Amirkabir University of Technology
(Tehran Polytechnic)
Vol. 46, No. 2, Winter 2014, pp. 23- 25

Amirkabir Journal of Science & Research (Civil & Environmental Engineering)
(AJSR - CEE)

Experimental Study of Concrete Hinge Connections with Usual Details

M. Mohammadi[1*], M. Amin[2]

1- Assistant Professor, International Institute of Earthquake Engineering and Seismology, Tehran, I.R. Iran,
2- M.Sc. Student, Science and Research University, Tehran, I.R. Iran

(Received 1 August 2011, Accepted 15 Nov 2014)

ABSTRACT

Applying hinge connection in concrete buildings can sometimes decrease the element sizes or improve the seismic behavior of the structures. Two details are famous as hinge for the regular concrete buildings, however none of them has been confirmed experimentally. Therefore, they are not applied in the practical projects. In this study, the details are experimentally studied. For this, three cantilever concrete beam specimens with different connections were constructed and loaded by the displacement-controlled loading. The first specimen had rigid connection that was used as the reference. The second and third specimens had crossed reinforcements at the hinge part; however, the last one was also equipped with two grooves at the top and bottom of the section. Moment- rotation diagrams of the specimens show that connections with the crossed reinforcement with or without the grooves cannot be considered for hinge connections, for their brittle behaviors and considerable bending strengths.

KEYWORDS

Hinge Connection, Rigid Connection, Semi Rigid Connection, Concrete Building.

*Corresponding Author, Email: M.mohammadigh@iiees.ac.ir

1- INTRODUCTION

Structural connections are very important in the seismic behavior of structures. They transfer the loads from an element to other or to supports. In seismic design of structures, the connections are designed stronger than the connecting elements in order not to have any hinge in these parts. The required ductility is supplied by nonlinear behavior of the elements. Rigidity of a connection is determined by comparing moment-rotation diagram of the connection with ideal connection specifications [1]. In a rigid connection, all loads of each side, including axial, shear loads and moments are transferred to the other without any change in the angle between the connecting elements. Despite, in hinge connections, the angle of the connecting elements changes. In such connections, shear forces transfers but the moment cannot convey. Most connections in the concrete structures are rigid.

Semi-rigid connections are those in which a fraction of the moment of one side (not whole of it) transfers to the other side by changing the connecting elements' angle.

Hinge connection is very common in steel structures, however, in the concrete structure, especially in buildings, there is not any details for the purpose, accepted by the codes. However, a detail has been proposed in some references which has not been confirmed experimentally yet. In this detail, longitudinal reinforced bars of the section are crossed at the hinge section. The connection section may have two grooves at the top and bottom.

Some advantageous applications of hinge connections are as follows:

1- Beams in short spans of tall buildings: they should be designed for a very large shear force, if they have rigid connections. But in case of hinge connections, they will be much more economical.
2- Beams with probable unequal settlements at two ends.
3- Connections of joists to the main beams.
4- Connection of two distinct buildings (with separated foundations).

Furthermore, buildings with rigid connections normally will be more expensive than those with the simple connection for more restricted criteria [2].

In this paper, behavior and rigidity of the concrete connections with the abovementioned details (with and without the grooves) studied experimentally. Moment rotation of these connections are compared with ones of rigid connection in order to determine their rigidity.

2- METHODOLOGY

In this research three specimens, with the same material and dimensions have been tested by cyclic loadings. The first specimen (spec.1) had rigid connection, as shown in Fig. 1. The other two ones, shown in Fig. 2 (spec.2) and Fig. 3 (spec.3), had details which are proposed for hinge connections (without having any experimental verification): in both of them, the longitudinal reinforced bars were crossed at the connection section, however in one of them (spec.3), the section was equipped with grooves at the top and bottom of the connection section as well [3, 4]. Loading protocol was determined based on ATC-24 [5].

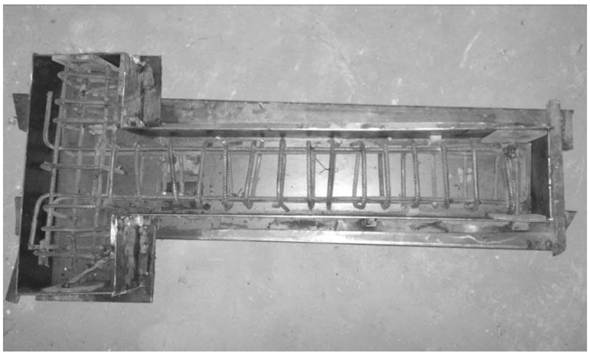

FIG1. The SPECIMEN WITH RIGID CONNECTION (SPEC.1)

