Crews place concrete for the internal walls of the Tacoma caisson. More than 77,600 cubic yards of concrete were placed in the bridge's two caissons, up to 1,300 cubic yards at a time. Reduced testing frequencies were used for large placements in accordance to the project's Quality Plan.

As the sun sets and with the help of a crane, crews place concrete for new towers using a 4-cubic yard bucket. Concrete has to be pumped more than 2.000 feet to the crane. Engineers designed a specialized high strength, "high slump" concrete to ensure that it consolidated properly within the tower legs.

The underside of one of the 46 deck sections for the suspension bridge. Fabrication of the superstructure in Korea requires continuous international coordination and communication between project staff.

Factory workers at the Kiswire plant in Pusan, Korea fabricated the suspension bridge's main cable wire. TNB managers and staff visited the factory last winter to conduct audits and inspections. The plant had to pass inspection before the TNB Project would authorize wire production for the new bridge cables.

Environmental compliance is a core value of the project. Given the environmental sensitivity of Puget Sound area, and specifically the Narrows, erosion and sediment control efforts are inspected and monitored daily.

Glossary (continued)

Quality Verification (QV) Compliance Audits. Independent audits of design-builder activities and operations (including construction, environmental compliance, management and business functions) performed by WSDOT oversight staff. Audits based on objectively collected evidence by the auditor are evaluated as either conforming or not conforming to the project requirements.

Field Change Requests/Notices (FCRs and FCNs). Defined project procedures internal to the design-builder. These forms document the requested design changes that take place in the field. Forms also document construction and the subsequent review and approval (or disapproval) by the design engineer. FCRs and FCNs that deviate from established project standards and criteria must be reviewed by WSDOT for concurrence.

Requests for Information (RFIs). A project procedure internal to the design-builder that provides identification, notification and resolution of technical questions from field personnel, subcontractors, and material and equipment vendors. RFIs do not authorize design changes.

The Subjective Tools

Monthly quality awards. Issued by the TNC quality control manager to recognize construction crews for work performed at high level of quality.

Partnering and co-location. WSDOT and TNC are committed to working as a cohesive team by co-locating and through formal partnering sessions, all in an effort to achieve clearer communication.

Performance Matrix. Depicts the performance of the current project activities and operations. Various and specific work items are placed in one of four quadrants. The matrix serves as a benchmark and allows owner and design-builder to confer face-to-face about the quality of ongoing and completed activities.

Ongoing Issues	Steady Performance
Current Issues	Good Trends

Taskforce meetings. Open bi-weekly forums with WSDOT and TNC staff to discuss and evaluate specific quality topics: project materials testing and statistical analysis; upcoming operations; current project non-conformance items; field-change documentation; and applicability of project standards to non-typical activities and project deviations.

Ratings. Assigned bi-weekly by owner representatives and based on the general level of quality and coordination for major construction operations.

The Tacoma Narrows Bridge Quality Program

PROJECT COMPLETION DATES:
New Bridge: Spring 2007 **1950 Bridge (Retrofit): Early 2008**

At a Glance

What unique challenges face the team in their pursuit of high standards?
It's an international project that involves more than 20 subcontractors, some as far away as Japan, Korea and England, page 1

Who ensures quality on the project?
Tacoma Narrows Constructors and WSDOT maintain separate, yet complementary roles, page 2

What quality tools do team members use on a daily basis?
The combination of objective and subjective tools optimize results. See **Glossary**, pages 3-4

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For more information about the bridge project, visit the TNB web site: www.tacomanarrowsbridge.com

Washington State Department of Transportation

Tacoma Narrows Constructors

Two years into building the new Tacoma Narrows Bridge (TNB), design-builder Tacoma Narrows Constructors is more than halfway complete with the project. The new TNB is the largest suspension bridge to be built in the United States in four decades, and the third span to cross the Narrows. In addition to constructing a new bridge, the design-build contract includes improving 2.4 miles of roadway on State Route 16, retrofitting the adjacent bridge, building toll and bridge maintenance faciliies, an underpass and split interchange.

When design-builder TNC and WSDOT joined forces in October 2002, the two teams became one in their commitment to construct the toll funded project. Across the United States, design-build contracting has proven to be an effective method for delivering large, complex projects, typically totaling more than $200 million. In Washington state, the TNB is the second highway design-build project to be undertaken at WSDOT. The department is using the TNB Project to develop policies for design-build projects to come. What is more, the executive management team is documenting lessons to ensure that future projects are delivered efficiently.

