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14.0 BRIDGES

14.1 INTRODUCTION

This section contains design criteria for the analysis and design of pipeline and traffic bridges for the gas pipeline project. Pipeline bridges are bridges that support the gas pipeline over streams and rivers. Pipeline bridges include aerial crossings such as cable suspension bridges, plate girder bridges and pier supported stream crossings. Traffic bridges include both temporary and permanent bridge structures. Traffic bridges include prefabricated modular structures, and portable single span units.

Specifications, calculations, and drawings are not included in this section. Design criteria for drainage and erosion control are in Section 11, restoration is in Section 12, river and stream crossings in Section 16, stress analysis in Section 20, and geotechnical/geothermal analysis is in Section 21.

14.2 CODES AND CRITERIA

14.2.1 Codes

- Code of Federal Regulations (CFR),
  - Title 49 – Transportation, Part 192, Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards
  - Title 18 – Conservation of Power and Water Resources
- Alaska Statutes, Title 16 – Fish and Game
- Occupational Safety and Health Act
- United States Coast Guard Regulations, Office of Bridge Administration, Bridge Permit Application Guide, COMDTPUB P16591.3B
- Federal Right-of-Way Grant for the Alaska Natural Gas Transportation System Alaska Segment, Serial No. F-24538 (December 1, 1980), as such may be updated and/or amended from time to time
- Federal Energy Regulatory Commission conditional certificate of public convenience and necessity, issued on December 16, 1977, as such is finalized
- American Association of State Highway and Transportation Officials (AASHTO), Standard Specifications for Highway Bridges - 17th edition with revisions
- American Association of State Highway and Transportation Officials (AASHTO), AASHTO LRFD Bridge Design Specifications, U.S., 3rd Edition with revisions
- American Institute of Steel Construction (AISC), Manual on Steel Construction Allowable Stress Design (ASD), 9th edition

- American Institute of Steel Construction, Manual on Steel: Load and Resistance Factor Design-LRFD, 3rd edition
- American Welding Society (AWS), D1.1 2004 Structural Welsing Code – Steel
- American Welding Society (AWS) and American Association of State Highway and Transportation Officials (AASHTO), AASHTO/AWS D1.5M/D1.5:2002 Bridge Welding Code with revisions
- American Concrete Institute, Building Code Requirements for Structural Concrete, ACI 318-02/318R-02
- American Society of Testing Materials (ASTM)
  - A709/A709M-04, Standard Specification for Carbon and High-Strength Low-Alloy Structural Steel Shapes, Plates, and Bars and Quenched-and-Tempered Alloy Structural Steel Plates for Bridges
  - A6/A6M-04a, Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
  - A673/A673M-04, Specification for Sampling Procedure for Impact Testing of Structural Steel
  - A852/A852M-03, Specification for Quenched and Tempered Low-Alloy Structural Steel Plate with 70 ksi (485 MPa) Minimum Yield Strength to 4 inch (100 mm) Thick
  - A36/A36M-04, Standard Specification for Carbon Structural Steel
  - A586-98, Standard Specification for Zinc-Coated Parallel and Helical Steel Wire Structural Strand and Zinc-Coated Wire for Spun-in-Place Structural Strand
  - A90/A90M-01, Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-alloy Coatings
  - A490-04, Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength
  - A325-04, Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
  - A572/A572M-04, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
  - A588/A588M-04, Standard Specification for High-Strength Low-Alloy Structural Steel with 50 ksi (345 MPa) Minimum Yield Point to 4-in.(100mm) Thick
  - A514/A514M-00a, Standard Specification for High-Yield Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding
  - A352/A352M-03, Standard Specifications for Steel Castings, Ferritic and Martensitic, for Pressure-Containing Parts, Suitable for Low-Temperature Service

  - A320/A320M-03, Standard Specification for Alloy/Steel Bolting Materials for Low-Temperature Service
  - A194/A194M-03b, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
  - A350/A350M-04, Standard Specification for Carbon and Low-Alloy Steel Forgings, Requiring Notch Toughness Testing for Piping Components
  - A578/A578M-96(2001), Standard Specification for Straight-Beam Ultrasonic Examination of Plain and Clad Steel Plates for Special Applications
  - A615/A615M-04, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
- American Society of Civil Engineers, "Minimum Design Loads for Buildings and Other Structures", SEI/ASCE 7-02

