Section 15 - Integral Abutment Jointless Bridges

15.1 Characteristics of Integral Bridges

Integral abutment jointless type bridge structures are single or multiple span continuous bridge structures that have their superstructure cast integrally with their substructure. Due to the elimination of deck joints, construction and maintenance cost are lowered and fewer foundation piles are required. Also, research has indicated that this type bridge structure will perform better than a conventional bridge structure in a seismic event.

For these reasons, Designers should consider an Integral Abutment Jointless Bridge as the preferred choice when planning for a bridge replacement or new bridge design.

Integral abutment jointless bridges accommodate superstructure movements without conventional expansion joints. With the superstructure rigidly connected to the substructure and with flexible substructure piling, the superstructure is permitted to expand and contract. Relief slabs, connected to the abutment and deck slab with reinforcement, move with the superstructure. At its junction to the approach pavement, the relief slab may be supported by a sleeper slab. If a sleeper slab is not utilized, the superstructure movement is accommodated using flexible pavement joints.

The integral abutment jointless bridge concept is based on the theory that due to the flexibility of the piling, thermal stresses are transferred to the substructure by way of a rigid connection between the superstructure and substructure. The concrete abutment contains sufficient bulk to be considered a rigid mass. A positive connection with the ends of the beams or girders is provided by rigidly connecting the beams or girders and by encasing them in reinforced concrete. This provides for full transfer of temperature variation and live load rotational displacement to the abutment piling.

The connection between the abutments and the superstructure shall be assumed to be pinned for the superstructure's design and analysis. The superstructure design shall include a check for the adverse effects of fixity.

15.2 Criteria For Integral Abutment Bridge Design

The movement associated with integral abutment jointless bridge design can be largely associated with thermal expansion and contraction of the superstructure. By definition, the length of an integral abutment jointless structure shall be equal to the abutment center line of bearing to abutment center line of bearing dimension. This also applies to continuous span structure lengths with expansion bearings at the piers. This length of expansion mobilizes the horizontal passive soil pressure.

Where rock or glacial till is within a distance to the surface that would stipulate the use of piles with an effective length that is less than 15 feet in length, the suitability of the site shall be carefully studied for integral abutment jointless bridge construction. This is based on the understanding that piles with an effective length less than 15 feet may not permit the flexibility that is required to withstand the expected superstructure movement. The Designer shall assure that the effective length of piles is adequate.

Also, soil strata should be studied to access any potential of soil instability. If existing soils have any potential of instability, the Geotechnical Engineering Unit should be consulted for concurrence before proceeding with development of the Integral Abutment concept.

15.2.1 Relief Slab

1. Relief slabs will always be required for integral abutment jointless bridge structures. Their lengths shall vary from a minimum of 10 feet to a maximum that is based on the intercept of a 1 V to 1.5 H line from the bottom of the abutment excavation to the top of the highway pavement. This length is to be measured along the centerline of roadway. Standard Drawing 2.5-5 within this Manual provides details for Relief Slab construction.

   The relief slab detailing provided on Standard Drawing 2.5-5 is to be followed as the basis for its design. Of primary importance is the requirement that the relief slab shall include two complete layers of reinforcement.

2. The end of the relief slab shall be parallel to the skew. A width from face of rail to face of rail shall be provided. Special provisions shall be made to allow free movement of the relief slabs if curbs, barriers or sidewalks are present. Relief slabs shall always be a separate pour from the superstructure slab. However, they shall be joined together. The location of drainage structures in relief slabs is not permitted.
3. Where warranted, as per the Expansion Provisions stated below, to prevent the relief slab from moving excessively, it should rest on a keyed sleeper slab. The excavation for the sleeper slab shall be made after the compacted abutment backfill is placed. The sleeper slab shall be founded on undisturbed compacted material. No loose backfill may be used.
4. The relief slab shall be cast on two (2) layers of four (4) mil thick polyethylene sheets. It shall be designed as a structural slab that is supported at each end. Two layers of reinforcement shall be accounted for in the design and construction of the relief slab.
5. The provision of relief slabs for integral abutment jointless bridge construction will make the use of traditional approach slabs not necessary.

