UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION III
2443 Warrenville Road, Ste 210
Lisle, IL 60532-4362

March 15, 2011

Mr. Jack M. Davis
Senior Vice President and
Chief Nuclear Officer
Detroit Edison Company
Fermi 2 - 210 NOC
6400 North Dixie Highway
Newport, MI 48166

SUBJECT: NRC INSPECTION REPORT NOS. 07200071/2009001(DNMS) AND 05000341/2009009(DNMS); FERMI POWER PLANT, UNIT 2 DRY FUEL STORAGE ACTIVITIES

Dear Mr. Davis:

On February 15, 2011, the U.S. Nuclear Regulatory Commission (NRC) completed its inspection of dry cask storage pad construction activities at the Fermi Power Plant, Unit 2. The purpose of the inspection was to determine whether dry cask storage pad design and construction activities were conducted safely and in accordance with NRC requirements and design specifications. At the conclusion of the inspection on February 15, 2011, during an exit teleconference, the inspectors discussed the preliminary inspection findings with members of your staff. The enclosed report documents the inspection results.

During this inspection, the NRC staff examined activities conducted under your license as they relate to public health and safety. Areas examined during the inspection are identified in the enclosed report. Within these areas, the inspection consisted of selected examinations of procedures and representative records, observations of activities, and interviews with personnel. Specifically, the inspectors observed placement of structural fill, reinforcement, and concrete for the Independent Spent Fuel Storage Installation (ISFSI) pad. The inspectors also performed an in-office review of calculations related to the ISFSI pad design. Assistance from the Division of Spent Fuel Storage and Transportation was requested by the Region III staff during this inspection. The results of this Technical Assistance Request are enclosed.

The inspection was conducted under NRC Inspection Manual Chapter 2690, “Inspection Program for Dry Storage of Spent Reactor Fuel at Independent Spent Fuel Storage Installations and Guidance for 10 CFR Part 71 Transportation Packages,” and used Inspection Procedure 60853, “On-Site Fabrication of Components and Construction of an Independent Spent Fuel Storage Installation,” and Inspection Procedure 60856, “Review of 10 CFR 72.212(b) Evaluations” as guidance.

Based on the results of this inspection, the NRC has determined that one Severity Level IV violation of NRC requirements occurred. The violation is being treated as a Non-Cited Violation (NCV), consistent with Section 2.3.2 of the Enforcement Policy. The NCV is described in the subject inspection report. If you contest the violation or significance of the NCV, you should provide a response within 30 days of the date of this inspection report, with the basis for

your denial, to the Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington DC 20555-0001, with copies to: (1) the Regional Administrator, Region III; (2) the Director, Office of Enforcement, United States Nuclear Regulatory Commission, Washington, DC 20555-0001; and (3) the NRC Resident Inspector at the Fermi Power Plant, Unit 2.

In accordance with Title 10 of the Code of Federal Regulations (CFR) 2.390 of the NRC's "Rules of Practice," a copy of this letter and your response, if you choose to provide one, will be available electronically for public inspection in the NRC Public Document Room or from the NRC's Agencywide Documents Access and Management System (ADAMS), accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. To the extent possible, your response should not include any personal privacy, proprietary, or safeguards information so that it can be made available to the public without redaction.

Sincerely,

/RA/

Christine A. Lipa, Chief
Materials Control, ISFSI, and
Decommissioning Branch
Division of Nuclear Materials Safety

Docket No. 72-071; 50-341
License No. NPF-43

Enclosure:
1. Inspection Report No. 07200071/2009001(DNMS) and
05000341/2009009(DNMS)

cc w/encl: Distribution via ListServ

U. S. NUCLEAR REGULATORY COMMISSION

REGION III

Docket No:	072-071/050-341
License No:	NPF-43
Report No:	07200071/2009001(DNMS) 05000341/2009009(DNMS)
Licensee:	Detroit Edison Company
Facility:	Fermi Power Plant, Unit 2
Location:	Newport, MI
Dates:	Onsite: June 4, 2009; June 29, 2009; July 1, 2009; and July 24, 2009. In-office review completed on February 15, 2011.
Exit teleconference:	February 15, 2011
Inspectors:	R. Jones, Resident Inspector T. Steadham, P.E., Resident Inspector J. Tapp, Health Physicist J. Bozga, Reactor Inspector M. Learn, Reactor Engineer
Approved by:	Christine A. Lipa, Chief Materials Control, ISFSI and Decommissioning Branch Division of Nuclear Materials Safety

Enclosure

EXECUTIVE SUMMARY
Fermi 2
NRC Inspection Report 07200071/2009001(DNMS) and
05000341/2009009 (DNMS)

The purpose of the inspection was to observe and evaluate the licensee's activities associated with construction of a new Independent Spent Fuel Storage Installation (ISFSI) pad. During this inspection period, the inspectors also reviewed the design of the new pad to ensure compliance with the regulations.

Review of Title 10 of the Code of Federal Regulation (CFR) 72.212(b) Evaluations

- The inspectors identified one Severity Level IV Non-Cited Violation (NCV) of 10 CFR 72.212 (b)(2)(i)(B), "Conditions of general license issued under 72.210," involving the licensee's failure to adequately evaluate the cask storage pad to support static and dynamics loads of the stored casks considering potential amplification of earthquakes. The ISFSI pad at Fermi has not been loaded with any storage casks at this point in time and the licensee plans to resolve this issue prior to loading storage casks on the ISFSI pad. (Section 1.1)

- The licensee adequately evaluated the proposed transfer route for the expected dry cask loads. (Section 1.2)

Independent Spent Fuel Storage Installation Pad Construction

- The licensee's site characterization was adequate and the soil compaction activities were performed in accordance with applicable specifications, design drawings, and industry standards. (Section 2.1)

- The licensee adequately placed the correct size of rebar and met the requirements for the rebar spacing. (Section 2.2)

REPORT DETAILS

1 Review of 10 CFR 72.212(b) Evaluations (IP60856)

1.1 Site Characterization and Design of the ISFSI Pad

a. Inspection Scope

The inspectors evaluated the licensee's soil and engineering design evaluations in preparation for a new ISFSI storage pad to verify the licensee's compliance with the Certificate of Compliance (CoC), 10 CFR Part 72 requirements, and industry standards.

b. Observations and Findings

The ISFSI pad was designed to hold 64 HI-STORM dry storage casks. The ISFSI pad is classified as Important to Safety, Category C.