14.2.2 Criteria

14.2.2.1 Gas Pipeline Bridges

- Refer to Section 20 for pipeline design stresses.
- A design life of 50 years.
- A maximum design wind velocity of 100 miles per hour. A refined value of wind velocity, attack angles, gusting and flutter considerations will be derived on a site-specific basis and in accordance with applicable AASHTO/ASCE wind specifications.
- Minimum clearance for structures will be the greatest distance determined by:
  - Four feet above the pipeline design flood (PDF) to the bottom of structural members.
  - Specifications by regulatory agencies for navigation requirement. The necessary U.S. Coast Guard permit applications will be submitted for their review.
  - Four feet above the elevation of floating debris, ice jams and/or aufeis build-up, based upon field evidence or available historical records.
  - Four feet above the design flood used for the design of existing structures that may be affected, assuming such information is made available.
- Pipeline bridges in near proximity of existing crossing facilities (highway bridges, Trans Alaska Pipeline System [TAPS], and others) will be designed to be compatible with existing structures. Compatibility will include such considerations as the effect on freeboard, scour, discharge intensities, flood- plain flows due to backwater effects, and other effects that may adversely impact the existing structure. Compatibility to adjacent third party facilities will be evaluated using third party design flows if available.

- Construction documents prepared by the project will include considerations and/or limitations for possible use of cofferdams or other in-stream structures.
- Construction plans for major structures including plans for cofferdams and other temporary structures will be reviewed for comparability with third party structures.
- An ambient temperature range from -70°F to 100°F. Refinements in this range will be made on a site-specific basis.
- Seismic design data as derived from "Seismic Design Criteria for the Alaska Segment of the ANGTS,"* April 1981, and "Addendum – Seismic Design Criteria for the Alaska Segment of ANGTS,"* February 1982. Criteria will be updated to incorporate current seismic characterization.
- Soils data derived from subsurface investigations.
- Environmental Constraints for Permanent Structures:
  - Increased velocities caused by instream structures will not impede fish passage. Permanent channel constriction will be avoided.
  - Accelerated upstream or downstream erosion impacts will be minimized in accordance with Section 11 and Section 16.
  - For additional environmental concerns related to river and stream crossings refer to Section 16.
- Environmental Constraints for Temporary Structures:
  - Temporary structures located in fish streams will provide for fish passage. These criteria are included in Section 11.
  - Placement of temporary structures will not result in channelization at or near TAPS or other existing facilities.
  - Configuration of adjacent staging areas will be in accordance with the criteria established in Section 16 particularly in regard to providing sufficient area for sediment control structures and in regard to environmental concerns including preservation of buffers. See Section 10 for clearing.
- Design Approach
  - The project design approach is based on Allowable Stress Design (ASD). The Load-and-Resistance Factor Design (LRFD) is an alternate acceptable approach. Either approach will be acceptable for any gas pipeline bridge, but must be used consistently in the design of all elements of any gas pipeline bridge.

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- Design Loads
  - Pipeline and the loads as indicated in Section 20. Structural members – Deadweight as calculated for each member.
  - A two-inch growth of ice on all exposed structural elements will be included in the dead weight and added as projected area for wind loading (when the load combination includes a below freezing ambient temperature).
- Allowable Stresses and Design Details
  - Concrete design

    ACI 318, AASHTO Division I, Section 8
  - Structural steel design

    AISC 9th edition, AASHTO Division I, Section 10, and Division I-A
  - Timber design

    AASHTO Division I, Section 13
  - Pipe design

    Refer to Section 20
  - Structural cable design

    Maximum tension = (breaking strength) /3

    Minimum tension = (breaking strength) /15

14.2.2.2 Traffic Bridges

- Design life: Permanent – 50 years

  Temporary – 5 years.
- A maximum design wind velocity: Permanent – 100 mph

  Temporary – 50 mph

Site-specific values and other considerations developed in accordance with applicable AASHTO/ASCE wind specifications

- Minimum clearance for permanent structures will be the greatest distance determined by:
  - Four feet above the 50-year frequency flood, to the bottom of structural members.
  - Specifications by regulatory agencies for navigation requirement, if applicable. The necessary U.S. Coast Guard permit applications will be submitted for their review.
  - Four feet above the elevation of floating debris, ice jams, and/or aufeis on site-specific basis.