15.2.2 Expansion Provisions

1. For bridge lengths 150 feet or less, provision for expansion at the relief slab ends may be waived if it is determined by the Designer that allowance for expansion at the relief slab end is not warranted.
2. For bridge lengths over 150 feet and up to 300 feet, provisions shall be made for expansion at the end of each relief slab by installation of a sleeper slab.
3. For bridge lengths over 300 feet and up to 450 feet, integral designs shall be approved by the Manager, Bureau of Structural Engineering, on an individual basis. Provision for expansion shall be made at the end of each relief slab by installation of a sleeper slab.
4. For bridge lengths over 450 feet, integral abutments should not be considered.
5. When planning the deck slab construction, the concrete placement must be planned to be a monolithic pour. No joints other than sawcut control joints or construction joints are to be considered for the planned pour.

15.3 Design Procedure Guidelines

The following criteria shall be utilized in providing integral abutment jointless bridge designs:

15.3.1 Hydraulics

Integral abutment jointless bridge structures provide fixity between the superstructure and substructure and provide greater protection against translation and uplift than conventional bridges. The NJDOT Bridge Scour Evaluation Program and Structure Inventory and Appraisal Inventory records shall be studied to verify scour potential at a project site. To address potential impact of a scour effect on proposed Integral abutment bridge sites, the following areas should be reviewed and analyzed where scour potential exists:

1. Stream Velocity

   Any history of erosion or scour at the bridge site should be reviewed and a determination made if the new structure will alleviate any problems (alignment, restricted opening etc.) that may contribute to scour. Where a scour history is determined, the potential positive effects of an Integral abutment jointless bridge should be noted. Scour information may be obtained by researching the NJDOT Bridge Scour Evaluation Program and Structural Inventory and Appraisal coding records referred to above.

2. Bank Protection

   Suitable slope protection construction, to provide protection against scour, should be provided. On all integral abutment jointless bridges, geotextile bedding shall be used against the front face of the abutment, under the slope protection and down the slope a minimum of 6 feet.

15.3.2 Skew Angle/Curved Girders

The maximum skew angle for integral abutment jointless bridge designs shall be thirty (30) degrees. Skew angles greater than this shall preclude the use of integral abutment jointless bridge designs.

Superstructure configurations that require the use of horizontally curved girder schemes shall also preclude the use of integral abutment jointless bridge designs.

15.3.3 Foundation Types

1. The abutment and pile design shall assume that the girders transfer to the piles all moments and vertical and horizontal forces that are produced by the superimposed dead load, live load plus impact, earth pressure, temperature, shrinkage, creep and seismic loads. The transfer of these forces shall be considered to be achieved after the rigid connection to the abutments is made. The rigid connection shall be detailed to resist all applied loads.

   Use of pile supported reinforced concrete abutments are required. Alternate or proprietary type abutments are not permitted for Integral abutment designs.

   All abutment substructure units shall be supported on a single row of piles. Due to the nature of the integral abutment jointless bridge design, flexibility in the vicinity of the pile to pile cap connection is important to help reduce the buildup of stresses which would normally be relieved through the use of expansion bearings and joints. Therefore, pile type selection shall be based on providing this increased flexibility and in accounting for the thermal movement of the superstructure.

Cast-in-place (C.I.P.), hollow steel pipe piles, prestressed concrete piles or steel H piles may be used for structures with span lengths of 150 feet or less.

In the use of hollow steel pipe piles, the thickness of the pipe shall be considerate of loss of its thickness due to corrosion that may occur over the life span of the bridge structure. If deemed necessary, additional corrosion protection, such as application of a coal tar epoxy coating or galvanizing of the pipe may be stipulated. Section loss due to corrosion also applies to H piles.

