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ENGINEERING INSTRUCTION

NEW YORK STATE DEPARTMENT OF TRANSPORTATION

SUBJECT: STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGE DESIGN - SEISMIC CRITERIA

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This Engineering Instruction establishes new seismic design standards for bridges. These seismic design standards have been developed in accordance with the expected level of seismic activity in New York State.

Effective immediately, therefore, the New York State Department of Transportation is adopting the provisions of the AASHTO Guide Specifications for Seismic Design of Highway Bridges (1983) as part of the New York State Standard Specifications for Highway Bridges. These specifications shall be applied to the design of conventional steel or reinforced concrete main members, using the Single-Mode Spectral Analysis Method. A more rigorous analysis using the Multimode Spectral Analysis Method shall be required for seismic design of non-conventional type bridges such as suspension bridges, cable-stayed bridges, arches, trusses and moveable bridges.

DETERMINATION OF SEISMIC SENSITIVITY

The level of expected seismic activity is indicated by the Rock Acceleration Coefficient. Contour maps of Rock Acceleration Coefficients for the United States are shown in both the AASHTO Guide Specifications for Seismic Design of Highway Bridges (1983) and the NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings (1988). Based on these maps, New York State can be divided into regions of Seismic Performance Categories 'A' and 'B' (Figure 1). Seismic Performance Category (SPC) 'A' is assigned to regions with a Rock Acceleration Coefficient less than or equal to 0.09, and SPC 'B' is assigned to regions with a Rock Acceleration Coefficient greater than 0.09 and less than or equal to 0.19.

Bridges in SPC 'A' and 'B' can be divided into two groups: single span and two or more spans. Special requirements have been identified for each group and are shown in Figure 2.

DESIGN OF NEW BRIDGES

To maximize earthquake resistance in new bridges, special detailing standards have been developed for four basic components of the bridge system (superstructure, bearings and joints, substructure, and foundation). These standards improve resistance to seismic loading and help reduce the potential of catastrophic bridge failure during an earthquake (See APPENDIX). Many of these standards are in our current practice, but others are new. For example, for multiple span bridges our current practice of using continuous spans rather than a series of simple spans is consistent with the standards. However, the new standards recommend that skew angle of the supports be minimized to preclude rotation of the superstructure under seismic loading.

In designing new or replacement bridges for seismic loads, the designer shall use the AASHTO Guide Specifications and shall incorporate the seismic resistance standards presented in the APPENDIX. It is estimated that adoption of these standards will increase construction costs of new and replacement bridges by 1 to 3 percent. The method for applying seismic loads computed using the Guide Specifications is presented in Figure 3. A detailed description of this method is in Chapter 4 of the Guide Specifications. The Guide Specifications also recommend that a Single-Mode Spectral Analysis Method be used for SPC 'A' and 'B'.

The seismic design requirements of the AASHTO Guide Specifications will be incorporated into the New York State Standard Specifications for Highway Bridges, through the issuance of "Blue Pages", in the near future. Effective immediately, however, designers shall use a Rock Acceleration Coefficient equal to 0.19 (which is the upper limit of SPC 'B') for both SPC 'A' and 'B'.

REHABILITATION OF EXISTING BRIDGES

Seismic design standards to be used in the rehabilitation design of existing bridges have not yet been formulated. A future Engineering Instruction will address this subject in detail.

Questions concerning this Engineering Instruction should be directed to the Structures Division.