Title 10 CFR 72.212(b)(2)(i)(B) requires that written evaluations be performed to establish that the cask storage pads and areas have been designed to adequately support the static and dynamic loads of the stored casks, considering potential amplification of earthquakes through soil-structure interaction, soil liquefaction potential, or other soil instability due to vibratory ground motion.

Soil Analysis and Soil Liquefaction Analysis

The licensee evaluated the potential for ISFSI pad soil liquefaction in Calculation No. DC-6382, "Storage Pad Design for ISFSI Casks," Revision B. The licensee determined that a factor of safety of 3.48 existed for the horizon where loose granular material was encountered, and therefore the soil is not likely to liquefy. The licensee identified that loose soil pockets existed in a few borings, as low as six blows per foot. The liquefaction analysis at these locations showed that the factor of safety is 1.16. The licensee determined that due to confined condition, the soil is not likely to experience permanent horizontal deformation, and that the potential post-earthquake settlement is less than 0.5 inch at these locations.

Seismic Soil Structure Analysis and ISFSI Pad Structural Analysis

In order to demonstrate compliance with 10 CFR 72.212(b)(2)(i)(B) the licensee performed Calculation No. DC-6382, "Storage Pad Design for ISFSI Casks," Revision B. Calculation No. DC-6382, Revision B performed a seismic analysis and soil structure interaction analysis of the ISFSI pad in accordance with the requirements of American Society of Civil Engineers Standard (ASCE) 4-98, "Seismic Analysis of Safety-Related Nuclear Structures," dated 2000. The structural design of the ISFSI storage pad was

performed in Calculation No. DC-6382, Revision B in accordance with the requirements in American Concrete Institute (ACI) 349 “Code Requirements for Nuclear Safety Related Concrete Structures,” dated 2001.

On April 2, 2010, NRC Region III transmitted a Technical Assistance Request (TAR) to the NRC Office of Nuclear Materials Safety and Safeguards (NMSS) Division of Spent Fuel Storage and Transportation (SFST), concerning the ISFSI pad constructed at the Fermi Power Plant, Unit 2. The SFST was requested to perform a technical review of Calculation No. DC-6382, Revision B to determine whether the licensee’s seismic analysis and design of the pad met the regulatory requirements of 10 CFR 72.212. Specifically, the TAR requested a review to determine if the licensee has correctly applied the methodology in ASCE 4-98 and ACI 349-01 and appropriately calculated loads for the design of the pad. On June 10, 2010 the NRC Region III office received the enclosed response to the Technical Assistance Request for Fermi Power Plant, Unit 2.

The inspectors identified a Severity Level IV NCV of very low safety significance of 10 CFR 72.212 (b)(2)(i)(B),”Conditions of general license issued under 72.210.”

Specifically, the inspectors identified three examples where the licensee’s evaluations failed to demonstrate that the ISFSI pad was designed to adequately support the static and dynamic loads of the stored casks, considering potential amplification of earthquakes through soil-structure interaction, soil liquefaction potential, or other soil instability due to vibratory ground motion.

1) On November 24, 2009, the licensee completed Calculation No. DC-6382, Revision B. The ASCE Standard 4-98 Section 3.1.1(d) states “The model shall represent the actual locations of the centers of masses and centers of rigidity, thus accounting for the torsional effects caused by the eccentricity.” In addition, ASCE Standard 4-98 Section 3.1.4.1(b) states “When appropriate, three translational and three rotational degrees of freedom shall be used at each node point. Some degrees of freedom may be neglected, such as rotation, provided their exclusion does not affect the response significantly. The following conditions shall be met 1) Structural mass shall be lumped so that the total mass, as well as the center of gravity, is preserved, both for the total structure and for any of its major components that respond in the direction of motion and 2) The number of dynamic degrees of freedom, and hence the number of lumped masses, shall be selected so that all significant vibration modes of the structure can be evaluated.” The ASCE Standard 4-98 Section 3.3.1.8(a) states “Structural models defined in Section 3.1 may be simplified for soil structure interaction analysis. Simplified models may be used provided they adequately represent the mass and stiffness effects of the structure and adequately match the dominant frequencies, related mode shapes, and participation factors of the more detailed structure model.” The seismic and soil structure interaction analysis contained in Calculation No. DC-6382, Revision B evaluated a single configuration for all 64 casks on the pad. This single configuration and lumped mass approach resulted in no eccentricity of the cask mass with respect to the center of rigidity, which in turn precludes any rocking or torsional response. This seismic response of the casks

and the seismic demand on the ISFSI pad is non-conservative and does not demonstrate compliance with the ASCE Standard 4-98 Section 3.1.1(d), 3.1.4.1(b) and 3.3.1.8(a) requirements.

2) On November 24, 2009, the licensee completed Calculation No. DC-6382, Revision B. The ASCE Standard 4-98, Section C3.3.1.6 discusses the effects of mat (ISFSI pad) flexibility. This section states that:

> For typical nuclear power plant structures, the effect of mat flexibility for mat foundation need not be considered in [Soil Structure Interaction] SSI analysis. Although foundations and walls may appear to be flexible when taken by themselves, an effective stiffness of the foundation must be evaluated to adequately assess its flexibility. The effective stiffness is a function of the foundation itself and the stiffening effect of structural elements tied to the foundation. The latter item contributes significant stiffening effects in typical nuclear power plant containment and shear wall structures.

Since there are no structural elements tied to the foundation pad, the pad must be considered flexible and its effects considered. The influence of pad out-of-plane flexibility on seismic response of the casks and the seismic demand on the ISFSI pad was not addressed in Calculation No. DC-6382, Revision B.