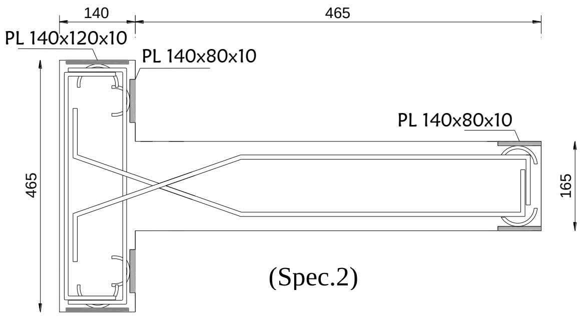

FIG.2. The SPECIMEN WITH CROSSED LONGITUDINAL BARS

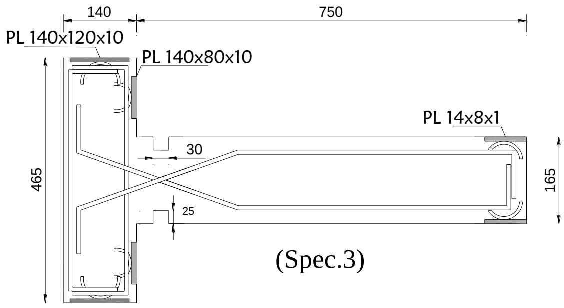

FIG.3. THE SPECIMEN WITH GROOVES

To calculate the rigidity of the connections, beam-line theory is applied [6, 7]. Beam line is a line connecting two points in the moment-rotation diagram, both obtained for a concentrated load applied at the mid-length of the beam: 1- θ_s on the horizontal axis: rotation of the connection when k_θ is zero 2- M_r on the vertical axis: moment at the connection when k_θ is infinitive (for completely rigid connection). Moment-rotation diagram of the connections in spec.2 or spec.3 is calculated similarly for a concentrated load at the mid-length of the beam, assuming that the same connection detail are applied at two ends of the beam, as shown in Fig. 4. The ratio of the moment, corresponding to the intersection of these diagrams with the beam line, to M_r shows the rigidity of these connections. As shown in Fig. 4, for the first connection detail, with crossed reinforcements, the rigidity is 81% and for the second detail, with grooves, it is greater than 50%. It is worth mentioning that the rigidity of the hinge connection should be less than 20% [8].

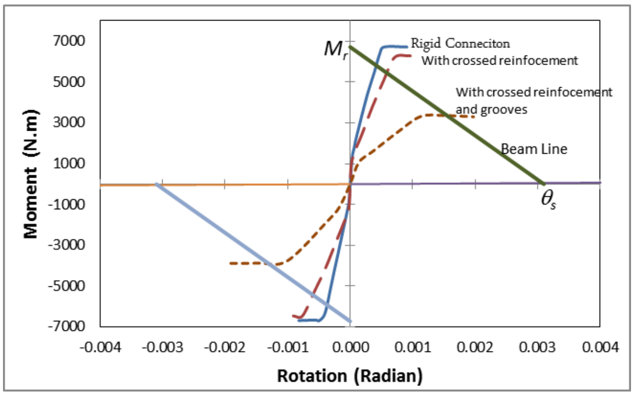

Fig. 4- Comparing behavior of the connections with beam line

3- CONCLUSIONS

In this paper, the behaviors of two details, which are sometimes assumed for hinge connection in concrete buildings, are studied experimentally. For this, two specimens in which the longitudinal reinforced bars were crossed at the connection, were tested. One of these had also grooves at top and bottom of the section. A specimen with the rigid connection is also tested as the reference.

The obtained results show that the rigidity of the proposed details, without and with grooves is greater than 50% and 81%, respectively and therefore, none of them can be considered for hinge connection.

4- REFERENCES

[1] AISC, “Qualifying Cyclic Tests of Beam to Column and Link to Column Connections”, Seismic Provisions for Steel Building, 2002.

[2] Iranian Code of Practice for Seismic Resistant Design of Buildings, Standard No. 2800- 05, 3rd Edition, Building and Housing Research Center, 2005.

[3] K. M. Holford ; R. Pullinand R.J. Lark, “Acoustic Emissinon Monitoring of Concrete Hinge Joint Models”, DGZfP-Proceedings BB 90-CD, Lecture 19, 2004.

[4] Building Code Requirements for Structural Concrete (ACI 318-10) and Commentary, 2010.

[5] ATC-24, Guidelines for Seismic Testing of Components of Steel Structures, Applied Technology Council, 1992.

[6] M. Haskett, D. J. Oehlers, M.S. Mohamed Ali, C. Wu-2009, “Rigid body moment-rotation mechanism for reinforced concrete beam hinges”, - Engineering Structures 31, 2009.

[7] M. Badiei., “Elemnetary Structural Analysis”, Khaje Nasireddin Toosi University publication, Vol. 1, 1992.

[8] M. Foroughi, “Making Moment Rotation Diagram Dimensionless; a method compare rigidity of connections”, 4th National Congress of Civil Engineering, Tehran University, 1996.