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LAYLAH HEATH

Reinforced Concrete Beam-column Joints Under Seismic Actions. Draft LAP Lambert Academic Publishing
Before the seismic events of Northridge (Los Angeles, 17 January 1994) and Hyogoken-Nanbu (Kobe, 17 January 1995), MRFs were supposed to be the most reliable seismic resistant systems due to the high number of dissipative zones that are able to develop. Before these earthquakes, especially in the United States, MRFs were realized, generally, by adopting fully welded connections, which, at the time, were retained to perform better compared to other joint typologies. In addition, the economic advantages deriving from the adoption of field fully welded connections strongly influenced choices of building owners and, as a result, led to the adoption of this joint typology in almost all pre-Northridge steel MRFs. After the Northridge earthquake, even though the loss of life was limited, the unexpected amount of damages occurred in structures adopting as seismic resistant system welded Moment Resisting Frames put into question the role played by welded connections on the whole of structural behavior. Therefore, after the seismic events, two strategies were identified to improve the behavior of fully welded connections. The first one is related to the improvement of the welding technique, usually strengthening the critical area subjected to fracture. The second one is based on the possibility of concentrating the energy dissipation in the beam, reducing the bending resistant area of beams by properly cutting the flanges in a zone close to beam-to-column

connection. This weakening approach is commonly called RBS. A new design approach, which has been the subject of many studies in the last few decades, has gained growing interest in recent years. In fact, Eurocode 8 has opened the door to the idea of dissipating the seismic input energy in the connecting elements of beam-to-column joints. In this work, attention is focused on this last approach. The first part of the work is descriptive and deals with the historical development and, in general, with the seismic behavior of Moment Resisting Frames. In the same chapter, general concepts concerning the component method, as introduced by last version of Eurocode 3, are given. Finally, the influence of the joint behaviour on main characteristics of partial strength and/or semi-rigid MRFs is evaluated by properly accounting for existing literature. The third chapter deals with an experimental analysis on the cyclic behaviour of classical partial strength beam-to-column joints. The main scope of the experimental campaign is to show how to control the dissipative behaviour of joints by properly designing the weakest joint component and by over-strengthening the other connecting elements. A design procedure is pointed out and the comparison among the results obtained by cyclic tests is presented in terms of energy dissipation capacity. In addition, by monitoring during the experimental tests both the whole joint and the single joint components it is shown that the energy dissipated by the joint is equal to the sum of the energy dissipated by the joint components. This result assures that the first phase of the component approach, i.e. the component identification, is properly carried out and that interaction between components under cyclic loads is negligible. Chapter 4 represents the extension of the work carried out in the previous chapter. In fact, on the base of the obtained results, the goal is to provide a mechanical cyclic model for the prediction of the overall joint behaviour, starting from existing literature models. Hence, a state-of-the-art review is first presented and then, a model employed to set up a computer program devoted to the prediction of the cyclic behaviour of steel beam-to-column joints is defined. In particular, the proposed cyclic model adopts Kim & Engelhardt's approach to model the shear panel behavior, Cofie & Krawinkler's model to predict Panels in Tension and Compression cyclic behavior, and Piluso et al.'s model for the prediction of the T-stub modelling

Retrofit of Existing Concrete Beam-column Joints Using Advanced Carbon-fiber Composites

LAP Lambert Academic Publishing

Definition of semi-rigid steel structural connections, classification and influence to the structural response of sway and non-sway steel frames. Sources of connection compliance, ductility and the application of the component method for characterization of the joint properties. Verification procedures for the available and the required capacity of joints and the design of semi-rigid steel structural connections. Application of the Finite Element Method for the simulation of the structural response

of semi-rigid connections taking into account all prominent nonlinear phenomena (cf. e.g. contact, friction and plasticity).