Only steel H piles should be used for structures with span lengths over 150 feet. When steel H piles are used, the web of the piles shall be perpendicular to the centerline of the beams regardless of the skew. This will facilitate the bending about the weak axis of the pile.

To facilitate expansion, for bridge span lengths of 100 feet or more, each pile at each substructure unit shall be inserted into a pre-bored hole. The pre-bored hole shall extend a distance of 8 feet below the bottom of the planned finished ground line elevation. Steel casings may be used to shore up the augered hole. All details and notes required by the Foundation Design Report shall be placed on the plans. For bridge lengths under 100 feet, pre-boring is not required.

The diameter of the augered hole shall be twice the size of the pile. After insertion of the pile, the hole or casing shall be filled with cushion or uncompacted sand. The cushion or uncompacted sand shall conform, according to the provisions of the NJDOT Standard Specifications, to designation I-8 sand.

The cost of pre-boring the holes, use of any casings and cushion sand shall be included in the Unit Price Bid of the pile item.

4. To provide adequate penetration, all piles shall then be driven to a minimum depth that accounts for a stilt type effect, provision for loss of lateral support caused by scoured material, lateral loading and provision for sufficient lateral support.

5. The Designer must determine the practical point at which the embedded pile is determined to be fixed. The following steps may be followed to perform such an analysis:

   Calculate the thermal movement demand. For a bridge structure with equal intermediate bent stiffness, the movement demand will be equal. The atmospheric temperature range, coefficient of expansion and the structure's length should be considered.

   The plastic moment capacity of the embedded length of the pile (embedded in the concrete cap) must be calculated. As stated earlier, the pile shall be oriented for bending about the weak axis.

   The column capacity must then be calculated.

   The adequacy of the backwall to resist passive pressure due to expansion must be calculated.

6. When CIP or hollow steel pipe piles are used, pipe casings conforming to ASTM A252, Grade 2 minimum with a minimum wall thickness of ¼ inches shall be used. This shall be noted on the plans. Higher grades may be used if it is

determined that a higher grade meets the design parameters that have been considered in the pile selection.

7. A pile bent configuration should be used for the integral abutment substructure detailing. One pile per girder shall be used. Intermediate piles, as required, may be provided.
8. Pile selection shall be based upon the recommendations that are contained in the Geotechnical Report. The axial loads shall be based upon the reactions from the superstructure design. This shall include the superstructure dead load, live load plus impact and the substructure dead load.
9. As stated earlier, live load impact shall be included in the design of piles. The total length for single span bridges and the end span length for multiple span length bridges should be considered.
10. Steel H-piles may be socketed into a rock strata by means of drilling or boring. After drilling, the piles shall be driven to refusal. This method is permitted with the condition that the remaining effective length of pile is sufficient to permit the required bridge structure flexibility.
11. A pinned connection of the superstructure and abutments shall be assumed for the superstructure design and analysis. The superstructure design should include a check for the adverse effects of fixity.
12. Provision of pile splices shall not be planned. However, if required during construction, splices will not be permitted in the top and bottom 10 feet length of the pile.
13. Following is a flowchart that provides a simple procedure for determining the selection of a steel H-pile section.

Design Procedure for Integral Abutment Steel H-Pile Size Selection

Step 1. Superstructure

The bridge is assumed to act simply-supported.

Step 2. Design the abutment piles for vertical loads

2.1 Choose the pile that can carry the applied vertical loads

- Choose pile cross section
- Allow 1/16” corrosion around the pile perimeter.
- Calculate the allowable pile stress for the corroded section.
- Check the axial load capacity: If the total pile design load is more than the allowable force on the pile corroded section. Redesign

Step 3. Design the piles for horizontal loading

3.1 Calculate the total thermal movement demand at the abutment

3.2 Calculate the plastic moment capacity of the section of the pile, Mp

3.3 Check the ability of the surrounding concrete to develop the plastic moment capacity within the embedded length of pile penetrating the abutment.

