SEISMIC DESIGN OF BRIDGES

SECTION 5

DETAILING FOR DUCTILITY AND DUCTILITY CAPABILITY

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5.1 Detailing for Ductility

5.1.1 General

Flexural members, whether or not they carry axial load, should be designed and detailed to meet the minimum requirements of the current New Zealand Codes of Practice.

5.1.2 Solid Concrete Members

Concrete structures should be designed and detailed in accordance with DZ3101 1980 (reference [5.1]). This draft gives provisions for the design and detailing of solid reinforced concrete members that may be subjected to yielding under the action of the design earthquake.

5.1.3 Hollow Reinforced Concrete Section

Where hollow reinforced concrete sections are designed to undergo ductile yielding they shall be designed in accordance with the above draft, DZ3101, but special studies should be performed to establish the appropriate dependable member displacement ductility factor.

5.1.4 Structural Steel

Structural steel members should be designed and detailed to conform to the requirements of NZS 3404[5.2].

5.2 Ductility Capability

5.2.1 Reinforced Concrete

Solid reinforced concrete members designed and detailed in accordance with DZ3101[5.1] may be assumed to have an available minimum member displacement ductility factor of 8.

Where special studies are performed and additional transverse reinforcing is provided member displacement ductility factors greater than 8 may be depended upon.

5.2.2 Prestressed Concrete

Prestressed concrete members should be the object of special study. For design procedures refer to DZ3101[5.1].

5.2.3 Structural Steel

Structural steel members complying with NZS 3404[5.2] may, unless special studies are performed, be assumed to have a minimum member displacement ductility factor of 8.

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COMMENTARY - SECTION 5

C.5.1.3

At the present stage of development it is recommended that studies of hollow, thin walled piers be based on the detailing and design methods developed for shear walls.

C 5.2 Ductility Capability

To establish the minimum seismic horizontal shear force for which bridge structures are to be designed requires assessment of the overall structural displacement ductility factor. This is defined as the ratio of maximum displacement under the design earthquake to the theoretical yield displacement both measured at the centre of mass.

The calculation of the displacement ductility factor for a particular bridge structure is discussed in Section 2. This factor is derived from considerations of the stiffness of the horizontal load resisting structure and from the minimum dependable ductility of those members that form part of the load resisting structure and which are required to undergo yielding during the Design Earthquake.

If the bridge structure is designed on the basis of no yielding under the action of the design earthquake then a member ductility factor of unity will be adopted. In general however it will be advantageous to design for extensive yielding to take place under the design earthquake. The maximum structure displacement ductility factor that may be used in design unless special studies are made is 6.

For solid reinforced concrete members the amount of member ductility that can be relied upon depends primarily upon the type and disposition of reinforcing and the average axial stress in the member.

The provisions of the Draft New Zealand Standard Code of Practice for the Design of Concrete Structures DZ 3101, are the minimum provisions recommended for members which may be subjected to yielding under the design earthquake. Research has indicated that these minimum provisions should lead to dependable member displacement ductility factors in excess of 8.

If special studies are performed, however, and additional transverse reinforcing is provided, increased member displacement ductility factors may be justified.

Research is continuing into dependable member ductility factors[5.3,5.4].

In particular work is continuing on the NZMWD document CDP 810/A[5.5] which, it is intended, will develop a method by which the member displacement ductility factor can be calculated for particular cases involving reinforced concrete sections.

The use of prestressed concrete or structural steel members as the flexural members that are required to undergo inelastic deformations so as to resist the earthquake reduced accelerations is not common in New Zealand.

Provisions for their design are however given in DZ 3101 and NZS 3404. Even greater member ductility factors than 8 should be available for structural steel, however care is essential in detailing so that the possibility of premature buckling or fracture is avoided.

C 5.3 References

5.1 Standards Association of New Zealand, "Draft New Zealand Standard, Code of Practice for the Design of Concrete Structures" : 1980.

5.2 Standards Association of New Zealand, "Code for Design of Steel Structures, (with commentary)" NZS 3404:1977.

5.3 Potangaroa, R.T., "Ductility of Spirally Reinforced Concrete Columns under Seismic Loading", University of Canterbury, Department of Civil Engineering, Report Number 79-8 February 1979.

5.4 Gill, W.D., "Ductility of Rectangular Reinforced Concrete Columns with Axial Load", University of Canterbury, Department of Civil Engineering, Report Number 79-1, February 1979.

5.5 New Zealand Ministry of Works and Development, "Ductility of Bridges with Reinforced Concrete Piers", Civil Division Publication CDP 810/4, April 1975, 109pp.