3) On November 24, 2009, the licensee completed Calculation No. DC-6382, Revision B. The ACI 349-01, Section 9.2.2 states that "where the structural effects of differential settlement, creep or shrinkage may be significant, they shall be included with dead load D in Load Combinations…." The Calculation No. DC-6382, Revision B did not perform an analysis of soil consolidation and settlement due to long term loading. The differential settlement effects cannot be evaluated without an analysis of soil consolidation and settlement due to long term loading. The ACI 349-01, Section 9.2.2 was not addressed in Calculation No. DC-6382, Revision B.

The licensee entered these issues into their corrective action program as Condition Assessment Resolution Document (CARD) 10-24248, "NRC ISFSI Issue-ISFSI pad soil/structure interaction evaluation," dated May 21, 2010.

The inspectors determined that the previously discussed examples were a violation that warranted a significance evaluation. Consistent with the guidance in Section 2.2 of the NRC Enforcement Policy, ISFSIs are not subject to the Significance Determination Process and, thus, traditional enforcement will be used for these facilities. The inspectors determined that the violation was of more than minor significance using Inspection Manual Chapter 0612, Appendix E, "Examples of Minor Issues," Example 3i. Consistent with the guidance in Section 2.6.D of the NRC Enforcement Manual, if a violation does not fit an example in the Enforcement Policy

Violation Examples, it should be assigned a severity level: (1) Commensurate with its safety significance; and (2) informed by similar violations addressed in the Violation Examples. The inspectors determined that the violation could be evaluated using Section 6.5.d.1 of the NRC Enforcement Policy as a Severity Level IV Violation.

Title 10 CFR 72.212 (b)(2)(i)(B) requires, in part, that the licensee perform written evaluations prior to use, that establish that the cask storage pads and areas have been designed to adequately support the static and dynamic loads of the stored casks, considering potential amplification of earthquakes.

Contrary to the above, on June 10, 2010, the licensee's evaluations failed to demonstrate that the ISFSI pad was designed to adequately support the static and dynamic loads of the stored casks, considering potential amplification of earthquakes through soil-structure interaction, soil liquefaction potential, or other soil instability due to vibratory ground motion. This is a violation of 10 CFR 72.212 (b)(2)(i)(B), "Conditions of a General License Issued under 72.210." Because this matter was of very low safety-significance (Severity Level IV), and has been entered into the licensee's corrective action program (CARD 10-24248), this violation is being treated as a NCV consistent with the NRC Enforcement Policy. (NCV 07200071/2009001-01).

Flooding Analysis

The licensee performed Calculation DC-6416, "ISFSI Flood Evaluation," Revision 0 to evaluate the impact of flooding due to the Probable Maximum Meteorological Event as well as the Probable Maximum Flood. The design change evaluated whether the presence of the storage casks could change the flood flow pattern to increase flood levels or velocities at any safety-related structure, and also determined whether velocities, depths and wave forces pose any risk to the storage casks.

The licensee's evaluations indicated that the ISFSI installation will have negligible effect on flood velocity at any safety-related structure.

The licensee's evaluation determined that the maximum flood velocity where the ISFSI will be located is 0.08 feet per second. The flood accident affects the HI-STORM 100 overpack structural analysis in two ways. The flood water velocity acts to apply an overturning moment, which attempts to tip-over the loaded overpack. The flood affects the Multi-Purpose Canister (MPC) by applying an external pressure. The HOLTEC UFSAR Section 3.4.6 analyzed the flood velocity design basis at 15 feet/sec, which is greater than the site specific maximum flood velocity; therefore, the site specific velocity is bounded by the analyzed velocity.

c. Conclusion

The inspectors identified one violation of 10 CFR 72.212, (b)(2)(i)(B), involving the licensee's failure to adequately evaluate the cask storage pad to support static and dynamics loads of the stored casks considering potential amplification of earthquakes. The ISFSI pad at Fermi has not been loaded with any storage casks at this point in time and the licensee plans to resolve this issue prior to loading storage casks on the ISFSI pad.

1.2 Dry Cask Transfer Route

a. Inspection Scope

The inspectors reviewed the licensee's evaluation of the new transportation route from the reactor building to the ISFSI pad to verify that the licensee evaluated the proposed transfer route for the expected dry cask loads.

b. Observations and Findings

The licensee performed a detailed characterization and review of the proposed ISFSI haul path. The haul path starts near the Unit 2 Reactor Building inside the protected area and then transits to the east of the Residual Heat Removal Complex and leads to the ISFSI pad. The licensee identified buried commodities including mechanical/civil pipes, electrical duct vaults and conduits, drainage piping, manholes, monitoring wells, and cathodic protection wells. The evaluation resulted in modifications of the haul path. The licensee provided protective concrete bridging slabs over an electrical manhole and a mechanical pipe. In addition, the licensee provided bridging steel plates over sanitary piping, cathodic protection wells, and monitoring wells.

c. Conclusion

The licensee adequately evaluated the proposed transfer route for the expected dry cask loads.

2 Independent Spent Fuel Storage Installation Pad Construction (IP 60853)

2.1 Excavation and Soil Compaction Activities

a. Inspection Scope

The inspectors evaluated the licensee's site characterization, and observed soil compaction activities for the construction of the dry cask storage pad to verify the licensee's compliance with its specifications, design drawings, and industry standards.

b. Observations and Findings

The licensee constructed a reinforced concrete ISFSI storage pad to the north west of the Residual Heat Removal Complex. The license excavated soil, ensuring removal of topsoil, organic, and all undesirable material until bedrock was reached. Rolling of the underlying in-situ material ensured that a suitable subgrade existed under the pad area. Following receipt of satisfactory compaction results for the subgrade, the licensee backfilled the area with non-frost susceptible granular base material (gravel/sand) and

compacted the fill as indicated in American Society for Testing and Materials (ASTM) D1557 “Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort.” The licensee’s contractor obtained data by performing field tests which included wet and dry density, moisture content, and lift thickness. After placement of the engineered backfill, the licensee placed a mudmat which provided a work surface to facilitate reinforcement bar (rebar) installation and concrete placement. The inspectors observed the backfilled and compacted pad area prior to rebar and form placement.