3.4 Calculate the displaced shape and the bending moment diagram of horizontally loaded pile embedded in soil (using LPILE)

- The boundary condition needed to model the pile-abutment system is fixed head + displacement. Using LPILE start modeling using fixed head condition (slope at the pile head = 0) and apply the lateral load that is needed to achieve the horizontal displacement.
- If M TOP (moment at the top of pile) is less than the plastic moment M p then reduce the pile section or the steel grade. Redesign
- If M TOP is approximately equal to the plastic moment then remodel the system as a free head with an applied M p at the top.

3.5 Check the unbraced length section of the pile as a beam column

- Determine the applicable group load cases on the unbraced length (Lc) of the pile (unbraced = length of pile between zero moments)Calculate the pile capacities and develop an interaction diagram for an umbraced length
- Superimpose the group loading on the interaction diagram
  - If the group loading is under the interaction diagram, OK
  - If not Redesign (increase pile cross section or the grade of steel)

15.3.4 Superstructure

1. Adjacent precast prestressed box beams, spread precast prestressed box beams, precast prestressed concrete girders and structural steel beams may be used for integral abutment jointless bridge configurations.

   When precast prestressed box beams are to be used, thermal movement stresses shall be judged to be critical when the beams act by pulling an abutment with a relief slab. Mild reinforcement shall be added to the ends of the precast prestressed box beams to resist such stresses.

2. Standard Drawings 2.5-1 and 2.5-2 provide detailing for rigidly connecting structural steel type superstructures to the abutments.

   As detailed in Standard Drawing 2.5-3, prestressed concrete girders may be connected by doweling them to the abutments. Inserts for the dowels should be planned as part of the fabrication process.

   Slotted holes should be used when doweling of prestressed concrete members to the abutments is planned. Placement of prestressed concrete members on plain elastomeric pads should be detailed.

3. As detailed in Standard Drawing 2.5-2, steel girders may also be placed on plain elastomeric pads. Anchor bolts, if used, should pass through both the pad and the bottom flange of the girder. Another method is to use a longer bolt so that nuts may be placed above and below the bottom flange. The grade of the girder may be better controlled this way. Slotted holes should be used to allow better flexibility in aligning the girder.

   Weathering steel, subject to the guidance provided in Subsection 24.19 of this Manual, may be used.

   According to the NJDOT Standard Specifications, when weathering steel is used in Integral Abutment construction, the ends of the girders shall be painted for a distance that extends to one foot beyond the concrete diaphragm. To facilitate the shop fabrication of the girders, a length, to meet this requirement, shall be provided on the Plans.

15.3.5 Abutments

1. In integral abutment jointless bridges, the ends of the superstructure beams are fixed to the integral abutments. Expansion joints are thus eliminated at these supports. When the expansion joints are eliminated, forces that are induced by resistance to thermal movements must be proportioned among all substructure units. This must be considered in the design of integral abutments.
2. The integral abutment jointless bridge concept is based on the theory that, due to the flexibility of piles, thermal stresses are transferred to the substructure by way of a rigid connection. The concrete abutment contains sufficient bulk to be considered a rigid mass. To facilitate the stress transfer, abutments shall be placed parallel to each other and ideally be of equal height.
3. The connection between the girder ends and the abutment shall provide for full transfer of temperature variation and for live load rotational displacement to the abutment piling.
4. To support the integral abutment jointless bridge, a single row of piles shall be used. The piles are driven vertically and none are battered. This arrangement of piles permits the abutment to move in a longitudinal direction under temperature effects.
5. If construction of a Mechanically Stabilized Earth (MSE) wall system is planned and the location of the wall system will be in front of the abutment, abutment piles shall be placed in plastic sleeves while the MSE wall is constructed. After the MSE wall is constructed, the piles, as required, shall be driven to refusal or to a minimum tip elevation. The pile sleeves shall then be filled with un-compacted sand.

