SEISMIC PERFORMANCE OF SLENDER WALL-TYPE PIER WITH CONCRETE HINGES

Chodai Co. Ltd. Regular Member ○Nazeer Rafeeque Ahmed
Kyoto University Regular Member Prof. Yoshikazu Takahashi
West NEXCO Regular Member Masaki Hahinoki

1. INTRODUCTION

Hinges are used from past 19th century in reinforced concrete bridges piers to reduce base fixity and thereby decreased cost of foundation. There are no specific design guidelines in codes. Therefore concrete hinges details are commonly designed based on purely axial load and shear load capacity offered by the amount of longitudinal hinge reinforcement at hinge. The concrete hinges allow repeated small rotation at pier base and hinge prevents excessive flexural stresses from pier entering into the foundation. In past Earthquakes, bridge structures pier with hinged base were damaged. Since then structural safety of past bridges are of great concern. Therefore Meshin expressway constructed in 1960 is chosen with pin connections in intermediate slender wall type pier base and moment restrained end supports. Objective is to investigate moment transfer mechanism in weak direction during large rotational for as built pier with one way concrete hinge as shown in **Fig.1**. Seven full scale test specimens with slight changes in parameter are fabricated. Five specimens were subjected to reversed cyclic loading test and rest two specimen subjected to monotonic load all specimens tested in weak direction with constant axial force.

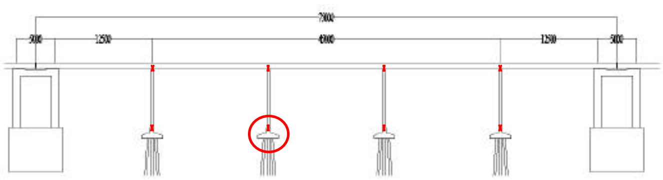

Fig.1 Typical Meshin Expressway bridge

2. EXPERIMENTAL PROGRAM

All the test specimens are categorized based on total cover concrete on both sides of hinge section and loading type. Concrete hinge specimen without cover concrete as bare hinge bar, basic specimen with total 138 mm cover concrete at hinge and conventional specimen with 278 mm cover respectively. Bare hinge reinforcement at center without concrete cover for 20 mm height connecting end blocks, basic specimen is as built bridge pier and conventional RC pier without reduced throat portion subjected to monotonic load. Basic and bare test specimen structural details are as shown in **Fig.2**. Two specimens of each type fabricated one with deformed bar and other with plain bar. Additional basic specimen with deformed hinge bar and rubber protection surrounding throat is constructed.

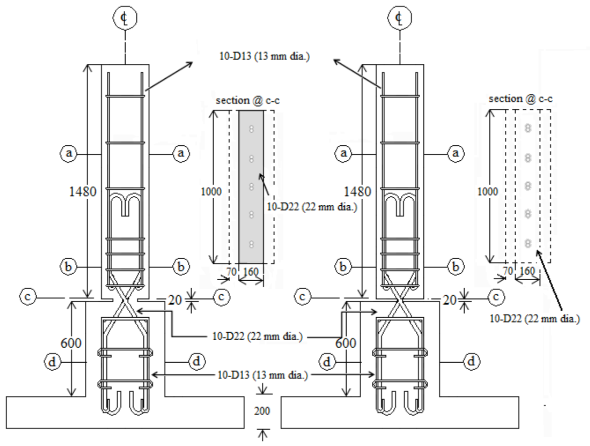

Fig.2 Basic and bare hinge specimen

3. TEST RESULTS

Fig.3 shows the pure hinge behavior with and without second order effect. **Fig.4** shows rotational stiffness degradation response of basic target test specimen representing actual bridge pier details. **Fig.5** shows rotational stiffness difference for basic specimen hinge section gap with rubber and without rubber effect at hinge throat during small and large rotation. **Fig.6** shows conventional reinforced concrete pier with Mesnager hinge reinforcement details response under monotonic loading.