WSDOT and TNC have built an environment where quality is a core value. Through quarterly partnering sessions and mutual endorsement of the quality program, the two organizations are one team. Team members are committed to safely delivering the highest quality bridge – on schedule and on budget.

Quality challenges

Due to the complexity of building a parallel suspension bridge, WSDOT and TNC were posed the enormous challenge of building an internationally recognized team of engineers, managers, and suppliers. With project suppliers of materials and products all over the world, each one is evaluated based on qualifications and in-house quality programs. Project personnel perform on-site audits and inspections of materials, work processes and documentation packages for all supplier facilities prior to approving production.

Heavy emphasis is placed on quality management practices so that materials and bridge components are manufactured to the highest level of quality. International coordination is required, too. Outside the U.S., major components of the bridge are fabricated in various parts of the world. WSDOT and TNC staff plays active roles in the inspection of bridge components being fabricated in this country and overseas:

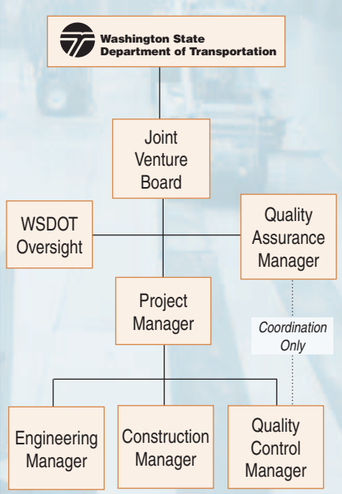
- Korea: prefabricated superstructure deck sections and main cable wire;
- Japan: superstructure steel and suspension system components;
- England and Canada: suspension system components;
- United States: suspension system and permanent access components.

Narrows Bridge Quality Team

WSDOT requires on-going confirmation that the design-builder is delivering a project that conforms to contract requirements. As defined in the design-build agreement, TNC performs quality control and quality assurance for the project; that includes materials testing, acceptance and project documentation. TNC is tasked with contract administration and quality assurance (QA) for project design and construction.

WSDOT takes on independent oversight and verification duties (quality verification or QV). By pursuing complementary programs, owner and design-builder work as a cohesive team, one that strives to achieve the highest level of quality in the areas of design, construction, materials and documentation. As owner, WSDOT is responsible for quality oversight verification of the design-build activities. To that end, field and office staff must document that the bridge is being built to state and federal standards.

Tacoma Narrows Bridge
Project Organization Chart



TNC Quality Program Defined

The TNC management team develops and implements the project-wide quality program. It begins at the top with the TNC project manager who stresses to all staff – engineers, field workers, and quality staff – the importance of meeting contract, regulatory and statutory requirements.

TNC's program is made up of five elements:

Contract documents include the design-build agreement between TNC and WSDOT, its appendices and other referenced documents that apply to design and construction of the Tacoma Narrows Bridge Project.

Quality plan refers to an integrated set of requirements used in conjunction with the project quality procedures. The focus is on what is required to achieve quality in design, construction and administration.

Project quality procedures are defined procedures in two categories: 1) project administrative procedures, and 2) project quality procedures. Project staffs apply both sets of procedures to fulfill the quality program requirements.

The existing bridge appears in the background as crews place prefabricated roof trusses atop the toll operations building. Before any of the building parts arrive on site, fabrication inspectors visit the plants to ensure the quality of workmanship and materials.

Quality tools include logs, flowcharts, and written instructions that all staff use for the purpose of implementing, measuring and monitoring the quality requirements.

Quality records are completed documents that identify the quality results achieved. The records provide evidence of those quality activities performed. Quality records may include completed inspection and test reports, as-builts, meeting minutes and audit findings.

TNC management roles and responsibilities

Quality Control Manager (QCM) reports directly to the TNC project manager and is responsible for coordinating and implementing the quality plan and project quality procedures. He or she manages those staff performing acceptance testing and inspection of construction work as it relates to WSDOT standards.

Construction Manager (CM) reports directly to the TNC Project Manager and is responsible for the successful planning and execution of the project's construction with an emphasis on safety, quality, environmental compliance, cost control and meeting the contract requirements.

Engineering Manager (EM) reports directly to the TNC project manager and is responsible for managing all levels of design production. This manager's duties include the overall coordination of the design team. A well-coordinated staff works to ensure that project designs and specifications adhere to contractual requirements and results in efficient construction.

