

Accident Investigation Board Report

**Construction Accident at the Naval Reactors Facility
June 17, 2012**



August 24, 2012

Naval Reactors Headquarters
U.S. Department of Energy
Washington, DC

Appointing Official's Acceptance Statement

On June 18, 2012, I established a Type "B" Accident Investigation Board to investigate the collapse of the partially-erected steel structure of Overpack Storage Expansion #2 that occurred at the Naval Reactors Facility on June 17, 2012, resulting in loss and damage to property greater than \$1M. The Investigation Board's responsibilities have been completed with respect to this investigation. The analysis; identification of direct, root, and contributing causes; and judgments of need reached during the investigation were developed in accordance with Naval Reactors DOE Order Implementation Bulletin Number 225.1-95, Accident Investigation.

I accept the findings of the Accident Investigation Board and authorize the release of this report for general distribution.



S. J. Trautman

Deputy Director, Naval Nuclear Propulsion

Disclaimer

This report is an independent product of the Overpack Storage Expansion #2 collapse Accident Investigation Board appointed by S. J. Trautman, Deputy Director for Naval Reactors.

The Board was appointed to perform an investigation of this accident and to prepare an investigation report using DOE Order 225.1B, Accident Investigations, as guidance.

The discussion of facts, as determined by the Board, and the views expressed in the report do not assume and are not intended to establish the existence of any duty at law on the part of the U.S. Government, its employees or agents, contractors, their employees or agents, or subcontractors at any tier, or any other party.

This report neither determines nor implies liability.

Executive Summary

Introduction:

This report documents the Naval Reactors investigation into the collapse of a partially-erected spent fuel storage building, Overpack Storage Expansion #2 (OSE2), at the Naval Reactors Facility. The Accident Investigation Board inspected the scene, collected physical and photographic evidence, interviewed involved personnel, and reviewed relevant documents to determine the key causes of the accident. Based on the information gathered during the investigation, the Board identified several engineering and safety deficiencies that need to be addressed to prevent recurrence.

Accident description:

At 5:15 PM on June 17, 2012, one-fourth of OSE2's structural steel, all that had been erected at the time, collapsed during a period of high winds. In addition to the structural steel, the collapse damaged the concrete foundations, the adjacent overpack storage building, and three pieces of contractor equipment.

Causes:

The cause of the collapse was inadequate lateral support for the partially-erected structure to resist expected wind loads. The erection subcontractor made an incorrect judgment concerning the stability of the structure. The general contractor and operating contractor did not challenge or validate the subcontractor's assertion.

Judgments of need:

The erection subcontractor, general contractor, and operating contractor need to modify current practices to ensure that engineering and safety decisions are made by qualified personnel.

Investigation Report

Facility description:

The Naval Reactors Facility (NRF) is located on the Idaho National Laboratory in Idaho and is owned by the U.S. Department of Energy – Naval Reactors (NR). The primary mission of NRF is to receive, examine, and store spent nuclear fuel from U.S. Navy submarines and aircraft carriers. NRF is currently operated by the Bechtel Marine Propulsion Corporation (BMPC).

Naval spent nuclear fuel is stored dry in stainless steel spent fuel canisters inside reinforced concrete overpacks. NRF currently has two overpack storage buildings and is building a third to support future dry storage needs. The new building will be located adjacent to one of the existing storage buildings and will have a floor area of approximately 190 feet by 180 feet and be 40 feet tall. As of June 17, 2012, the concrete foundations of the new storage building were constructed and structural steel columns, beams, and joists for the southwest quadrant had been erected and temporarily fastened in place.

The general contractor for the new overpack storage building is Okland Construction Company, Inc. (Okland). The subcontractor for steel erection is Intermountain Erectors Inc. (IEI). BMPC provides project management, technical, and safety oversight. The Idaho Branch Office (IBO) is the local Department of Energy field office.

Means of investigation:

The Board commenced the investigation on June 19, 2012 and submitted this report to the Deputy Director for Naval Reactors on August 24, 2012. The investigation was conducted using DOE Order 225.1A as guidance.