The licensee committed to follow ASTM D1194 “Standard Test Method for Bearing Capacity of Soil for Static Load and Spread Footings” at the site. The tests used four steel plates having diameters of 30, 24, 18, and 12 inches. The 1 inch thick steel plates were placed concentrically in a pyramid on leveling sand. At least 6 load increments were utilized for each test to meet ASTM specifications. At each load increment measurements were taken using three separate gauges to determine soil deflection. Load-deformation curves were then plotted using the average deflection of the three gauges. Based on the determined load deformation curves the licensee calculated the modulus of subgrade reaction for each test site, which were within the maximum admissible value specified in the design document.

c. Conclusion

The licensee’s site characterization was adequate and the soil compaction activities were performed in accordance with applicable specifications, design drawings, and industry standards.

2.2 Pad Construction Activities

a. Scope

The inspectors evaluated whether construction activities for the ISFSI pad and the east approach slab complied with specifications contained in the licensee’s approved design change package, design drawings, work orders and applicable industry standards. The inspectors also reviewed select material, batch plant tickets, and personnel certification records.

b. Observations and Findings

Placement of Reinforcing Steel

After placement and satisfactory compaction of the engineered fill the licensee placed rebar and installed forms using Drawing #1, “Fermi Cask Storage Pad, Pad Slab Reinforcing,” Revision 4P and Specification No. 3071-393, “Fermi 2 ISFSI Storage Pad Reinforcing Steel,” Revision A. Once all work was completed the licensee performed an inspection of the as-built condition of the proposed pad before placement of concrete. The inspectors reviewed the design drawings and construction specification and performed an independent walkdown of the proposed pad. The area inside the installed forms was free of debris and excessive moisture and the condition of the rebar was

satisfactory. The rebar was placed in two upper and lower layers joined by U-shaped bars with an adequate overlap. The licensee placed the correct size of rebar and met the requirements for the concrete cover between the rebar and the forms as well as the bottom of the pad for protection of rebar steel as specified in the construction specification and design drawings.

The inspectors identified several areas where the rebar was not placed in accordance with the design drawings and specifications; however the rebar was within code allowable limits for spacing. The licensee immediately evaluated the situation and brought the tolerances back into compliance with the design drawings and specifications. The licensee entered the issue into their corrective action program as Condition Assessment Resolution Document 09-25147, "ISFSI Storage Pad Rebar Spacing Discrepancies," dated July 2, 2009. In addition, the licensee initiated a recovery plan which included the performance and documentation of a 100% inspection of the ISFSI pad.

Placement of Concrete for the Storage Pad

The inspectors observed concrete placement of the ISFSI pad. The licensee checked the concrete batch tickets for every truck to confirm that each concrete batch was mixed as specified in the mix design and the mixing time and number of drum revolutions satisfied code requirements to ensure the concrete was suitable for placement.

Concrete Field Tests

The licensee's contractor obtained concrete samples approximately every 50 cubic yards to test air content, temperature, and slump tests.

In addition to the field tests, qualified individuals collected concrete samples in cylinders for the concrete strength tests. The cylinders were adequately stored in accordance with ACI and ASTM standards. The cylinders were cured and tested after 28 days by an independent laboratory to measure the compressive strength of the concrete. The inspectors reviewed the 28-day concrete compressive strength test results taken from the storage pad to ensure they met the specified design requirements. Three 28-day test results exceeded the 4,200 pounds per square inch (psi) maximum strength, the highest one being at 4,370 psi. Although the design requirements indicated a maximum value of 4,200 psi, the tip-over analysis discussed in the Holtec HI-STORM FSAR used a bounding value of 4,500 psi thus no revision to the calculation was required.

c. Conclusion

The inspectors identified several areas where the rebar was not placed in accordance with the design drawings and specifications; however the rebar was within code allowable limits for spacing. The licensee immediately evaluated the situation and brought the tolerances back into compliance with the design drawings and specifications.

3 Exit Meeting Summary

On February 15, 2011, the inspectors conducted an exit teleconference to present the results of the inspection. The licensee acknowledged the findings presented and did not identify any information discussed as being proprietary in nature.

Attachments:
1. Supplemental Information
2. Response to Region III Technical Assistance Request for Fermi Power Plant, Unit 2

SUPPLEMENTAL INFORMATION

PARIAL LIST OF PERSONS CONTACTED

*B. Keck, Nuclear Engineering Manager
*C. Wolfe, Engineering Projects Manager
D. Bergmooser, Project Manager
J. Flint, Licensing
*J. Slaback, Nuclear Engineering
*R. Johnson, Licensing Manager
*R. Salmon, Nuclear Engineering

* Persons present during the February 15, 2011 exit meeting.

INSPECTION PROCEDURES USED

IP 60853 Construction of an Independent Spent Fuel Storage Installation

IP 60856 Review of 10 CFR 72.212 (b) Evaluations

ITEMS OPENED, CLOSED, AND DISCUSSED

Opened	Type	Summary
07200071/2009001-01	NCV	Failure to Design the ISFSI Pad to Adequately Support the Static and Dynamic Loads of Stored Casks (Section 1.1)

Closed	Type	Summary
07200071/2009001-01	NCV	Failure to Design the ISFSI Pad to Adequately Support the Static and Dynamic Loads of Stored Casks (Section 1.1)

Discussed

None

LIST OF DOCUMENTS REVIEWED

The following is a list of documents reviewed during the inspection. Inclusion on this list does not imply that the NRC inspectors reviewed the documents in their entirety, but rather, that selected sections of portions of the documents were evaluated as part of the overall inspection effort. Inclusion of a document on this list does not imply NRC acceptance of the document or any part of it, unless this is stated in the body of the inspection report.