Photo 1 shows the final failure mode for basic specimen with plain hinge reinforcement due splitting tensile cracks above throat. **Photo 2** shows for deformed bar basic test specimen. In conventional pier severe brittle flexural failure occurred at weakest section under small rotation is as shown in **photo 3**.

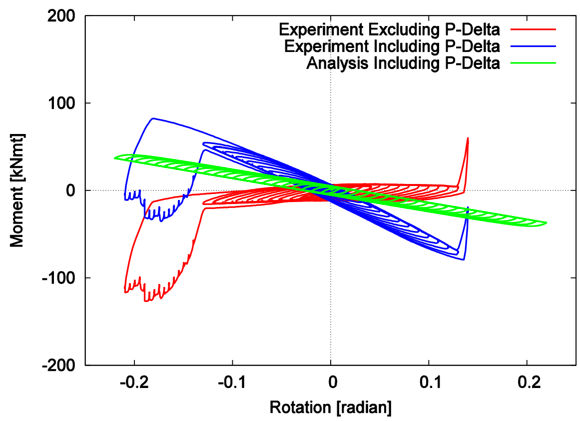

Fig.3 Moment Rotation for bare hinge specimen

Keywords: Bridge-piers, Reinforced Concrete Hinges, lateral loads (earthquake loads)
Contact address: Tokyo Nissan Taito Bldg, 2-6-6, Moto-Asakusa, Taito-ku, Tokyo, 111-0041, Japan, Tel:03-68605974

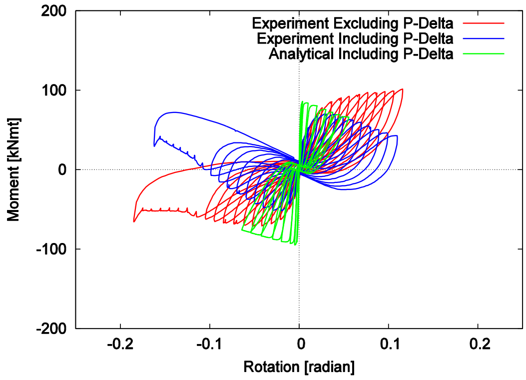

Fig.4 Moment Rotation for basic target specimen with plain bar

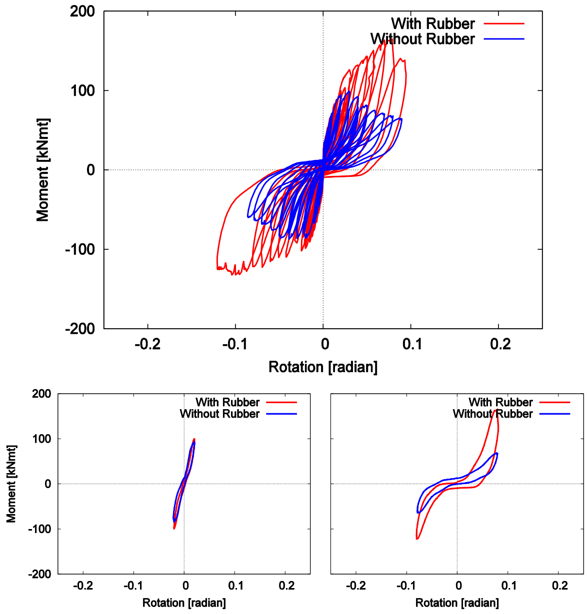

Fig.5 Moment Rotation basic specimen with and without rubber at 0.02 & 0.08 radian