   - Four feet above the design flood used for the design of existing structures that may be affected, assuming such information is made available.
- Minimum clearance for temporary structures will be four feet above the 5-year frequency flood to the bottom of structural members.
- Traffic bridges in near proximity of existing crossing facilities (highway bridges, TAPS, and others) will be designed to be compatible with existing structures. Compatibility will include such considerations as the effect on freeboard, scour, discharge intensities, flood plain flows due to backwater effects, and other effects that may adversely impact the existing structures. Compatibility to adjacent third party facilities will be evaluated using third party design flows if available.
- Construction plans for major structures including plans for cofferdams and other temporary structures will be reviewed for compatibility with third party structures prior to construction.
- An ambient temperature range -70°F to 100°F
- Soils data as derived from subsurface investigations.
- Seismic design data as derived from “Seismic Design Criteria for the Alaska Segment of the ANGTS,” [*] April 1981 and “Addendum – Seismic Design Criteria for the Alaska Segment of ANGTS,” February 1982.
- Environmental Constraints for Permanent Structures:
   - Increased velocities caused by instream structures will not impede fish passage. Permanent channel constriction will be avoided where practical.
   - Accelerated upstream or downstream erosion impacts will be minimized in accordance with Section 11 and Section 16.
   - For additional environmental concerns related to rivers and stream crossings refer to Section 11 and Section 16.
- Environmental Constraints for Temporary Structures:
   - Temporary structures located in fish streams will provide for fish passage. These criteria are included in Section 11.
   - Configuration of adjacent staging areas will be in accordance with the criteria established in Section 16 particularly in regard to providing sufficient area for sediment control structures and in regard to environmental concerns.
- Embankment approaches for vehicular bridges will not encroach on active stream channels.
- Design Approach

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   - The project design approach is based on Allowable Stress Design (ASD). The Load-and-Resistance Factor Design (LRFD) is an alternate acceptable approach. Either approach will be acceptable for any gas pipeline bridge, but must be used consistently in the design for all elements of any gas pipeline bridge.

- Design Loads
   - Bridge design will comply with AASHTO specifications
   - Highway traffic loads will be in accordance with the load requirements specified in AASHTO, Division I, Section 3 – Loads for HS20-44. They consist of a tractor truck with semi-trailer or of the corresponding lane loading. Variable axle spacing from 14' – 30' will be used to find maximum stresses.
   - Off-highway vehicular traffic loads will be specified as required. Controlling vehicle loads will arise from consideration of the type of traffic and number of passes anticipated. The loads from the construction equipment (pipelayer, tractor scraper, and off-highway end-dump truck) will produce the maximum axle loads. Details of the loading and dimensions of the vehicles will be used to designate the design loadings. A minimum roadway width of approximately 16 feet will be used for off-highway vehicular traffic bridges.
- Allowable Stresses and Design Details
   - Concrete design

     ACI 318, AASHTO Division I, Section 8
   - Structural steel design

     AISC, AASHTO Division I, Section 10, and Division I-A
   - Timber design

     AASHTO Division I, Section 13

14.3 <u>DESIGN PROCEDURES</u>

14.3.1 Gas Pipeline Bridges

Pipeline bridges will be of either cable suspension bridge or plate/box girder bridge design.

14.3.1.1 Conceptual Design (completed for Gas Pipeline Bridges on Rev. 4 Alignment)

- Review criteria and develop scope of work for each bridge crossing.
- Environmental Considerations

  Avoid where practical the following when developing the crossing alignment:
   - Sensitive or restricted fish and wildlife habitats or populations.
   - Sensitive or unique vegetation.

- Antiquities and Cultural Resource areas.