Documents Reviewed

Procedure 22.000.05; Temperature/Pressure Data Sheet; September 30, 2009
Calibration Report, Toby's Instrument Shop, Inc.; Certificate Nos. 000019696 and 000019697
Calibration Report, Oven Calibration Nos. 0796
Calibration Report, Oven Calibration Nos. 1138
Calibration Report, InstroTek, Inc. Gauge Calibration Model 3411
Calculation No. DC-6382, "Pad Design for ISFSI Casks," Revision 0
Calculation No. DC-6390, "Analysis of Underground Utilities in the Loaded Haul Path for the ISFSI Project," Revision 0
Calculation No. DC-6402, "Qualification of 18" RCP Drainage Pipe in the ISFSI Haul Road," Revision 0
Calculation No. DC-6404, "Analysis of Underground Utilities in the Holtec Loaded Truck Delivery Route for ISFSI project," Revision 0
Calculation No. DC-6407, "Underground Utility Bridging Design for ISFSI Haul Path," Revision 0
Calculation No. DC-6408, "Design of ISFSI Reactor Building Airlock Access Pad," Revision 0
Calculation No. DC-6412, "Bridging Slab Over the Electrical Manhole #16945 positioned at location N7303, E4966," Revision 0
Calculation No. DC-6416, "ISFSI Flood Evaluation," Revision 0
Calculation No. DC-6433, "ISFSI Storage pad Soil Modulus Analysis," Revision 0
Certification Documents (4); Personnel Qualification Certification
Concrete Compressive Strength Tests, Quad 1, Sets 1 and 2; July 17, 2009
Concrete Compressive Strength Tests, Quad 2; July 17, 2009
Concrete Compressive Strength Tests, Quad 3; July 20, 2009
Engineering Design Package 34474, "ISFSI Storage Pad," Revision 0
Engineering Design Package 34475, "ISFSI Roadway Modification," Revision C
Detroit Edison Quality Assurance Surveillance 09-015
Information Notice 1995-28, "Emplacement of Support Pads for Spent Fuel Dry Storage Installations at Reactor Sites," June 5, 1995
Information Notice 2003-16, "Icing Conditions Between Bottom of Dry Storage System and Storage Pad," October 6, 2003
Storage Pad Rebar Certification Packages; Truck Nos. 1 - 10, less Truck #9
Specification No. 3071-392, "Construction," Revision 0
Specification No. 3071-395, "ISFSI Storage Pad Excavation and Backfill," Revision 0
Test Reports "Geotechnical Evaluation for Enrico Fermi Power Plant Unit 2, ISFSI," Revision 0
Test Reports, Project 5293.01, ISFSI Concrete Pad Construction; Backfill; June 4, 2009
Test Reports, Project 5293.01, ISFSI Concrete Pad Construction; Concrete Placement; July 23, 2009
Test Reports, Project 5293.01, ISFSI Concrete Pad Construction; Daily Reports; May 21, 26, 29, and June 2 4, 2009
Test Reports, Project 5293.01, ISFSI Concrete Pad Construction; Daily Reports (Revised), May 20 – 22, May 26 – 29, June 2, 2009

Test Reports, Project 5293.01, ISFSI Concrete Pad Construction; Moisture-Density Relationship Data; April 30, May 7, 8, 19, 20, 21,
Test Reports, Project 5293.01, ISFSI Concrete Pad Construction; Mechanical Analysis Report; May 7, 19, 2009
Test Reports, Project 5293.01, ISFSI Concrete Pad Construction; Percentage of Compaction Determined by Nuclear Density Method; May 20 – 22, 26 – 29, June 1 – 3, 2009
Test Reports, Project 5293.01; Static Plate Load Tests, June 22, 2009

Condition Reports Initiated as a Result of NRC inspection

CARD 09-28645, "Commitment to Revise Calc DC-6412-ISFSI Concern," dated November 6, 2009
CARD 09-28659, "Commitment to Revise Calc DC-6382-ISFSI Concern," dated November 6, 2009
CARD 09-28643, "Commitment to Revise Calc DC-6402-ISFSI Concern," dated November 6, 2009
CARD 09-28644, "Commitment to Revise Calc. DC-6404-ISFSI Concern," dated November 6, 2009
CARD 09-28846, "Revise DC-6390 (ISFSI Concern)," dated November 14, 2009
CARD 09-28847, "NRC Question on DC-6412 (ISFSI Concern)," dated November 14, 2009
CARD 09-28848, "Revise DC-6408 for NRC ISFSI Question (ISFSI Concern), dated November 14, 2009
CARD 09-28849, "NRC ISFSI Question 6404-3 (ISFSI Concern)," dated November 14, 2009
CARD 10-20387, "(ISFSI Concern) Evaluate How to Address the "Seismic I" Reference in EDP-34474 Investigation," dated January 15, 2010
CARD 10-20522, "Revise Holtec Report on ISFSI Pad Icing (ISFSI Concern)," dated January 21, 2010
CARD 09-25147, "ISFSI Storage Pad Rebar Spacing Discrepancies," dated July 2, 2009
CARD 10-24248, "NRC ISFSI Issue-ISFSI pad/soil/structure interaction evaluation," dated May 21, 2010

Condition Reports Reviewed as part of NRC inspection

CARD 09-28845, "Provide ISFSI Storage Pad Icing Report to NRC (ISFSI Concern)," dated November 14, 2009
CARD 09-28890, "Provide DC-6427 to NRC (ISFSI Concern)," dated November 16, 2009

Technical Assistance Request

Office of Nuclear Materials Safety and Safeguards Response to Region III Technical Assistance Request for Fermi Power Plant, Unit 2, June 10, 2010

LIST OF ACRONYMS USED

ACI	American Concrete Institute
ADAMS	Agencywide Documents Access and Management System
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
CARD	Condition Assessment Resolution Document
CFR	Code of Federal Regulations
CoC	Certificate of Compliance
DNMS	Division of Nuclear Materials Safety
ISFSI	Independent Spent Fuel Storage Installation
MPC	Multi-Purpose Canister
NCV	Non-Cited Violation
NMSS	Office of Nuclear Materials Safety and Safeguards
No.	Number
NRC	U. S. Nuclear Regulatory Commission
psi	Pounds per Square Inch
rebar	Reinforcement Bars
SFST	Division of Spent Fuel Storage and Transportation
SSI	Soil Structure Interaction

Response to Region III Technical Assistance Request [TAR]
For Fermi Power Plant, Unit 2
Independent Spent Fuel Storage Installation (ISFSI) Pad
SFST Ticket Number: 20100008
Prepared By: Gordon S. Bjorkman

Scope:

United States Nuclear Regulatory Commission (NRC) Region III requested assistance from the Division of Spent Fuel Storage and Transportation, (NMSS/SFST); by memorandum dated April 2, 2010, to perform a technical review of the Fermi Power Plant, Unit 2 (Fermi) licensee (Detroit Edison) calculation DC-6382 (Reference 1) for the design of the Independent Spent Fuel Storage Installation (ISFSI) Pad to determine whether the licensee's seismic analysis, and design of the pad met the regulatory requirements of 10 CFR 72. This technical review was limited to the licensee's documentation, and the relevant calculations prepared by Fermi and/or their contractors and furnished together with the Technical Assistance Request (TAR) to NMSS/SFST.