15.3.6 Piers

1. Piers for integral abutment jointless bridges have similar design requirements and share common design procedures with the piers of a more traditional bridge. The primary distinguishing features of the piers for an integral abutment bridge involve their ability to accommodate potentially large superstructure movements and the sharing of lateral and longitudinal forces among the substructure units.
2. As with integral abutments, the piers must also be designed to accommodate the movements of the superstructure. Thermal movements are usually the major concern, although superstructure movements, due to concrete creep and drying shrinkage, will also be present to some degree.
3. As part of the overall structural system, integral abutment jointless bridge piers will typically be required to carry a portion of externally applied longitudinal and transverse loads. In addition, thermal movements of the superstructure will induce forces as the piers attempt to restrain those movements.
4. As the superstructure expands and contracts with seasonal temperature changes, and to a lesser extent, creep and shrinkage, the tops of the piers will be forced to undergo displacements relative to their bases. These displacements will produce curvatures in columns that can be closely estimated based on the magnitude of the movements, the fixity conditions at the top and bottom of the columns and the height of columns.
5. Once curvatures are estimated, an effective column stiffness must be considered to compute internal moments and shears. A set of equivalent external forces, in equilibrium with the computed internal moments and shears, must be computed.

This set of equivalent forces is used in subsequent analysis to represent the effects of superstructure movements on the piers.

6. Forces induced by the distribution of the superstructure movements must be computed. Also, the distribution of externally applied loads to the substructure units must be estimated.
7. Similar to the design of a traditional pier, piers of integral abutment jointless bridges are designed for load combinations. Often, load combinations involving temperature, creep and shrinkage, as opposed to combinations containing external loads only, control the design. A pier must be capable of undergoing the imposed superstructure movements while simultaneously resisting external forces.
8. A bearing at a pier of an integral abutment jointless bridge structure should only be fixed when the amount of expected expansion from the bearing to both abutments or adjoining pier is equal. All other cases should use expansion bearings.
9. The following guidance shall be followed in determining the type of pier selection in integral abutment jointless bridge designs:
   a. Continuity at Piers.
      1.) The concrete deck slab must be physically continuous, with joints limited to sawcut control joints or construction joints. Distinction must be made between slab continuity and girder continuity at the piers.
      2.) If, in accommodating the load transfer, girder continuity is deemed appropriate by the design, the superstructure shall be assumed continuous for live loads and superimposed dead loads only. Girders shall be erected as simple spans and made continuous by the addition of mild steel in the deck slab.
      3.) Longer span integral jointless bridges; i.e., those with spans over 100 feet shall be detailed to provide a deck slab placement sequence if girder continuity is to be provided.

         Where applicable, casting of concrete diaphragms over the piers should be done concurrently with placement of the slab.
      4.) When slab-only continuity is provided over the piers, girders are to be designed as simply supported for all loads.
   b. Types of Piers.

      To design piers to accommodate potentially large superstructure movements, the following options are available:
      1.) Flexible piers, rigidly connected to the superstructure;
      2.) Isolated rigid piers, connected to the superstructure by means of flexible bearings;
      3.) Semi-rigid piers, connected to the superstructure with dowels and neoprene bearing pads;
      4.) Hinged-base piers, connected to the superstructure with dowels and neoprene bearing pads.

c. Flexible Piers.

1.) A single row of piles, with a concrete cap that may be rigidly attached to the superstructure, provides a typical example of a flexible pier. This type of pier is assumed to provide vertical support only. The moments induced in the piles due to superstructure rotation or translation are small and may be ignored.

2.) A bridge constructed with flexible piers relies entirely on the integral abutments for lateral stability and for resisting lateral forces. Passive pressures behind the backwalls, friction, and passive pressures on the abutment piles should be mobilized to resist lateral and longitudinal forces.