- Potential impacts and mitigation techniques for ensuring water quality will be analyzed in accordance with Section 16.
- Visual Resource Guidelines

  Consider the following factors in determining the potential for visual impact when locating the crossings on a site-specific basis:

  - Extent of clearing and approach preparation
  - Location and number of potential viewers.
  - Duration of view.
  - Type of proposed structure.

Visual resource impacts will be reduced in accordance with Section 12 and Section 16.

- Hydrology Review

  Consider the site-specific hydrological requirements for the river including the estimated scour depth, design flow, normal breakup flow elevations, pipeline design flood elevations and any special requirements for hydrological opening such as debris, ice jamming and/or aufeis. This will be accomplished as described Section 16.
- Navigation Requirements

  Satisfy U.S. Coast Guard requirements or clearance between water elevations to bottom of structural member.
- River Training Works

  Prepare a conceptual design of the river training works at each location, when required. This will include an estimate of required setback from bank; distance needed for the training works and a general plan geometry of the training works.
- Survey

  Utilize existing mapping and survey data of the area to indicate feasibility of approaches to the bridge and bridge orientation. Consider ownership and environmental factors in developing a crossing alignment.
- Conceptual Evaluation Design

  Review all relevant data to demonstrate why an aerial crossing is required. Using the preliminary estimate from the engineering tasks above, develop a conceptual design which is feasible from a construction, environmental and engineering viewpoint.
- Submit conceptual design for review.

14.3.1.2 Preliminary Design

- Review criteria, scope of program, schedules and logistics for each bridge crossing.
- Hydraulic/Hydrologic Analysis

Perform detailed hydraulic and hydrologic analysis of the location utilizing the methodologies outlined in Section 16 and referenced hydrology reports. The results of the analysis will be used to compare pre- and post-construction conditions for assessing potential impacts on adjacent facilities and to enable detailed design of river training structures, where required. Details for design of river training structures and for assessment are presented in Section 16 and referenced hydrology reports.

- Detailed Survey

  Using the geometry produced from the conceptual design, perform a site reconnaissance and a site survey to accomplish the following tasks:

  - Locate and describe any features that would be affected by the proposed crossing alignment.
  - Evaluate environmental features at the site including: fish and wildlife use; vegetation; visual resources; potential staging areas; apparent bank stability; potential restoration needs.
  - Establish a baseline at the site for the alignment.
  - Determine the existing profile at 100-foot intervals and include supplemental profile elevations at all significant slope changes, cross roads, drainage courses, and at both banks of crossing.
  - If there are existing highways, training works, bridges, or other alignments within 500 feet of the proposed gas pipeline alignment, tie in the survey with the structure. If practical, establish a benchmark on an existing structure.

- Borehole

  Boreholes are placed to assess the feasibility of foundation units at the proposed crossing location. This phase involves, as a minimum, two holes at each crossing. Additional requirements for the borehole investigation would depend on the subsurface conditions anticipated.

- Site-Specific Criteria

  Based upon the performed engineering tasks, as well as the general criteria summarized in Section 14.2.2, establish a set of site specific design criteria to be applicable to each crossing.

- Preliminary Analysis

  Using approximate structural analysis procedures, apply the loadings to the conceptual design to develop sizes for the major components of the structure. Modify conceptual design, as required.

- Type, Size, and Location (TS&L)

  Produce a set of standard size drawings showing a plan and elevation of the proposed design. Indicate the best estimate of sizes of major components from the preliminary analysis. Depict a typical cross section of the structure.

- Submit TS&L for review.

14.3.1.3 Detailed Analysis

- Geometry of Structure

  Using the TS&L, define the location, orientation and detailed geometry of all components to be included in the structural analysis. In accordance with engineering judgement, define the points of fixity of the connections.

- Load Combinations

  Arrange the basic design load components into loading combinations included in the analysis. For gas pipeline bridges, assign a factor to the basic unit stresses for each load combination as noted in Table 14-1.