Quality Assurance Manager (QAM) reports to the Joint Venture Board (executive sponsors and management representing the design-build project). This manager is responsible for independent surveillance of the implementation of the quality program relating to quality control, engineering and construction. He coordinates with the QCM on matters relating to performance of the quality program and compliance to the design-build agreement.

WSDOT Oversight and Verification Program

WSDOT project personnel are responsible for the oversight of the design, construction and administration of the new Tacoma Narrows Bridge. Staff takes on quality verification (QV) tasks for all activities in order to ensure that the design-builder is following the contractual requirements.

Design. To begin, WSDOT performed design oversight during the initial design phase to ensure the design-builder followed established design standards as it related to project's basic configuration. Design coordination tools included task forces assigned to specific aspects of the project, and a professional review of interim design plans at the 35- 65- and 90-percent levels. In addition, design reviewers received supplemental help from WSDOT technical specialists and consultants. Even after plans have been issued for construction, the design oversight continued as revisions are proposed by the design-builder through field change requests and notices (see Glossary, page 4).

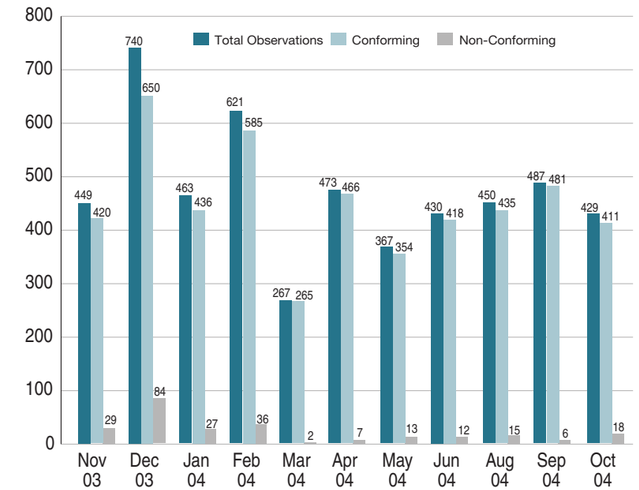
The TNB project employs independent surveyors who verify alignments for both the towers and anchorages.

Molten steel is poured into a mold casting forming one of the bridge's main cable saddles. To ensure the highest level of quality before casting, project inspectors analyzed the physical properties of the molten steel.

Construction and Management Systems

WSDOT has implemented a compliance audit system (CAS) to measure and evaluate the level of quality on the project. This system has been used successfully on other design-build projects across the country. Using this system, WSDOT field auditors collect objective evidence of construction activities and materials concerning TNC's adherence to design, construction, and environmental standards. In the auditing of management systems, staff ensure that practices comply with all requirements as they relate to quality, subcontractors, insurance and project controls. WSDOT uses audit findings to evaluate TNC's quality management practices and overall compliance to the design-build agreement. These results are communicated to TNC for coordination purposes and, also, reported to the WSDOT executive team.

Monthly Audit Results
Number of Observations



The compliance audit system allows WSDOT to track and monitor how TNC is complying with practices as it relates to quality management. Between November 2003 through November 2004, WSDOT conducted 460 audits that comprised of 6,400 observations in the field. Of those observations, inspectors noted 304 as non-conforming (NC) activities. These and other project results are published in the quality oversight monthly report. Visit the TNB web site at: www.tacomanarrowsbridge.com

A Glossary of Quality Tools

In the pursuit of continual improvement, WSDOT and TNC use several complementary objective and subjective tools for evaluating the quality of activities, materials, and management.

The Objective Tools

Audit Surveillance Reports (QASRs). A project procedure internal to the design-builder conducting and documenting quality assurance surveillance of all project related activities for conformance to the Design/Build Agreement, the quality plan and procedures.

Oversight Monthly Reports. WSDOT publishes a monthly report that conveys the general effectiveness of quality management activities for TNC and WSDOT. The report is based on owner CAS and design-builder quality program results including evaluating conforming observations vs. nonconforming observations.

Materials Testing Database. Shared database where WSDOT and TNC report testing results for project materials for statistical analysis (QC vs. QA vs. QV).

QC Non-conformance Reports. Reports showing deficiencies in workmanship or materials that need to be corrected.

QA Corrective and Preventative Action Reports (CPARs) An investigative process internal to the design-builder performed by the QAM used to determine the root cause of problems or potential problems identified by a reoccurring NCR or QASRs.

continued on page 4