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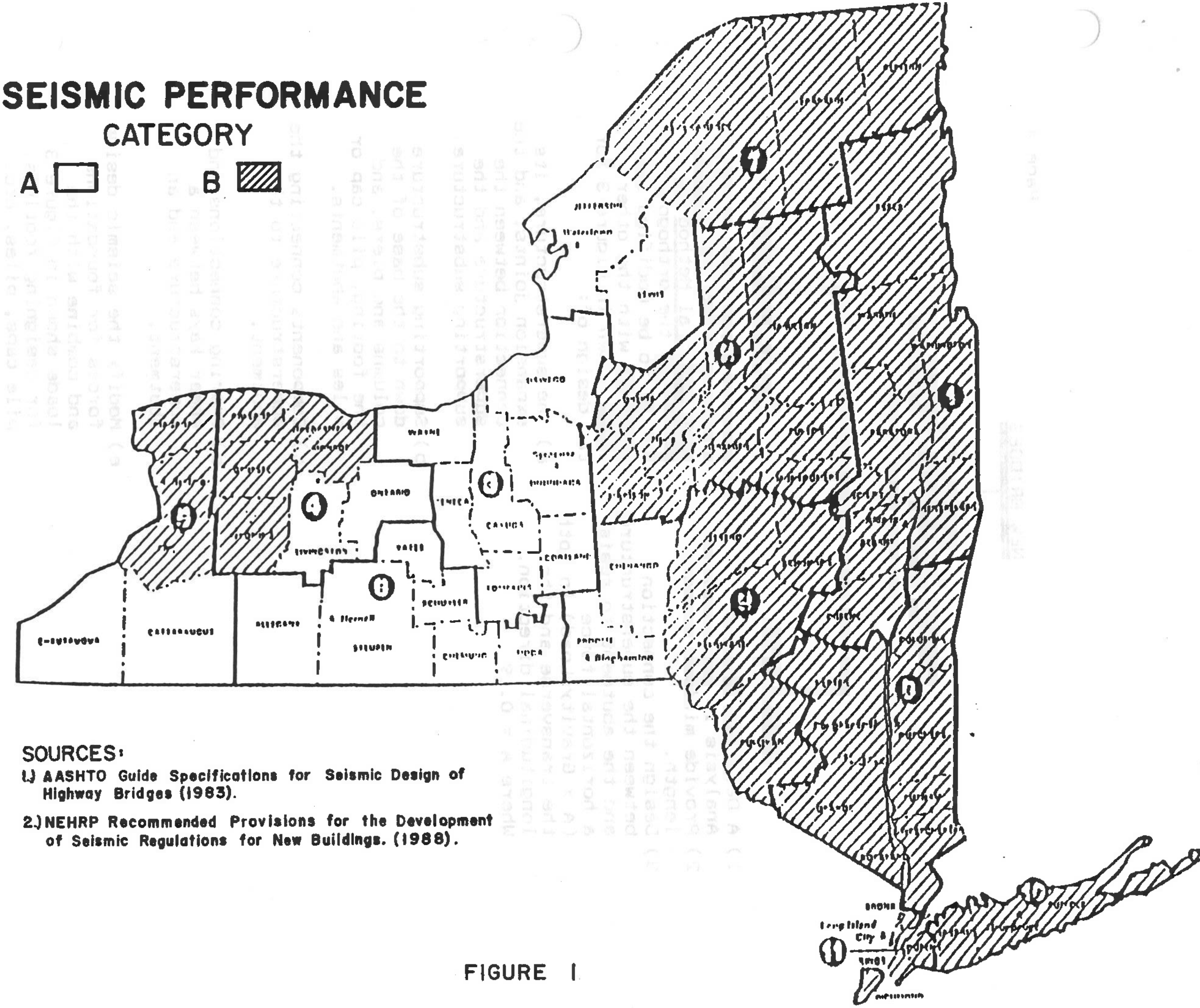
SEISMIC PERFORMANCE

CATEGORY

A ☐ B ▨



SOURCES:

1.) AASHTO Guide Specifications for Seismic Design of Highway Bridges (1983).

2.) NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings. (1988).