- Static Structural Analysis

  Perform static structural analysis using applicable procedures. Applicable structural analysis tools include the following:

  - Standard manual techniques such as the moment distribution method.
  - Computer analysis programs such as ANSYS, STRUDL or equivalent.
  - Continuous Beam Analysis

    For beam element analysis, analytical programs will be used to solve for the moments and shears.

  - Column Analysis

    For reinforced concrete column design, programs will be used to determine the interaction diagrams for moment and axial load using the applicable ACI strength design methodology. Biaxial column loadings can also be analyzed. The program will be used in the design mode to produce an economical reinforcement schedule.

    For steel column analysis, manual analyses will be performed in accordance with AISC and AASHTO specifications.

    Programs to perform an analysis or design a column will be used when complex biaxial bending situations and/or unusual structural geometry is required.

  - Special purpose programs

    As site-specific conditions arise, special purpose programs may be used to aid analysis.

- Seismic Structural Analysis

  All permanent structures will be analyzed for seismic loading. Seismic loading will consist of two earthquake levels. The lower level of earthquake hazard is designated the design operating earthquake (DOE) and is the normal AASHTO code level earthquake in accordance with AASHTO Division I-A. The higher level of earthquake hazard is designated the design contingency earthquake (DCE) and is that associated with a return period of about 200 to 400 years in accordance with “Seismic

Design Criteria for the Alaska Segment of the ANGTS," [1]April 1981, and it's Addendum, February 1982[2]. The input for the DOE seismic loading will be derived from AASHTO Division I-A. The input for the DCE seismic loading will be derived from "Seismic Design Criteria for the Alaska Segment of the ANGTS" and it's Addendum. The seismic loading applicability depends on the location, subsurface conditions and type of structure.

The general method of analysis for all permanent structures will include the design for both earthquake levels (DOE and DCE). Application of the general method will be proven for specific cases. Proven simplifications of the general method will be accepted based upon the order of magnitude of the earthquake loads and/or dimensions of the structure.

Analysis for the DOE: normal code level earthquake will be in accordance with AASHTO. Analysis for the DCE will be as follows:

- The response spectrum method will be used to analyze the effects of seismic loading. The earthquake will be input as acceleration response spectra.
- The three major directions of earthquake motion will be analyzed by separate mode frequency analysis.
- The response of each separate direction of earthquake motion will be found by appropriate combination of the individual vibration mode response. Combination of modal responses will be accomplished by using the Complete Quadratic Combination Method (CQC) or the square root of the sum of the squares (SRSS) method, modified for closely spaced (10 percent separation) modes. The criteria for finding the closely spaced modes will be governed by:

  Freq. of Mode J - Freq. of Mode K / Freq. of Mode J ≤ 0.10

  Other responses will be found similarly. The three spatial responses will be summed by the SRSS method for the total response of the structure.
- Where proven important, the effect of out-of-phase motion of the structure will be added to the total response of the structure. This will be done by a static analysis in which the substructure will be given differential displacements. The differential displacement in the lateral direction will be:

$$S = \frac{Vd}{c}$$

The differential displacement in the longitudinal direction shall be:

$$S = \frac{Vd}{2c}$$

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[2] Ibid.

Where:

V = maximum ground velocity (soil response)

c = effective horizontal wave propagation velocity

d = horizontal span distance

Finally, the lateral or longitudinal displacement results, whichever leads to the greatest total response when combined with initial shaking effects, will be combined by the SRSS method with the results from the response spectra analysis.

- Component Design

  Scan the results of the various load groups analyzed for each component to find the load group that controls. Isolate the member by a free body diagram to find details of the stress distribution within the member. Perform detailed design of the member. Using the forces at the ends of the member, perform detailed design of the connection.

- Reanalyze

  Using the refined design, reanalyze the controlling load cases with the new member design to check sufficiency. This cycle will continue until all criteria are satisfied.

- Subsurface Investigation

  Concurrently with the analysis, perform detailed subsurface investigation corresponding to the TS&L design. At least one borehole will be placed at each foundation unit. Details of the borehole investigation are site specific. Spread footings will be designed so that the maximum pressure calculated beneath the footing will not exceed the allowable soil pressure. The allowable soil pressure will be calculated from conventional bearing capacity formulae with site specific data. The maximum pressure beneath the footing will be calculated based on the most severe loading condition.