The TAR requested assistance to resolve concerns related to the methodology and assumptions used in the seismic analysis of the ISFSI pad and the apparent lack of an evaluation for the effects of differential settlement. The results of the technical review will be forwarded to the United States Nuclear Regulatory Commission (NRC) Region III office to assist in assessing the issues identified in the inspection report(s) related to the adequacy of the design of the ISFSI pad at Fermi.

Problem Statement:

The licensee performed a seismic analysis and soil structure interaction analysis of the Independent Spent Fuel Storage Installation (ISFSI) storage pad in accordance with the guidance described in American Society of Civil Engineers Standard (ASCE) 4-98, "Seismic Analysis of Safety-Related Nuclear Structures" (Reference 2). The structural design of the ISFSI storage pad was performed in accordance with the requirements in American Concrete Institute (ACI) 349 "Code Requirements for Nuclear Safety Related Concrete Structures" (Reference 3). This Technical Assistance Request (TAR) requests a review to determine if the licensee has correctly applied the methodology in ASCE 4-98 and ACI 349 and appropriately calculated loads for the design of the pad.

Background:

Title 10 CFR 72.212(b)(2)(i)(B) requires that written evaluations be performed to establish that the cask storage pads and areas have been designed to adequately support the static and dynamic loads of the stored casks, considering potential amplification of earthquakes through soil-structure interaction, soil liquefaction potential, or other soil instability due to vibratory ground motion. At the Fermi Power Plant, Unit 2, the licensee performed calculation DC-6382, "Storage Pad Design for ISFSI Casks", Revision 0, which was subsequently revised to Revision B, to demonstrate compliance with the above regulatory requirement. Calculation DC-6382 was performed to analyze the pad, taking into consideration the soil structure interaction and the soil

liquefaction potential, in order to determine the loads on the pad under a design basis seismic event.

During review of Calculation No. DC-6382, the inspectors made a number of observations, which are documented in Attachment A.

Based on these observations, the Region III inspectors have concerns that the licensee has not demonstrated that the Fermi ISFSI pad design meets the requirements stated in 10 CFR72.212(b)(2)(i)(B). In addition, since the methodology of ASCE Standard 4-98 used by the licensee for determining the loads on the pad and the methodology of ACI 349-01 used by the licensee for the structural design of the ISFSI pad involves a number of assumptions, the inspectors need assistance in determining the adequacy of the licensee evaluations.

Action Requested:
For assistance in resolution of the concerns identified in the TAR (Attachment A), the region is requesting a review of the licensee calculation DC-6382 by the NMSS staff. The specific questions / concerns are as follows:

1. Are the methodology and assumptions used in the seismic analysis of the storage pad and for determination of loads on the pad adequate? Does the seismic analysis of the ISFSI storage pad comply with the requirements in ASCE Standard 4-98 Section 3.1 and Section 3.2?

2. Is the licensee justification for seismic stability of ISFSI based on no amplification of the peak vertical and horizontal ground accelerations from the top of the pad to the center of gravity of the storage cask adequate? The licensee's justification for not amplifying the seismic accelerations from the top of the pad to the center of gravity of the cask is that the cask is rigid and that the maximum seismic accelerations of the storage cask are equal to zero period acceleration at the top of the storage pad.

3. Are the methodology and assumptions used in the soil structure interaction analysis of the storage pad for determination of loads on the pad adequate? Does the soil structure interaction analysis of the ISFSI storage pad comply with the requirements in ASCE Standard 4-98 Section 3.3.

4. Are the methodology and assumptions used for the structural design of the ISFSI storage pad adequate? Does ISFSI storage pad design comply with the requirements in ACI 349-01 Section 11 and Section 9.2?

Staff Evaluation of the Licensee's Seismic Soil-Structure Interaction Analysis:

Licensee Seismic Analysis Results

The licensee performed a seismic soil-structure interaction (SSI) analysis of the ISFSI pad using the impedance method given in ASCE 4-98 (Reference 2, Section 3.3.4). This simplified SSI analysis method assumes the ISFSI pad and casks are rigid bodies and models them as lumped masses attached to soil springs and dash-pots.

The licensee developed one single degree of freedom (DOF) model to evaluate horizontal translational motion and another to evaluate vertical translational motion. The lumped mass in each model consisted of the weight of the pad and the smeared weight of all 64 casks. Each model employed two different soil spring stiffnesses, one for the lower bound soil shear wave velocity and one for the upper bound soil shear wave velocity. The frequency results from these models are tabulated below as taken from Reference 1.

Horizontal Translation:

Shear Wave Velocity	Frequency
520 fps	3.35 Hz
1100 fps	7.09 Hz

Vertical Translation:

Shear Wave Velocity	Frequency
520 fps	3.67 Hz
1100 fps	7.76 Hz

The site specific horizontal and vertical spectra are essentially flat between 3.5 Hz and 9.0 Hz with a peak horizontal value of 0.32g and peak vertical value of 0.22g at 10% damping. Given the frequency range associated with the lower and upper bound shear wave velocities, the licensee chose to use the peak 10% damped values and convert them to 20% damped values as allowed by ASCE 4-98 Section 3.1.5.4 (Reference 2). The 20% damped values for horizontal and vertical ground motion are 0.23g and 0.17g respectively.

Staff Assessment

The modeling guidance provided in ASCE 4-98 for the dynamic analysis of structures and seismic SSI analysis is as follows:

> Section 3.1.1(d) The model shall represent the actual locations of the centers of masses and centers of rigidity, thus accounting for the torsional effects caused by the eccentricity.
>
> Section 3.1.4.1(b) When appropriate, three translational and three rotational DOF shall be used at each node point. Some DOF may be neglected, such as rotation, provided their exclusion does not affect the response significantly. The following conditions shall be met:
>
> > 1. Structural mass shall be lumped so that the total mass, as well as the center of gravity, is preserved, both for the total structure and for any of its major components that respond in the direction of motion.
> >
> > 2. The number of dynamic DOF, and hence the number of lumped masses, shall be selected so that all significant vibration modes of the structure can be evaluated.