3.) With this type of pier use, temporary lateral bracing may be required to provide stability during construction. Designers must consider a means to account for passive soil pressures in the vicinity of the backwalls.

d. Isolated Rigid Piers.

1.) Rigid piers are defined as piers whose base is considered fixed against rotation and translation, either by large footings bearing on soil or rock, or by pile groups designed to resist moment. The connection to the superstructure is usually detailed in a way that allows free longitudinal movement of the superstructure, but restrains transverse movements. This type of detailing permits the superstructure to undergo thermal movements freely, yet allows the pier to participate in carrying transverse forces.

2.) With this class of pier, the superstructure is supported on relatively tall shimmed neoprene bearing pads. A shear block, isolated from the pier diaphragm with a compressible material such as cork, is cast on the top of the pier cap to guide the movement longitudinally, while restraining transverse movements.

3.) This type pier represents the traditional solution taken with steel girder bridges at so called expansion piers. It offers the advantage of eliminating the stresses associated with superstructure thermal movements. It also provides piers that require no temporary shoring for stability during construction.

4.) In utilizing this system, additional consideration must be given to the detailing associated with the taller bearing pads and the detailing associated with the shear key. In addition, because the pier and the superstructure are isolated longitudinally, the designer must ensure that the bearing seats are wide enough to accommodate seismic movements.

e. Semi-Rigid Piers.

1.) These piers are similar to rigid piers. Their bases are considered fixed by either large spread footings or pile groups; however, the connection of the piers to the superstructure differs significantly.

2.) In utilizing prestressed concrete girders that bear on elastomeric pads, a diaphragm is placed between the ends of the girders. Dowels, perhaps combined with a shear key between girders, connect the diaphragm to the pier cap. Compressible materials are frequently introduced along the edges of the diaphragm, and, along with the elastomeric bearing pads, allow the girders to rotate freely under live load.

3.) The dowels force the pier to move with the superstructure as it undergoes thermal expansion and contraction and, to a lesser extent, creep and shrinkage. Accommodation of these movements requires careful analysis during the design of the piers. Normally, the stiffness of the piers is assumed to be reduced due to cracking and creep.

4.) There are several advantages to this type of pier: detailing is simplified, use of thin elastomeric pads are relatively inexpensive, temporary shoring is not required during construction, all piers participate in resisting seismic forces and the girders are positively attached to the piers. In addition, with many piers active in resisting longitudinal and transverse forces, the designer need not rely on passive soil pressures at the integral abutments to resist lateral forces.

5.) Design of semi-rigid piers is slightly more complicated because careful assessment of foundation conditions, pier stiffnesses and estimated movements is required. In some situations semi-rigid piers are inappropriate. For example, short piers bearing on solid rock may not have adequate flexibility to accommodate movements without distress.

f. Hinged-Base Piers.

1.) This type of pier may be used to avoid the need for an expansion pier in a situation where semi-rigid piers have inadequate flexibility. A "hinge" is cast into the top of the footing to permit flexibility of the column.

2.) Temporary construction shoring may be required, and additional detailing requirements at the top of the footing may increase cost; however, the designer should keep this alternate in mind under special circumstances where the other pier types are not feasible.

15.3.7 Wingwall Configuration

1. In-Line or wingwalls that are parallel to the abutment in excess of 12 feet should be supported on their own foundation independent of the integral abutment system. In this case, a flexible joint must be provided between the wingwall stem and the abutment backwall.

2. Flared walls cantilevered off of the abutments may be considered by the Designer on a case by case basis. The use of flared wingwalls should generally only be considered at stream crossings where the alignment and velocity of the stream would make in-line walls vulnerable to scour. Piles shall not be placed under any flared walls that are integral with the abutment stem.