- Steel Piles

  Steel piles will be either steel H piling or steel pipe piling in sizes commercially available. All welding for splicing piles will be in accordance with the AWS code. Lengths of piles depicted on the design drawings are estimated lengths so the lengths may be modified to take into account on-site field conditions. Thermal piles may be specified to maintain frozen soil conditions as required.

- Riprap and Bank Protection

  Riprap and bank protection will be as described in Section 16. The training works will be designed to guide the river flow, protect the foundation units against ice jamming and maintain TAPS protection. Site specific analysis and design conducted in accordance with Section 16 will be required at all crossing locations where existing facilities (highway bridges, TAPS, river training structures, etc.) are near either side of the pipeline crossing. Plans for the river training works indicate a typical cross section including slope of sides, width and elevation of top and detailed geometry of location of the works at each location. The plans for these earth structures will be included on the design drawings for each bridge. Refer to Section 11 and Section 16 for design details.

- Arctic Considerations

  Special consideration will be given to structural design in arctic conditions. All steel specifications will be reviewed for low temperature application. Special treating techniques, fracture toughness, or ductility requirements will be specified as needed. A limiting value of $^{1}/_{3}$ breaking strength will be used for cable design. Thermal devices will be specified to stabilize subsurface units on frozen soils where necessary. No supporting resistance will be utilized from the active layer.

- Environmental Considerations

  Design features to protect fish and wildlife will be incorporated where applicable. These features will minimize the constriction of flow and the increase of stream velocity.

- Final Design Drawings

  Design drawings are prepared on standard sheets. The drawings will include all information needed to fabricate and erect the components.

14.3.1.4 Final Design Review

14.3.1.4.1 Review and Approval of Shop Drawings

The fabricator will prepare the necessary drawings that will be submitted for review and approval. Any proposed modifications from the structure depicted on the design drawings will be analyzed to ensure that material properties equal or exceed those used in design. Proposed changes in material specifications will be reviewed to ensure that strength, ductility, and other structural parameters satisfy or exceed the requirements as shown by design.

14.3.1.5 Material Sampling and Testing

Material sampling and testing procedures will be in accordance with the ASTM designation for the material depicted on the design drawings. Relevant specifications are noted in Section 14.2.1.

Charpy V-Notch Impact requirements will follow the testing required for AASHTO Temperature Zone Designation Three (-31°F to –60°F). Further special testing required for fracture toughness requirements will depend on the site-specific ambient conditions.

Cables will conform to ASTM A586, Standard Specification for Zinc-Coated Parallel and Helical Steel Wire Structural Strand and Zinc-Coated Wire for Spun-in-Place Structural Strand". As a minimum, cables will have protection equivalent to Class A zinc coating on all wires. The weight of the coating will be tested in accordance with ASTM A90/A90M-01, "Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-alloy Coatings". The manufactured cable is tested to the design minimum breaking strength. The minimum modulus of elasticity will be noted by the designer and will be verified by testing of the manufactured cable. The manufactured cable will be tested under arctic conditions or a proven temperature correction factor may be used. A statistical sampling procedure will be specified for cable end fittings to test to the design breaking strength of the connection.

14.3.1.6 Construction

- Orientation

  Review criteria, scope of program, schedules and logistics.

- Cold Weather Concreting

  ACI 318, ACI Report 306R, Cold Weather Concreting, and AASHTO Division II.

- Assess Construction Procedure

  Review the contractor's construction methodology. The contractor's computations for erection stresses will be checked against applicable specifications. Environmental concerns will be resolved.

- Consult on Field Construction

  As unanticipated field conditions are encountered, check design to ensure that design criteria are not exceeded. Alter design if required.

14.3.2 Traffic Bridges

Traffic bridges may be prefabricated modular structures. For spans of 30 feet or less portable single span bridge units and timber structures will be considered. The impact assessment for temporary and permanent traffic bridges adjacent to TAPS will be conducted in the same manner as for pipeline bridges.