FIGURE 1

NEW BRIDGES

Design for
Seismic Performance Category 'B'
To be used for all locations
in New York State

SINGLE SPAN

1) A Detailed Seismic Analysis is Not required.
2) Provide minimum support length.
3) Design the connection between the superstructure and the abutment to resist a horizontal force (A x Gravity Load) in both the transverse and the longitudinal direction. Where A = 0.19

TWO OR MORE SPANS

1) Perform a Detailed Seismic Analysis using the Single-Mode Spectral Method to determine the orthogonal forces to be modified and combined with the other loads shown in Figure 3 for the design of:

   a) The superstructure, its expansion joints, and the connection between the superstructure and the supporting substructure.

   b) Supporting substructure down to the base of the columns and piers, and the footing, pile cap or piles and abutments.

   c) Components connecting the superstructure to the abutment.

   d) Bearing connections and shear keys between a superstructure and an abutment.

   e) Modify the seismic design forces for foundations and combine with the loads shown in Figure 3 for designing footings, pile caps, piles, etc.

FIGURE 2

GROUP LOAD = 1.0 (D + B + SF + E + EQM)

Where

D = Dead Load
B = Buoyancy
SF = Stream-Flow Pressure
E = Earth Pressure
EQM = Modified Elastic Seismic Force for either LOAD CASE 1 or LOAD CASE 2

Where

LOAD CASE 1 = 100% Long. + 30% Trans. (Due to Seismic Loading)
LOAD CASE 2 = 30% Long. + 100% Trans. (Due to Seismic Loading)

LOAD FACTOR DESIGN

The above equation is based on:

$$\gamma = \beta = 1.0$$

SERVICE LOAD DESIGN

With the above equation, the increase in allowable stress shall be:

50% Increase in Allowable Stress for Structural Steel
33% Increase in Allowable Stress for Reinforced Concrete

FIGURE 3

APPENDIX

Seismic Resistance Standards*	Remarks
1. Continuous load carrying main members on a multiple span bridge shall be used rather than a series of simply supported single span structures.	This is the existing practice.
2. Skew angle for bridges shall be minimized as much as possible. Skewed supports encourage rotation of the superstructure about a vertical axis under seismic loads.	
3. All bearings shall be properly connected with the superstructure to resist a horizontal force, in both the transverse and longitudinal directions, equal to 'A' X the sum of the dead load and live load reaction. Where 'A' = 0.19 for new bridges. However, for multiple span bridges this horizontal force shall not be less than the AASHTO Guide Specifications Chapter 4 group loading.	The existing practice is to provide a connection to resist 10% of the sum of the dead load and live load reaction forces.
4. The type of bridge bearings provided shall be either elastomeric pads (plain, or laminated with or without load plates) or Multi-Rotational (pot type or disc type). Steel rocker and steel sliding bearings shall not be used. At the time of bridge rehabilitation, steel rocker or steel sliding bearings shall be replaced with elastomeric bearings with load plates.	Under the existing practice, most (80-85%) of the bearings used are either elastomeric or pot bearings. Steel sliding bearings are completely banned from use on new bridges.
5. All expansion bearings with sliding surfaces (Multi-Rotational pot and disc type) shall be provided with guide bars to allow limited lateral movement.	Almost all the pot and disc type expansion bearings are provided with guide bars to allow limited lateral movement.

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*Selected from AASHTO Guide Specifications for Seismic Design of Highway Bridges (1983) and 1973 California Earthquake Design Criteria For Bridges.

6. Bearing anchorage to substructure:

a. All bearings shall be properly anchored to the substructure to resist a horizontal force, in both the transverse and longitudinal directions, equal to 'A' X the sum of the dead load and live load reaction. Where 'A' = 0.19 for new bridges.

However, for multiple span bridges this horizontal force shall not be less than the AASHTO Guide Specifications Chapter 4 group loading.

The existing practice is to provide a bearing connection to the substructure to resist 10% of the sum of the dead load and live load reaction.

b. All anchor bolts for a bridge bearing's masonry plate shall be provided with a 90° hook (Fig. 5A) at the embedded end.