The Board inspected the scene, collected physical and photographic evidence, interviewed involved personnel, and reviewed relevant documents. Personnel interviewed included engineers, managers, and work supervisors from IEI, Okland, BMPC, and IBO. Documents reviewed included the BMPC construction specification and drawings, International Building Code, American Institute of Steel Construction Manual of Steel Construction, IEI Steel Erection Plan, IEI Job Safety Analysis for steel erection, and Okland and BMPC approval documents for the Steel Erection Plan and Job Safety Analysis.

Accident description and damage assessment:

As required by the construction specification, IEI, via Okland, submitted the Steel Erection Plan to BMPC for approval on April 30, 2012. BMPC approved IEI's Steel Erection Plan on June 11, 2012. IEI had the steel for the south wall and southwest quadrant erected and temporarily fastened in place by June 15, 2012. Figure 1 shows the erected steel highlighted in red. Work was stopped for the weekend in this condition, which was judged to be structurally stable as documented in the Steel Erection Plan.

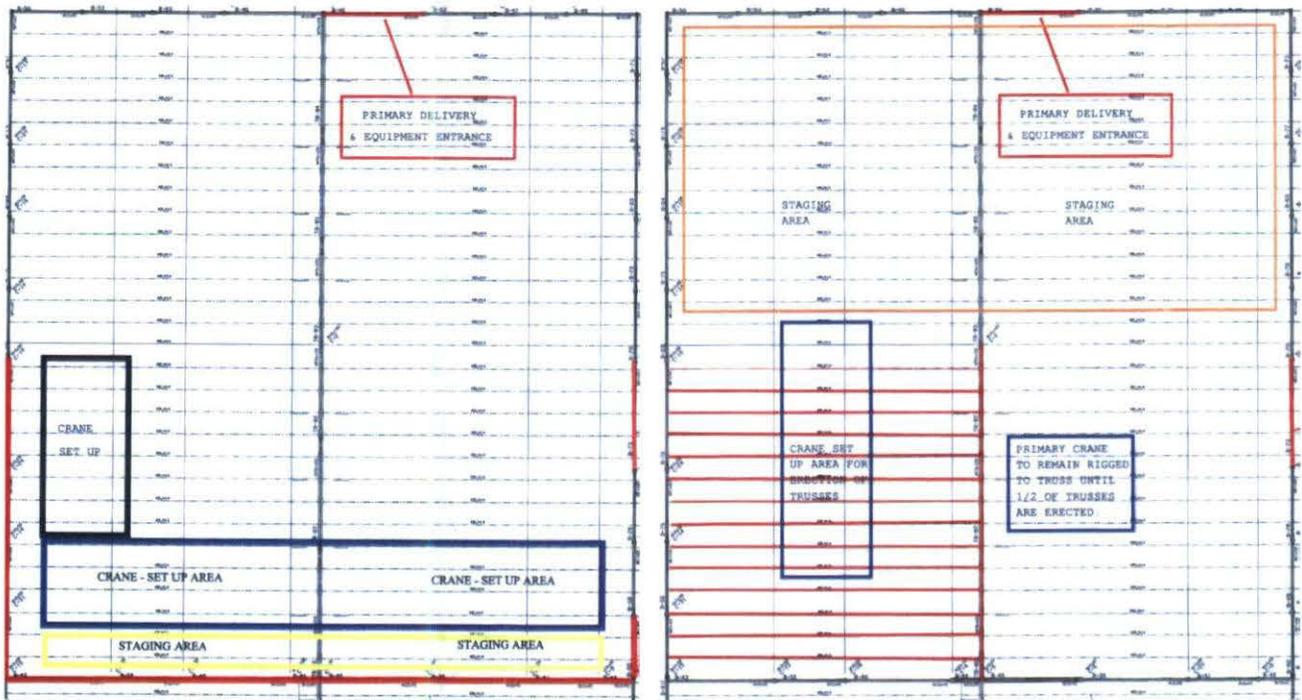


Figure 1: Sequences 1 and 2 of IEI Steel Erection Plan

The partial structure collapsed on June 17, 2012 at 5:15 PM during a period of high winds. Based on data collected about 400 yards from OSE2, the sustained wind speed during this period was over 40 miles per hour with gusts over 60 miles per hour. Wind speeds of this magnitude are expected at NRF and are bounded by the specification requirement of 96 miles per hour. Figure 2 shows the partially-erect OSE2 structure before and after the collapse.