3. U-walls, integral to the abutment, shall preferably not measure more than 10 feet from the rear face of the abutment stem. Refer to Standard Drawing 2.5-4 for conceptual detailing.

   If U-walls greater than 10 feet in length are required, the wingwall foundation should be separated from the abutment foundation. A flexible joint between the abutment backwall and wingwall stem should be provided. This type arrangement will maintain the abutment/pile flexibility so that the thermal movement of the superstructure is permitted.

4. The offset distance between the end of the relief slab and the rear face of the U-wall should preferably be a minimum of 4 feet. If the relief slab must extend to the rear face of the U-wall, they shall be separated by a 2 inch joint filled with Preformed Expansion Joint Filler material.

15.3.8 Horizontal Alignment

Only straight beams will be allowed. Provided that the beams are straight, structures on curved alignments will be permitted.

15.3.9 Grade

The maximum difference in elevations between abutments shall be 5%. This is meant to facilitate an even vertical alignment between abutments.

15.3.10 Stage Construction

Stage Construction is permitted. Special consideration shall be given to the superstructure's rigid connection to the substructure during concrete placement when staging construction. The superstructure should be secured, free from rotation, until all concrete, up to the deck slab, is placed.

15.3.11 Seismic Modeling and Design

If the seismic design category (SDC), displacement demand and type of abutment and backfill warrant the seismic design of the integral abutment, design the abutment according to the following:

1. Modeling

Refer to Section 5.2 of *AASHTO Guide Specifications* for seismic analysis.

   a. The general concept behind modeling the seismic response of a bridge structure is to determine a force-displacement relationship for the total structure that is consistent with the ability of the structure to resist the predicted forces and displacements.

   b Integral abutments shall be modeled to move under seismic loading in both the longitudinal and the transverse directions, thus distributing more transverse forces to the piers.

   Be aware that transverse seismic loads may overstress piles in the strong direction. To account for this, the pile tensile capacity may be increased. Otherwise, the integral wingwalls may be designed to resist transverse seismic loads. This will result in lower lateral seismic loads on a pier.

   c. The bridge structure shall be modeled in three dimensions for a stiffness analysis. A multi-mode analysis may be used. For a single span structure, a two dimensional single mode may be used to analyze the structure.

   d. To analyze integral abutment bridges under seismic loads, the stiffness of the abutments must be evaluated. This stiffness should be taken as the function of the abutment height, soil type, abutment thickness and theoretical movement.

   e. The pier type selection should be considered in the seismic modeling. Isolated rigid or semi-rigid piers can participate in resisting seismic loads in the transverse direction. Shear keys and use of dowels with these type piers should be designed to resist transverse forces using the appropriate R-factor for connections.

For isolated rigid piers, the required bridge seat should be accounted for in the modeling.

f. If necessary, a pinned connection between the superstructure and the abutments should be assumed for the modeling. However, a check for a fixed connection should also be made.

g. The piles supporting the abutments should be modeled using the length of fixity. The length of fixity can be estimated with the L-PILE program, as an example.

2. Design

    a. The abutment walls and piles should be designed for the controlling load case. The abutment walls should be designed by using the proper pressure distribution as determined from a dynamic analysis.

       The abutment wall cross section should be designed for the maximum shear and moments that act on them in both the vertical and horizontal direction. Girders can be assumed to act as monolithic supports in the horizontal direction.

    b. Design of abutment walls, piles, and footings shall be based on *AASHTO Guide Specifications for LRFD Seismic Bridge Design*.

    c. The soil pressure behind the abutments should be checked and compared to maximum stress limits and the girders should be checked for the additional axial stress that is imposed by the seismic loads.

15.3.12 Utilities

Rigid utility conduits, such as gas, water and sewer, are discouraged with integral abutment construction. However, if required, expansion joints in conduits must be provided at each abutment. Sleeves through the abutment should provide at least 2 inches of clearance around the conduit.

Flexible conduits for electrical or telephone utilities that are properly equipped with an expansion sleeve through the integral abutment are acceptable.

