BRIEF TECHNICAL NOTES ON
STRUCTURAL ANALYSIS
AND DESIGN

An Informational Series S9707

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STRUCTURAL DESIGN FOR HIGH SEAS

Most power plants are not designed for pitch, roll, and bottom slamming. However, the plant in the Dominican Republic at Puerto Plato was constructed for both high seas and hurricane winds.

The Donaldson air filter system for the gas turbine cogeneration facility at Puerto Plato at engineered for both fatigue was and high winds with help from ESI.

The entire power station was erected on a large, ship-size barge at a shipyard on the Gulf Coast. The barge was transported on a ship to the Dominican Republic. Once in position, pilings were driven to secure the station at Puerto Plato; and it was immediately put into service.

The project had many unique and interesting requirements not usually found in the design of most steel structures; and, the tall, narrow air filter system posed many challenges.

Power Plant on the Ship to Dominican Republic

LOADINGS AT SEA

Transportation loadings were severe. The equipment was designed for pitch, roll, heave and impact while at sea. The expected conditions translated into much higher than normal lateral forces, e.g., 0.65g from a 10 degree roll.

Pitch and heave motions resulted in a 0.60g fore/aft force while bottom slamming produced a 0.95g vertical force in addition to the dead load. These loads were all combined with nominal wind loads. Directional loadings from transportation were combined simultaneously to form a worst-case condition. This required checking several fore-aft-left-right load combinations.

FATIGUE DESIGN

The major concern was fatigue; and that's why Donaldson came to ESI. The entire air filter structure was designed for complete stress reversal. Given the maximum 7-day duration at sea and highest frequency of wave motion, ESI computed 120,000 cycles of loading would result, thus putting it in AISC's Fatigue Load Condition 2. This particular condition cut the allowable stresses to half the normal values and increased the size of most welds in the steel connections.

The filter house was composed of tubular bracing and angle sections using partial penetration and filet welds. The entire structure was thoroughly inspected after transit, and no cracks or points of distress were observed.

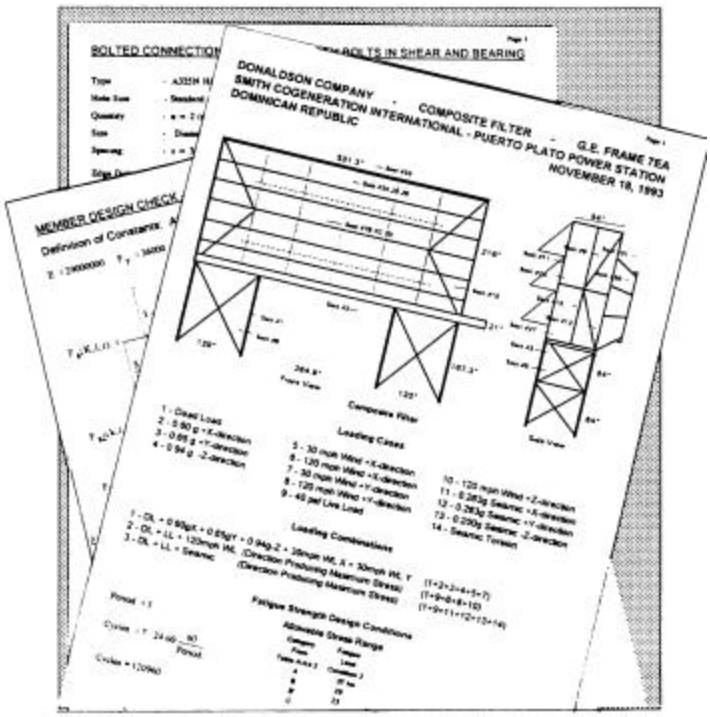
NORMAL OPERATING LOADS

The equipment was designed for 120 mph wind loads in service. These were increased by an importance factor of 1.11 for the hurricane coastline and exposure D for the flat, unobstructed coastal area. "Given its location, this equipment could easily see the full brunt of hurricane winds," according to David Pederson of ESI.

The zone 3 seismic condition loads were obviously exceeded by the high wind loading. All together there were 14 load conditions with three basic load combinations which could produce the maximum stress on any given member.

STRUCTURAL DESIGN WITH MATHCAD

The support structure and the filter house were composed of several hundred individual elements, and computer models played a major role in the design. For the member design, ESI used custom tailored calculation templates to check AISC requirements with Mathcad to integrate CAD sketches and drawings. This has been an extremely useful, time-saving tool to organize repetitive and iterative engineering calculations. "With fatigue, A36 and 316L stainless steels and torsion to consider, the member design calculations required tailoring," said Pederson.



Mathcad Calculation Sheets and Graphics

STAINLESS STEEL FILTER HOUSE

The modular filter house was built entirely of 316L stainless steel to combat corrosion. All steel in the substructure was galvanized. The 48-foot wide structure weighed approximately 60,000 lbs.

Six prefabricated filter modules were lifted onto the support structure and bolted side-to-side to house the filter cartridges. The stainless steel members were designed using AISI specifications with extensive use of stiffened and unstiffened compression elements.

Air Filter Module Lifted onto the Support Structure

The power plant was constructed in the winter and has been in service since June, 1994. Fabrication and erection of the structure went very smoothly.

ESI ENGINNERING, INC.

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- analysis of stress and fatigue
- design of equipment support structures
- vibration/noise control & testing

We also offer services in vibration analysis of floors, buildings and equipment for many clients.

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