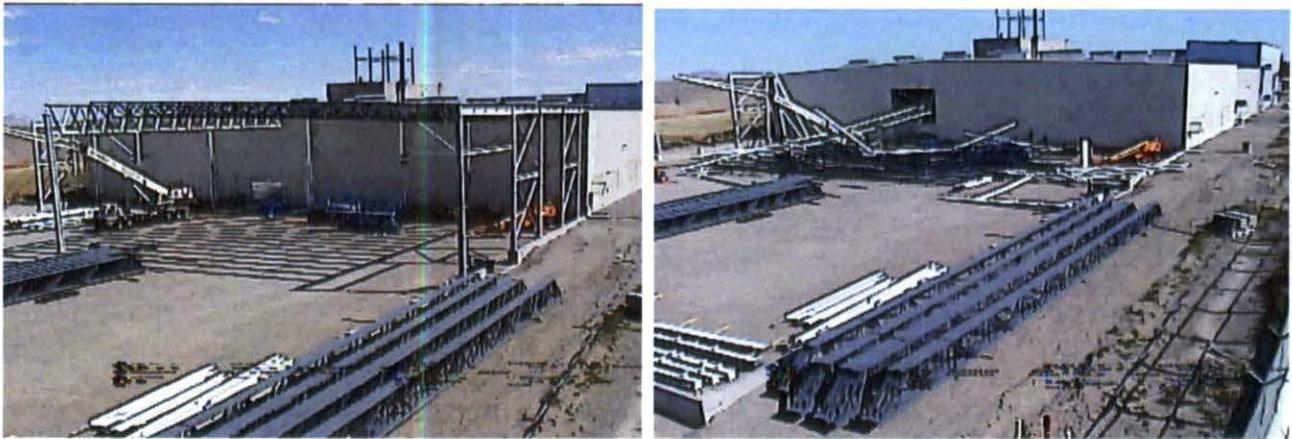


Figure 2: OSE2 photos before and after collapse

No personnel were injured. The damage caused by the collapse was (see Figure 3 for examples):

- Sheet metal, sheet metal framing, and electrical cables in the adjacent overpack storage building were damaged, including visible bending and breakage.
- A contractor crane and two manlifts parked under the structure were damaged, including visible denting and crushing.
- The concrete and anchor studs in the foundations for about twenty columns were damaged, including visible concrete fractures and broken studs.
- About twenty structural columns and associated cross bracing, one main truss girder, and fourteen truss joists were damaged, including visible bending and breakage.



Figure 3: Examples of damage to OSE2 and adjacent building

Causal analysis:

The structure collapsed because the horizontal loads imposed by the wind on June 17, 2012 exceeded the capacity of the partially-erected structure. The partial structure had cross bracing to resist horizontal loads on only two of the four sides, compared to all four sides for the finished structure. Evaluations performed after the collapse confirm that the partial structure could not resist the imposed wind loads; see Okland letter 7003268-F0041 dated July 9, 2012, BMPC letter B-EDOC-EASTMARS-2012-06-20 dated June 20, 2012, BMPC letter B-EDOC-EASTMARS-2012-06-21 dated June 21, 2012, Bechtel National Inc. Assessment for OSE #2 Building Collapse dated July 31, 2012, and Naval Facilities Engineering Command Structural Review dated July 30, 2012. For example, BMPC letter B-EDOC-EASTMARS-2012-06-20 dated June 20, 2012 shows that the stress created in the partial structure by 60 mile-per-hour wind, which is well below the 96 mile-per-hour design load, would exceed the partial structure's capacity by at least 50%. Evaluations demonstrate that the final structure will resist design wind loads; see Baker and Associates Engineering Design File BI-10970 dated March 9, 2011 and Naval Facilities Engineering Command Structural Review dated July 30, 2012.