15.4 Construction Procedures

The connection scheme of a steel or concrete superstructure governs the procedure that should be followed for the construction of an integral abutment bridge structure. Standard Drawings 2.5-1 and 2.5-2 specify a sequence of steps for integral abutment construction with a steel superstructure and Standard Drawing 2.5-3 specifies a sequence of steps for integral abutment construction with a concrete superstructure.

When constructing a relief slab and sleeper slab, the following procedure should be followed:

1. To permit unhindered longitudinal movement of the relief slab, the surface of the subbase course must be accurately controlled to follow and be parallel to the roadway grade and cross slope.

2. A filter fabric or some type of bond breaker such as polyethylene sheets should be placed on the finished subbase course the full width of the roadway prior to placement of relief slab reinforcement.
3. Pour the relief slab concrete starting at the end away from the abutment, progressing toward the backwall. If it can be so controlled, relief slabs should be poured in early morning so that the superstructure is expanding. Therefore, the slab is not placed in tension.
4. As shown on Standard Drawings 2.5-1 through 2.5-3, a construction joint between the deck slabs and relief slabs should be placed.

Suitable notes should be provided on the plans to incorporate these construction procedures. Other procedural construction methods, as determined by the Designer and as suitable for the selected superstructure type, may be provided.

The following pay items may be used to account for the respective work:

- Concrete in Superstructure, Relief Slab Integral Abutment
- Concrete in Superstructure, Sleeper Slab Integral Abutment

Abutment backwall and diaphragm concrete may be included in the overall deck slab pay item quantity.

15.5 Semi-Integral Abutment Design

A. A semi-integral abutment design structure is one whose superstructure is not rigidly connected to its substructure. It may be a single or multiple span continuous structure whose integral characteristics include the following:

   - jointless deck
   - integral end diaphragms
   - compressible backfill
   - movable bearings

   In this concept, the transfer of displacement due to the piles is minimized. The rotation is generally accomplished by use of a flexible bearing surface at a horizontal interface in the abutment. Horizontal displacements not eliminated in a semi-integral concept must still be considered in the design.

   In a semi-integral abutment concept, the girders extend onto the bridge seat and may be embedded into the backwall concrete. However, the girders are not connected to the abutments.

   In lieu of conventional deck joint bridges, or where a full integral bridge is not desirable, semi-integral bridges may be considered. The foundations for this type structure shall be stable and fixed. A single row of piles should not be utilized. The foundation piles should be stiffened by inclusion of battered piles or, the foundation may be founded on a spread footing.

B. The expansion and contraction movement of the superstructure should be accommodated at the roadway end of a relief slab. The geometry of the relief slab, design of the wingwalls and transition parapet, if any, must be compatible with the freedom required for the integral configuration (beams, deck, backwall and relief slab) to move longitudinally.

C. Refer to Standard Drawing Plate 2.5-6 for conceptual detailing of a Semi-Integral Abutment configuration.

D. Semi-Integral abutments can be designed as conventional abutments with the following exceptions:

   1. The suspended backwall must be designed for full passive soil pressure.
   2. Wingwalls must be independent from the suspended backwall.
   3. Provision for expansion at the ends of the relief slabs must be provided.
   4. The top reinforcement in the deck slab at the end of the span should be designed for the negative moment produced from the reaction of half the relief slab dead load and a live load reaction placed on the suspended backwall. The dead load of the suspended backwall should not be considered because the backwall is constructed in a separate placement before the deck and thus will not contribute to tensile stress in the deck slab.

Note: Refer to Standard Drawing 2.5-6 for detailing nomenclature.

E. Selection Criteria and Details. The following considerations will preclude use of the Semi-Integral abutment concept:

- Maximum skew - 30°
- Maximum expansion length – 200 feet (Distance to nearest Fixed Bearing)
- No restriction on abutment height