> Section 3.3.1.8(a) Structural models defined in Section 3.1 may be simplified for SSI analysis. Simplified models may be used provided they adequately represent the mass and stiffness effects of the structure and adequately match the dominant frequencies, related mode shapes, and participation factors of the more detailed structure model.

As discussed in the previous section, for both horizontal and vertical seismic input motion, the licensee constructed a single degree of freedom model lumping all of the pad and cask mass together at a single mass point, and only considered translational motion while ignoring the effects of rocking and torsion. In the licensee's calculation (Reference 1) there is no discussion as to why it was appropriate to lump all of the cask and pad mass at a single mass point or why the rocking and torsional modes of response were not considered, as required by the ASCE 4-98 Sections cited above, and which the licensee used as the referenced basis for construction of the SSI ISFSI pad model.

In addition, only one configuration of casks (all 64) on the pad was considered. In Section 9.5 of the licensee's calculation (Reference 1), where the results of the static computer analyses are presented, many cask loading configurations were considered, yet for the seismic SSI analysis only one configuration was used. This single configuration and lumped mass approach results in no eccentricity of the cask mass with respect to the center of rigidity, which in turn precludes any rocking or torsional response. This approach disregards the modeling guidelines of ASCE 4-98, and the licensee provides no explanation for deviating from these guidelines.

Staff's Independent SSI Analysis

To attempt to quantify the impact of the licensee's deviations from the guidelines of ASCE 4-98, the staff developed a number of two degree of freedom models following the guidelines of ASCE 4-98. The staff only performed analyses for a site soil shear wave velocity of 520 fps. Four analysis cases were evaluated.

1. Horizontal Translation + Rocking	All 64 Casks on Pad
2. Horizontal Translation + Rocking	8 Casks in Row 1
3. Horizontal Translation + Torsion	8 Casks in Row 1
4. Vertical Translation + Rocking	8 Casks in Row 1

For each case the staff calculated mode frequencies, mode shapes and participation factors. The spectral acceleration associated with each frequency was taken from the 20% damped response spectra and modal responses were combined using the SRSS method. The results from these four cases are given in Table 1 below:

TABLE 1

Analysis Case	SRSS Response at Cask c.g.
1	0.231 g
2	0.231 g
3	0.254 g
4	0.181 g

Combining the two horizontal spatial responses (Cases 2 and 3) using the 100-40-40 method given in ASCE 4-98 Section 3.2.7.1.2, the staff obtained a maximum horizontal response of 0.27g. The staff and licensee maximum responses are compared in Table 2 below.

TABLE 2

	Licensee Responses	Staff Response
Horizontal	0.23g	0.27g
Vertical	0.17g	0.19g

For the analysis cases considered by the staff, these results show that not following the guidelines of ASCE 4-98 results in an underestimate of seismic response. It is important to note that both results assume the pad is rigid, when in fact; a two foot thick pad with plan dimensions of 141' x 141' is not rigid. Section C3.3.1.6 of ASCE 4-98 discusses the effects of mat (pad) flexibility. This section states that

> "For typical nuclear power plant structures, the effect of mat flexibility for mat foundations… need not be considered in SSI analysis. Although foundations and walls may appear to be flexible when taken by themselves, an effective stiffness of the foundation must be evaluated to adequately assess its flexibility. The effective stiffness is a function of the foundation itself and the stiffening effect of structural elements tied to the foundation. The latter item contributes significant stiffening effects in typical nuclear power plant containment and shear wall structures."

Since there are no structural elements tied to the foundation pad, the pad must be considered flexible and its effects considered.

The influence of pad flexibility on response can be estimated from Reference 7, in which a series of SASSI SSI analyses are performed for a range of pad thicknesses from a very flexible 1.5 foot thick pad to a much stiffer 4.0 foot thick pad. By comparing the response at the cask center of gravity of the 4 foot thick pad to the response at the cask center of gravity of a more flexible 2 foot thick pad, which is the thickness of the licensee's pad, an estimate of the effect of pad flexibility on response can be made. Reference 7 considers two cases, one with 3 casks on the pad and another with all casks on the pad. From the seismic response output in the long (y) direction of the pad for three casks on the pad the response at the cask c.g. for a 4 foot thick pad is 0.172g and the response for a 2 foot thick pad is 0.206g. This results in an estimated increase in cask response due to pad flexibility of 1.20 (0.206/0.172 = 1.20) for the case of three casks on the pad. For the case in Reference 7 with all casks on the pad the increase in cask response due to pad flexibility is 1.05. This lower value results from the close interaction of adjacent casks when all casks are on the pad. The influence of pad flexibility on vertical response is small and can be neglected. Accounting for pad flexibility using the higher of the two values, the estimated response comparison is shown in Table 3.

TABLE 3

Licensee One DOF	Staff Two DOF	Pad Flexibility	Staff Estimated Final	Percent Increase

	Model	Model	Factor	Response	
Horizontal	0.23g	0.27g	1.2	0.32g	40
Vertical	0.17g	0.19g	1.0	0.19g	12

Based on the staff's independent assessment, the staff finds that by not following the modeling guidelines of ASCE 4-98 for performing a seismic SSI analysis and by not considering the influence of pad flexibility on response, the licensee may have significantly under-predicted the seismic response of the casks, and thus significantly under-estimated the seismic demand on the ISFSI pad.

Staff Evaluation of Differential Settlement:

The ACI 349-01 Code (Reference 3), which is the criteria document for the design of the ISFSI pad, states in Section 9.2.2 that "Where the structural effects of differential settlement, creep or shrinkage may be significant, they shall be included with dead load D in Load Combinations…." In response to Region III inspection questions the licensee contends that by having analyzed the pad for two different sets of modulus of sub-grade reactions with four different values at various locations beneath the pad that the effects of differential settlement have been considered (References 5 and 6).