14.3.2.1 Conceptual Design

- Review criteria and develop scope of work for each bridge crossing.
- Environmental Considerations

  Avoid where practical the following when developing the crossing alignment:

  – Sensitive or restricted fish and wildlife habitats or populations.

  – Sensitive or unique vegetation.

  – Antiquities and Cultural Resource areas.

Potential impacts and mitigation techniques for ensuring water quality will be analyzed in accordance with Section 16.

- Visual Resource Guidelines

Consider the following factors in determining the potential visual impacts when locating the crossing on a site-specific basis:

- Extent of clearing and approach preparation
- Location and number of potential viewers.
- Duration of view.
- Type of proposed structure.

Visual resource impacts will be reduced in accordance with Section 12 and Section 16.

- Hydrology Review

  Consider the site specific hydrological requirements for the river including the estimated scour depth, design flow, normal breakup flow elevations, pipeline design flood, elevations and any special requirements for hydrological opening such as debris, ice jamming and/or aufeis. This will be accomplished as described in Section 16.

- Survey

  Utilize existing mapping and survey data of the area to indicate feasibility of approaches to the bridge and bridge orientation. Consider ownership and environmental factors in developing a crossing alignment.

- Submit conceptual design for review.

14.3.2.2 Preliminary Design

- Review criteria, scope of program, schedules and logistics for each bridge crossing.
- Preliminary Analysis

  Using approximate structural analysis procedures, apply the loadings to the conceptual design to develop sizes for the major components of the structure. Modify conceptual design, as required.

- Type, Size and Location (TS&L)

  Produce a set of standard size drawings showing a plan and elevation of the proposed design. Indicate the best estimate of sizes of major components from the preliminary analysis. Depict a typical cross section of the structure.

- Submit TS&L for review.

14.3.2.3 Detailed Analysis

- Geometry of Structure

  Using the TS&L, define the location, orientation and detailed geometry of all components to be included in the structural analysis. In accordance with engineering judgement, define the points of fixity of the connections.

- Load Combinations

  Arrange the basic design load components into loading combinations included in the analysis. All load combinations for traffic bridges are identified in the AASHTO specifications.

- Static Structural Analysis

  Perform static structural analysis using applicable procedures. Applicable structural analysis tools include the following:

  - Standard manual techniques such as the moment distribution method.
  - Computer analysis programs such as ANSYS, STRUDL or equivalent.
  - Continuous Beam Analysis

    For beam element analysis, programs will be used to solve for the moments and shears due to AASHTO and overload vehicles. Influence diagrams will be plotted to visually aid the checking of wheel placement.

  - Column Analysis

    For reinforced concrete column design, programs will be used to determine the interaction diagrams for moment and axial load using the applicable ACI strength design methodology. Biaxial column loadings can also be analyzed. The program will be used in the design mode to produce an economical reinforcement schedule.

    For steel column analysis, manual analyses will be performed in accordance with AISC and AASHTO specifications.

    Programs to perform an analysis or design a column will be used when complex biaxial bending situations and/or unusual structural geometry are required.

  - Special purpose programs

    As site-specific conditions arise, special purpose programs may be used to aid analysis.

- Seismic Structural Analysis

  All permanent structures will be analyzed for seismic loading. The earthquake hazard is designated the DOE and is the normal code level earthquake in accordance with AASHTO Division I-A.

- Component Design

  Scan the results of the various load groups analyzed for each component to find the load group that controls. Isolate the member by a free body diagram to find details of the stress distribution within the member. Perform detailed design of the member. Using the forces at the ends of the member, perform detailed design of the connection.

- Reanalyze

Using the refined design, reanalyze the controlling load cases with the new member design to check sufficiency. This cycle will continue until all criteria are satisfied.

- Riprap and Bank Protection

  Riprap and bank protection will be in accordance with Section 16.

- Arctic Considerations

  Special consideration will be given to structural design in arctic conditions. All steel specifications will be reviewed for low temperature application. Special treating techniques, fracture toughness, or ductility requirements will be specified as needed. A limiting value of $^1/_3$ breaking strength will be used for cable design. Thermal devices will be specified to stabilize subsurface units on frozen soils where necessary. No supporting resistance will be utilized from the active layer.

