shear
- Interaction Equation for Simultaneous Forces and Moments
- Effect of Combined Thermal and Mechanical Loads
- Connection Design and Performance Requirements

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