Staff Assessment

On page 9 of the licensee's calculation (Reference 1) the soil sub-grade moduli are given for the center, middle, edges and corners of the ISFSI pad for the upper and lower bound soil properties, where the highest values are at the corners and edges of the pad. This distribution of higher soil spring stiffness around the pad perimeter and lower soil spring stiffness in the middle and center of the pad is the necessary distribution of soil foundation spring stiffnesses required to duplicate the behavior of a pad resting on actual soil (i.e., an elastic half-space). If an elastic half-space finite element model were used instead of a soil spring model to support the pad, this same distribution of soil spring stiffness would occur naturally. It is precisely because a soil foundation spring model is being used for the analysis instead of an elastic half-space foundation model that this distribution of soil spring stiffness must be used. The differences in stiffness among the soil sub-grade moduli within these four regions beneath the pad have nothing to do with differential settlement caused by soil consolidation and creep under load over time. The staff was unable to find evidence that an analysis of soil consolidation and settlement due to long term loading was performed by the licensee. Without such an analysis the effects of differential settlement cannot be evaluated. Therefore, the staff finds the licensee's argument that differential settlement has been incorporated in the calculation by virtue of the distribution of soil spring stiffnesses that were used to be without merit.

Summary and Conclusions:

NRC/HQ -SFST staff reviewed the licensee calculation DC-6382 and other pertinent documents presented to the NRC/HQ staff, for the Fermi ISFSI pad and storage casks. The purpose of the calculation by the licensee was to evaluate the seismic response of the ISFSI pad under the SSE for the site, and to qualify structural design of the ISFSI pad for all other design loads. In response to the concerns posed by the region, SFST staff finds the following:

(1) In the licensee calculation DC-6382 there is no discussion as to why it was appropriate to lump all of the cask mass with the pad mass at a single mass point, or why the rocking and torsional modes of response were not considered, as required by the ASCE Standard 4-98. In addition, only one configuration of all 64 casks on the pad was considered. In Section 9.5 of DC-6382, where the results of the static computer analyses are presented, many cask loading configurations were considered, yet for the seismic SSI analysis only one configuration was used. This single configuration and lumped mass approach used by the licensee results in no eccentricity of the cask mass with respect to the center of rigidity, which in turn precludes any rocking or torsional response. This approach disregards the modeling guidelines of ASCE 4-98, and the licensee provides no explanation for deviating from these guidelines.

To attempt to quantify the impact of the licensee's deviations from the guidelines of ASCE 4-98, the staff developed a number of two degree of freedom models following the guidelines of ASCE 4-98. Based on the staff's independent assessment, the staff finds that by not following the modeling guidelines of ASCE 4-98 for performing a seismic SSI analysis and by not considering the influence of pad flexibility on response, the licensee may have significantly under-predicted the seismic response of the casks, and thus significantly under-estimated the seismic demand on the ISFSI pad.

(2) In response to Region III inspection questions regarding differential settlement, the licensee contended that by having analyzed the ISFSI pad for two different sets of modulus of sub-grade reactions with four different values at various locations beneath the pad, that the effects of differential settlement have been considered. In the licensee calculation DC-6382 the soil sub-grade moduli are given for the center, middle, edges and corners of the ISFSI pad for the upper and lower bound soil properties, where the highest values are at the corners and edges of the pad. This distribution of higher soil spring stiffness around the pad perimeter and lower soil spring stiffness in the middle and center of the pad is the necessary distribution of soil foundation spring stiffness required to duplicate the behavior of a pad resting on an elastic half-space. If an elastic half-space finite element model were used instead of a soil spring model to support the pad, this same distribution of soil spring stiffness would occur naturally. It is precisely because a soil spring model is being used for the analysis instead of an elastic half-space that this distribution of soil spring stiffness must be used.

The staff concludes that the differences in stiffness among the soil sub-grade moduli within these four regions beneath the pad have nothing to do with differential settlement caused by soil consolidation under load over time. The staff was unable to find evidence that an analysis of soil consolidation and settlement due to long term loading was performed by the licensee. Without such an analysis the effects of differential settlement cannot be evaluated. Therefore, the staff finds the licensee's argument that differential settlement has been incorporated in the calculation by virtue of the distribution of soil spring stiffnesses that were used to be without merit.

The SFST staff does not concur with the methodology and approach currently presented for the seismic analysis and assessment of differential settlement for reasons discussed above. The results and conclusions presented by the licensee are therefore not acceptable to the staff. In view of the fact that the ISFSI pad at Fermi has not been loaded with any storage casks at this

point in time, staff found no immediate safety concerns regarding the robustness of the in-place ISFSI pad. However, the documentation provided, to date, falls short of demonstrating that the pad meets regulations specified in 10 CFR 72.212(b).

References

1. Calculation No. DC-6382, “Storage Pad Design for ISFSI Casks” Revision B, ML100900249
2. American Society of Civil Engineers Standard ASCE 4-98, “Seismic Analysis of Safety-Related Nuclear Structures”, 2000
3. American Concrete Institute ACI 349-01, “Code Requirements for Nuclear Safety Related Concrete Structures”, 2001
4. Certificate of Compliance (COC) for Spent Fuel Storage Casks issued to HOLTEC International, Docket No. 72-1014, Certificate No. 1014, Amendment No. 5, ML082030116
5. ISFSI Pad Inspection Document – “Response to Questions on December 1, 2009” ML100900268
6. ISFSI Pad Inspection Document – “Response to Questions on December 29, 2009,” ML100900270
7. Bjorkman,G., et al.,”Influence of ISFSI Design Parameters on the Seismic Response of Dry Storage Casks,” *Transactions*, Structural Mechanics in Reactor Technology Conference, Washington DC, August 2001.

your denial, to the Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington DC 20555-0001, with copies to: (1) the Regional Administrator, Region III; (2) the Director, Office of Enforcement, United States Nuclear Regulatory Commission, Washington, DC 20555-0001; and (3) the NRC Resident Inspector at the Fermi Power Plant, Unit 2.

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Sincerely,

/RA/

Christine A. Lipa, Chief
Materials Control, ISFSI, and
Decommissioning Branch
Division of Nuclear Materials Safety

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