- Environmental Considerations

  Design features to protect fish and wildlife will be incorporated where applicable. These features will minimize the constriction of flow and the increase of stream velocity.

- Final Design Drawings

  Design drawings are prepared on standard sheets. The drawings will include all information needed to fabricate and erect the components.

- Final design review

14.3.2.4 Material Sampling and Testing

Material sampling and testing procedures will be in accordance with the ASTM designation for the material depicted on the design drawings. Relevant specifications are noted in Section 14.2.1.

Charpy V-Notch Impact requirements will follow the testing required for AASHTO Temperature Zone Designation Three (–31°F to –60°F). Further special testing required for fracture toughness requirements will depend on the site-specific ambient conditions.

14.3.2.5 Construction

- Orientation

  Review criteria, scope of program, schedules and logistics.

- Cold Weather Concreting

  ACI 318, ACI Report 306R, Cold Weather Concreting, and AASHTO Division II.

- Consult on Field Construction

  As unanticipated field conditions are encountered, check design to ensure that design criteria are not exceeded. Alter design if required.

Table 14-1 Pipeline Bridge – Allowable Stresses For Load Combinations (Applies to Structural Elements only. See Section 20 for Pipe Design Stresses)

Percentage of Code Allowable Stress	Application	Loading Combinations (to be refined on a site specific basis)
100	Any credible combination of the basic design load components which can be expected to be sustained over long periods during normal operations.	1. Dead load + pressure in pipe + temperature increase in pipe from installation to maximum operating pipe temperature. 2. Dead load + pressure in pipe + ice and snow load on pipe + temperature decrease in pipe from installation to minimum operating pipe temperature.
125	Any credible combination of the basic design load components which will be maintained during short operational periods or over long periods during shutdown or pre-startup conditions.	1. Dead load + pressure in pipe + ice and snow buildup + temperature decrease in pipe from installation to minimum operating pipe temperature + temperature decrease in structure from installation to minimum ambient temperature. 2. Dead load + pressure in pipe + temperature increase in pipe from installation to maximum operating pipe temperature + increase in structure from installation to maximum ambient temperature. 3. Dead load + temperature decrease in pipe and structure from installation to ambient temperature. 4. Dead load + temperature increase in pipe and structure from installation to ambient temperature. 5. Dead load + hydrostatic test conditions.

Percentage of Code Allowable Stress	Application	Loading Combinations (to be refined on a site specific basis)
133	Any load combination which includes the design wind or design operating earth- quake (DOE) as a basic design load component. Any load combination which includes the design wind or design operating earth- quake (DOE) as a basic design load component.	1. Dead load + pressure in pipe + ice and snow buildup + temperature decrease in pipe from installation to minimum operating pipe temperature + temperature decrease in structure from installation to minimum ambient temperature + wind. 2. Dead load + pressure in pipe + temperature increase in pipe from installation to maximum operating pipe temperature + increase in structure from installation to maximum ambient temperature + wind. 3. Dead load + pressure in pipe + temperature increase or decrease in pipe from installation to operating pipe temperature + earthquake analysis using design operating seismic values.
150	Any load combination which includes the design contingency earthquake (DCE) as a basic design load component. Only for this case, the stress must be limited to ultimate capacity or 150 allowable, whichever is lower.	1. Dead load + pressure in pipe + temperature increase or decrease in pipe from installation to operating pipe temperature + earthquake analysis using design contingency seismic values. 2. Erection loads.
150	Any load combination which includes the design contingency earthquake (DCE) as a basic design load component. Only for this case the stress must be limited to yield or ultimate capacity (load factor = 1.00)	1. Dead load + pressure in pipe + temperature difference from tie-in to pipe + earthquake analysis using design contingency seismic values 2. Erection Loads

Notes:

1. For those load combinations including temperature decrease of the structure, include ice and snow load (86 lb./ft.) on the pipe and a 2-inch ice growth on exposed structural members.
2. For those load combinations including wind and a temperature decrease in the structure, a 2-inch ice growth on exposed structural members will be added as projected area of wind loading.