Monolithic Beam to Column Joints in Reinforced Concrete Buildings John Wiley & Sons

Although Moment Resisting Frames (MRFs) are the most widely used structural system for seismic-resistant steel buildings, several important aspects of their behavior under real earthquake loading are not well understood. This combined experimental and analytical research program addresses some of these important issues, focusing primarily on the behavior of beam-column joints. The experimental investigation focused primarily on conventional moment connections with bolted web and welded flange details. Beam sections with a relatively large web plastic modulus were used, as experimental data for such sections is very limited. The effects of various connection details and welding procedures on the performance of nineteen full scale beam-column subassemblages were studied. In particular, the effects of reinforcing ribs as well as the use of supplementary welds between the shear tab and the beam web were assessed. One of the important unresolved issues for steel MRFs is the effects of yielding in the column panel zone of the beam-column joint. Analytical research on the dynamic behavior of steel MRFs designed to allow active yielding of panel zone joints is very limited. For this reason, an analytical investigation was conducted for steel MRFs designed according to a recently developed building code. In this analytical work, the numerical procedure and nonlinear elements used in solving the nonlinear dynamic system are studied, and a special panel zone joint element is developed and incorporated into the ANSR-1 computer program in order to account for the inelastic shear deformation of panel zone joints. Several steel MRF designs for a six-story and a twenty-story office building are analyzed using various ground acceleration records. From these analyses, the maximum beam inelastic rotation and the dissipated energy demands at critical joints of the frame are compared with the maximum experimentally obtained capacity. The effects of various panel zone designs on the dynamic behavior of the MRF are studied in detail. Moreover, it is found that the panel zone shear deformations can be significant and should be included explicitly in the calculations of the frame lateral displacement. For this purpose, a method incorporating actual panel zone flexibilities into the computation of elastic story drifts of the steel MRF is developed. The method does not require an additional element for the panel zone joint and can be used conveniently in conjunction with traditional structural analysis computer programs.

Theoretical and Experimental Analysis of Dissipative Beam-to-Column Joints in Moment Resisting Steel Frames Department of Civil Engineering, University of Toronto

The Utah Department of Transportation, in conjunction with researchers from Utah State University and the University of Utah, began in late 1995 to investigate the application of advanced carbon-fiber composites to a bridge

pier cap and column joint. The Interstate 80 overpass crossing Highland Drive in Salt Lake City was chosen as a model for the investigation. The project was divided into three main areas, with Utah State University performing the design, fabrication, and physical testing of full-scale specimens to validate the ultimate capacities and ductilities of the advanced carbon-fiber retrofit schemes. This report outlines the work done by the research team at Utah State University in designing, building, testing, and analyzing data from six full-scale test specimens based on the design of pier #3 on the westbound lane of the I-80 overpass.

Structural Behavior of Beam and Column Joints in Reinforced Concrete Building Frames Springer

This book details the basic concepts and the design rules included in Eurocode 3 Design of steel structures: Part 1-8 Design of joints Joints in composite construction are also addressed through references to Eurocode 4 Design of composite steel and concrete structures Part 1-1: General rules and rules for buildings. Attention has to be duly paid to the joints when designing a steel or composite structure, in terms of the global safety of the construction, and also in terms of the overall cost, including fabrication, transportation and erection. Therefore, in this book, the design of the joints themselves is widely detailed, and aspects of selection of joint configuration and integration of the joints into the analysis and the design process of the whole construction are also fully covered. Connections using mechanical fasteners, welded connections, simple joints, moment-resisting joints and lattice girder joints are considered. Various joint configurations are treated, including beam-to-column, beam-to-beam, column bases, and beam and column splice configurations, under different loading situations (axial forces, shear forces, bending moments and their combinations). The book also briefly summarises the available knowledge relating to the application of the Eurocode rules to joints under fire, fatigue, earthquake, etc., and also to joints in a structure subjected to exceptional loadings, where the risk of progressive collapse has to be mitigated. Finally, there are some worked examples, plus references to already published examples and to design tools, which will provide practical help to practitioners.