The existing practice is to provide threaded anchor bolts.

c. A minimum of four anchor bolts shall be provided for connecting a steel masonry plate to the substructure with pot type and disk type bearings. All other types of bearings, including the elastomeric bearings, shall be provided with a minimum of two anchor bolts. Elastomeric bearings used with a concrete superstructure shall be provided with anchor rod.

The existing practice is to provide a minimum of four anchor bolts for a masonry plate used with pot type and disc type bearings. All other types of bearings, including the elastomeric type, are provided with two anchor bolts. Elastomeric bearings used with a concrete superstructure are provided with anchor rod.

7. Bridge bearing seats supporting the ends of girders shall be designed to provide a minimum support length "N" (inches) measured normal to the face of the abutment or pier (Figure 1A). The minimum support length shall also be provided perpendicular to the fascia girders. The support length is as defined below:

$N = 8 + 0.02L + 0.08H$ (inches)
L = length of continuous deck (ft.)
For Abutment:
H = Average height of piers (or columns) supporting the deck (ft.)
H = 0, for single span bridges
For Pier:
H = Pier height (ft.)

The existing practice is to provide for all conventional type bridges a minimum supporting length of 17" controlled by an 8" cover for anchor bolts, and the size of the bearings. A 17" minimum support length satisfies the required criteria for single spans up to 450 ft. Whereas for multispan bridges, at the simple support, a minimum of a 17" support length satisfies the required criteria for a 250 ft. long deck with a maximum height of the pier up to 50 ft. or a 370 ft. long deck with a 20 ft. high pier.

8. Abutments shall be provided with a continuous bridge seat. Stub type abutments with isolated bearing seats shall not be used.

   The existing practice is to use a continuous bridge seat for conventional type of bridges almost all the time.

9. Reinforced Earth abutments may only be used with the prior approval of the Deputy Chief Engineer (Structures).

   The existing practice is to use Reinforced Earth Abutments depending on the site conditions.

10. High concrete columns in a multi-column pier (slenderness > 60 in the direction parallel to the support) shall be provided with reinforced concrete strut(s) near the middle half of the columns' height.

    As per the existing practice, this is not necessary as long as slenderness effects are considered in design.

11. Lap splices in the main vertical reinforcement in the pier columns shall be provided (if necessary) only within the center half of a column's height. Dowels from the footing shall extend at least 1/4 of the column height or 10 ft. Splices in the vertical design reinforcement shall be staggered whenever possible (Figure 3A).

    As per the existing practice, there are no restrictions on the locations of lap splices in the columns.

12. Vertical reinforcement for columns shall be extended into the pier cap for full embedment length (Figure 3A).

    This is the existing practice.

13. The spacing of lateral ties into the interior of pier column(s) shall not exceed the least dimension of the compression member or 12 inches (AASHTO Art. 8.18.2.3). Additional ties shall be provided to make the spacing at 6" centers at the top and bottom of the column over a length equal to the maximum cross-sectional column dimension or one-sixth of the clear height of the column but not less than 18 in. The ties shall be continued for a distance equal to one half the maximum column dimension but not less than 15 in. from the face of the column connection into the adjoining cap beam or the footing (Figure 2A).

    The existing practice is to space ties not to exceed the least dimension of the compression member or 12 inches (AASHTO Art. 8.18.2.3). The ties stop at the face of the column connection to the cap beam or the footing.

14. When a plinth is provided at the base of the column, the design vertical reinforcement for the column shall be extended to dowel the footing. Any additional reinforcement in the plinth, if required, shall be provided.

Revise existing practice to comply with the seismic standards.

15. All stirrups and ties shall be provided with a 135° hook for anchorage.

Revise existing practice to comply with the seismic standards.

16. All footing reinforcement and dowel bars for abutments shall be provided with hooks (180° or 90°). Cantilever type abutments and walls shall be provided with dowels (#5 bars @ 1'-6" ctrs.) on the compression face to connect the footing with the stemwall (Figure 6A).