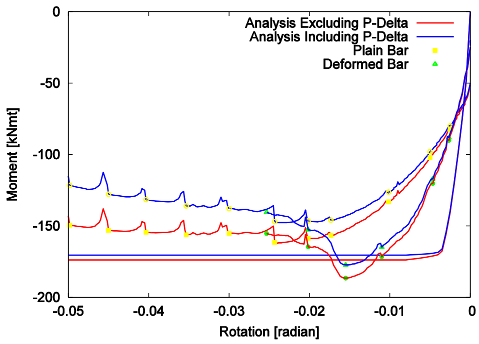

Fig.6 Moment Rotation for convensional pier test specimens under monotonic load

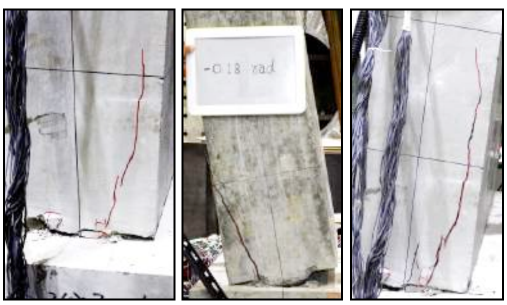

Photo 1 Failure mode for basic specimen with plain bar

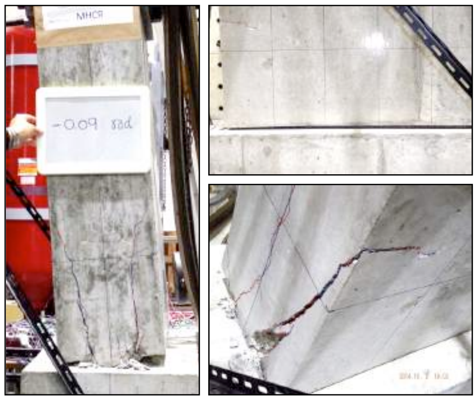

Photo 2 Failure mode for basic specimen with deformed bar

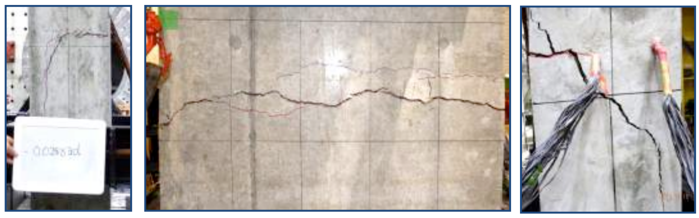

Photo 3 Failure mode for convensional pier with deformed bar

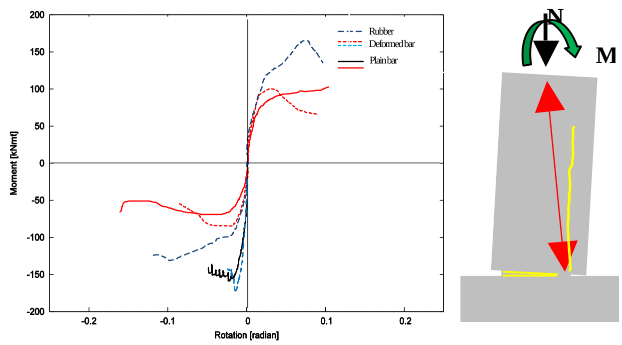

Fig.7 Backbone curve and general failure mode

4. CONCLUSIONS

The rotation stiffness was greatly influenced by cover concrete and basic target concrete hinge exhibited stable hinging behavior. The recommended safe allowable rotation in hinge for basic specimen considering elastic design is 0.015 radians. But test results showed stable moment rotation response even during large rotation up to 0.1 radian, when the applied rotation reached 0.11 radians sudden severe compressive shear splitting occurred. Therefore to fix increasing seismic demand during inelastic rotations this structural joint requires suitable strengthening at pier base.

REFERENCES

1.) Marx S., and Schacht G.: Concrete Hinges Historical Development and Contemporary Use, 3rd Fib International Congress, 2010, pp. 523-530.
2.) Parsons, D. E., and Stang. A. H.: Tests on Mesnager Hinges, Journals of the American Concrete Institute- Proceedings, 1935, No. 6, V-31, issue-1, pp. 304-325.

Keywords: Bridge-piers, Reinforced Concrete Hinges, lateral loads (earthquake loads)
Contact address: Tokyo Nissan Taito Bldg, 2-6-6, Moto-Asakusa, Taito-ku, Tokyo, 111-0041, Japan, Tel:03-68605974