The contributing causes of the accident were:

- IEI incorrectly concluded that the partially-erect structure, without temporary bracing, would be stable under expected wind loads. IEI based this conclusion on judgment and experience with similar construction projects.
- IEI did not explicitly address the specification requirement to temporarily brace partial structures against design wind loads for the final structure, which is more specific than American Institute of Steel Construction guidelines to temporarily brace partial structures against wind loads that are likely to be encountered during erection.
- Okland and BMPC did not request IEI to justify the assertion in the Steel Erection Plan that the partially-erect structure would be stable under wind loads.
- IEI, Okland, and BMPC did not consult the structure's designer (Baker and Associates) or perform independent structural calculations to determine whether the partially-erect structure would be stable under wind loads.
- BMPC's review and approval process did not ensure that personnel with training and experience in steel erection reviewed IEI's Steel Erection Plan.
- Okland and BMPC interpreted high risk work requirements narrowly, creating an inappropriate fixation and bias to avoid temporarily bracing the two sides of the partially-erected structure that had no cross bracing. This fixation and bias prevented an objective technical assessment of the risk presented by the partial structure (i.e., high potential energy of elevated structure without cross bracing on two sides).
- The behavioral dynamics of IEI, Okland, and BMPC resulted in a "groupthink" environment, where one flawed judgment was accepted and endorsed throughout the review chain.

As discussed in Okland letter 7003268-F0041 dated July 9, 2012, Okland letter 7003268-F0048 dated July 25, 2012, and BMPC letter AM-12-508 dated July 26, 2012, Okland and BMPC have identified that some hardware and welds were not fabricated in compliance with the drawings and specifications. Also, Michael Baker Jr., Inc. letter BI-11795 dated August 23, 2012 identified that shear lugs were inadvertently omitted from the design of the connections between the steel columns and the foundation. These non-compliances and omission are not contributing causes to the collapse because these features were not designed to resist wind-induced moments. However, compliant hardware and welds may have provided some additional resistance to the wind loads.

Judgments of need:

- IEI, Okland, and BMPC should evaluate and improve practices for generating and approving technical recommendations. The evaluations should specifically consider:
 - o establishing requirements for which departments need to review and concur in each contractor submittal for each construction project;
 - o establishing qualification (e.g., education, experience, and/or certification) requirements for personnel authorized to generate, concur with, and approve contractor submittals;
 - o engaging designer input during construction planning and execution, such as decisions involving the adequacy of a structure;
 - o highlighting and explicitly discussing all specification requirements that differ from standard industry practice; and
 - o seeking lessons learned and best practices from Bechtel National Inc.
- BMPC should evaluate improvements to general requirements for evaluating and mitigating the risks inherent in construction work at NRF. The evaluations should specifically consider:
 - o revising the General Conditions for construction contracts to establish realistic expectations for working in high wind conditions common at NRF; and
 - o proposing changes to high risk work requirements to ensure that determinations of high risk work are made based on real, inherent technical risk.
- IEI, Okland, and BMPC should evaluate improvements to quality assurance practices to ensure that materials of construction meet drawing and specification requirements.
- NR and IBO should develop a quality plan for IBO review and oversight of key deliverables and execution of construction projects.
- IEI, Okland, BMPC, IBO, and NR should incorporate this event into periodic lessons learned training to reinforce the need to maintain a questioning attitude. This training should specifically address the need to properly characterize and prioritize the many risk elements involved in complex projects such as steel erection.

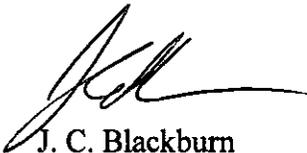
Accident Investigation Board



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