The existing practice is not to provide any dowels on the compression side of cantilever type abutments and walls.

17. Footing reinforcement for piers:

a. Minimum top reinforcement for an individual footing shall not be less than 50% of the area of the designed bottom reinforcement or #6 bars at 12" centers in the transverse and longitudinal directions.

a. The existing practice is to provide a minimum of #5 bars @ 18"centers (both ways).

b. Minimum top reinforcement for a continuous footing shall not be less than #6 bars at 12" centers in the transverse and longitudinal directions.

c. Top and bottom reinforcement for a pier footing in the transverse and longitudinal directions shall always be provided with hooks (180° or 90°). Footing dowels shall also be provided with hooks (180° or 90°).

c. The existing practice is to provide hooks only to satisfy the development length requirements.

d. Vertical stirrups (⊏), #4 bars at 48" centers (both ways), shall be provided to connect the top and bottom mats for pier and abutment footings (Figure 4A).

d. The existing practice is not to provide any vertical stirrups to connect the top and bottom mats.

18. Front row of piles (steel or CIP) of all abutment and wall footings, as well as the outside rows of piles of all pier footings, shall be battered a minimum of 6 on 1.

This is the existing practice.

19. Deep, loose to medium dense sand sites for spread foundations shall be avoided since liquefication risks are high.

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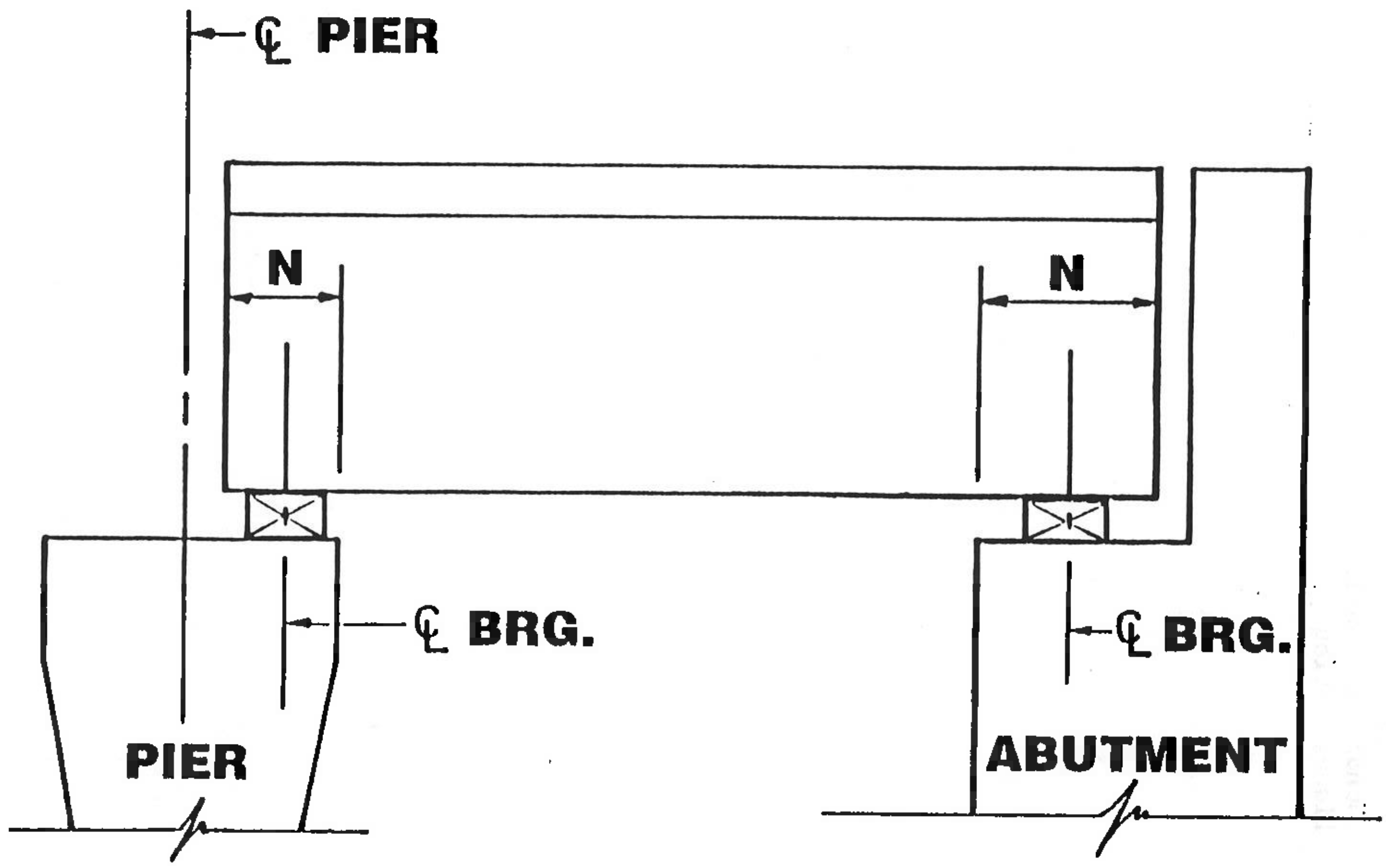
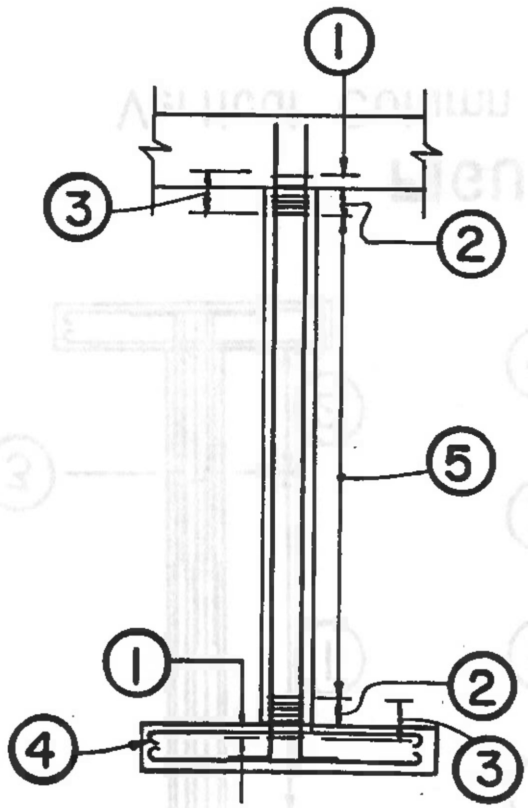


N = [8 + 0.02L + 0.08H] INCHES

	L =	LENGTH OF CONT. DECK (FT.)
FOR ABUTMENT	H =	AVERAGE HEIGHT OF PIERS (FT.)
FOR PIER	H =	PIER HEIGHT (FT.)

FIGURE 1A



(1) 15" or one half the Maximum Column Dimension.

(2) Maximum Column Dimension or one sixth the clear height of the column, but not less than 18".

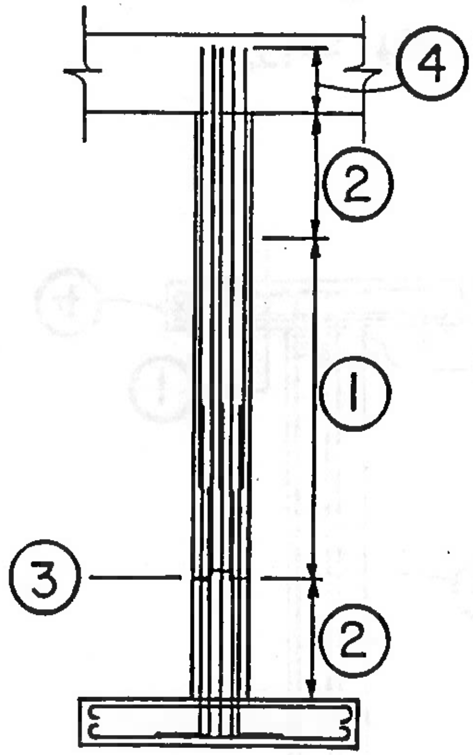
(3) Ties (spirals) spaced at 6" max.

(4) Hooks for all footing bars.

(5) Standard tie (spiral) spacing.

FIGURE 2A

Ties for Rectangular Columns
& Spirals for Round Columns



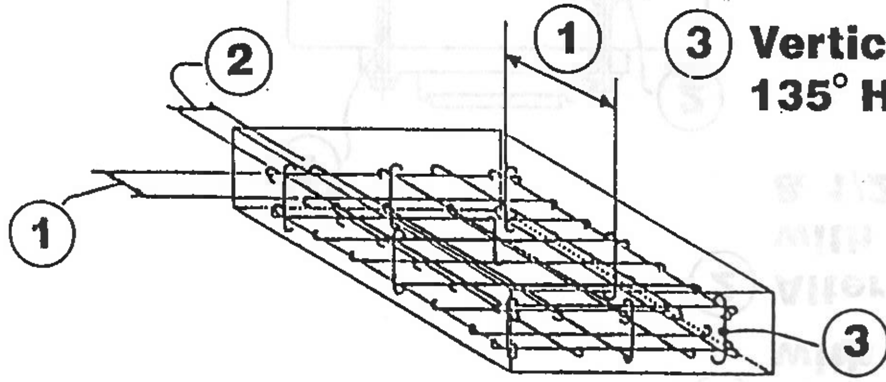
(1) Allowable Splice Area Middle Half

(2) No Splice within 10'-0"

(3) Optional Construction Joint

(4) Full Embedment Length of the Bar

FIGURE 3A
Vertical Column Reinforcement

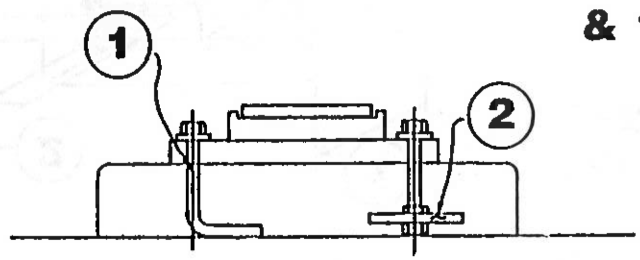


(1) 4'-0" Max. Grid with Vertical Stirrups.

(2) 1'-6" Max. Design Spacing.

(3) Vertical Stirrups with 135° Hook (Typ.).

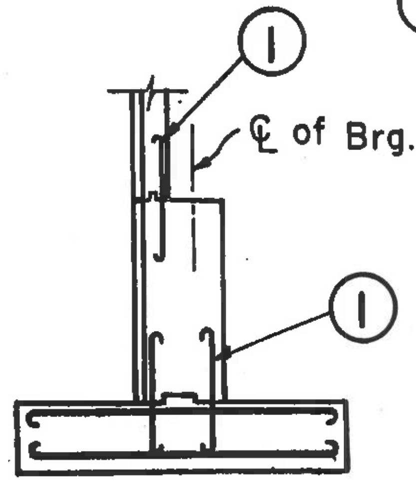
FIGURE 4A
Footing Layout
(Typical for Abut. & Piers)



(1) **Anchor Bolts with 90° Hook**

(2) **Alternate Anchor Bolt with Standard Nut & 1/2" thick 4x4 Plate**

FIGURE 5A
Anchor Bolt Detail



(1) Dowels with hooks on the compression side (#5 bars @ 1'-6" ctrs.). A dowel should have sufficient embedment length to fully develop its strength.

FIGURE 6A

Dowels for Abutments & Walls