Characterising the Seismic Behaviour of Steel Beam. Column Joints for Seismic Design John Wiley & Sons

This book details the basic concepts and the design rules included in Eurocode 3 "Design of steel structures" Part 1-8 "Design of joints". Joints in composite construction are also addressed through references to Eurocode 4 "Design of composite steel and concrete structures" Part 1-1 "General rules and rules for buildings". Moreover, the relevant UK National Annexes are also taken into account. Attention has to be duly paid to the joints when designing a steel or composite structure, in terms of the global safety of the construction, and also in terms of the overall cost, including fabrication, transportation and erection. Therefore, in this book, the design of the joints themselves is widely detailed, and aspects of selection of

joint configuration and integration of the joints into the analysis and the design process of the whole construction are also fully covered. Connections using mechanical fasteners, welded connections, simple joints, moment-resisting joints and lattice girder joints are considered. Various joint configurations are treated, including beam-to-column, beam-to-beam, column bases, and beam and column splice configurations, under different loading situations (axial forces, shear forces, bending moments and their combinations). The book also briefly summarises the available knowledge relating to the application of the Eurocode rules to joints under fire, fatigue, earthquake, etc., and also to joints in a structure subjected to exceptional loadings, where the risk of progressive collapse has to be mitigated. Finally, there are some worked examples, plus references to already published examples and to design tools, which will provide practical help to practitioners.

Design of Joints in Steel Structures

Universal-Publishers

Beam-Column Joints in a reinforced concrete moment resisting frame are crucial zones for transfer of loads effectively between the connecting elements (i.e. beams and columns) in the structure.The three main factors considered in design of a Beam -Column joint are Anchorage of main reinforcement of the beam, Confinement of the core of joint, Shear strength of the joint. In this book, the Beam-Column joint specimens were designed as per IS 456:2000 and also as per IS 13920:1993 and the influence of increasing their anchorage length by 25% and 50% was studied for load reversal condition. The results of the experimental investigation proved that the load carrying capacity and the energy absorption capacity of the beam column joint was enhanced considerably by the increase of anchorage length in the joint specimens. This book is very useful for the researchers who are doing research on Reinforced Beam-Column connections.

Seismic Shear Capacity of Beam-column Joints in Multistory Reinforced Concrete Frame Buildings

This study concentrates on two interrelated aspects pertaining to the deformation of beam-column joints under severe cyclic excitations. In the first part of this study, a closed form solution is developed for computing the slip and its distribution along reinforcing steel bars anchored inside a beam-column interior or exterior joint and subjected to generalized boundary steel stress excitations. The main advantage of the developed slip model, under which tremendous computation effort can be saved, is that: 1) it bypasses the local bond stress-slip relationship of unconfined concrete in its descending portion since no reliable experimental data describes this portion, and 2) it ignores the definition of local bond stress-slip relationship under severe load reversals. With its simplicity, the model reproduced quite accurately experimentally observed results and was shown to be in very good agreement with the presumably more accurate finite element prediction models. In the second part of the study, a joint model for describing the moment-rotation relationship of both interior and exterior beam-column joints

subjected to inelastic cyclic loading was developed. The model was derived based on idealized hysteretic material models for concrete and for the reinforcing steel bars. Interaction between steel and concrete through bond and slip of reinforcement inside the joint was taken into consideration using the slip model developed in the first part of this investigation. The joint model accounted for the two primary mechanisms responsible for the deformation of the beam relative to the column in the joint. These are: 1) inelastic rotation occurring within an equivalent plastic hinge length extending outside the beam column interface. and more importantly, 2) the fixed-end rotation arising from the slip of reinforcement at the beam-column interface cracks. The joint model allowed prediction of steel stresses and strains, slips, moments, curvatures, inelastic rotation and plastic rotation at any load level during the deformation or load history. Despite some discrepancy, the developed joint model reproduced within a reasonable degree of accuracy the experimentally observed results. On the other hand, with its simplicity in implementation and tremendous efficiency in computation, the developed joint model retained most of the accuracy of results obtained using finite element predictions.

Design and Response of Lower-level Beam-column Joints in Ductile Reinforced Concrete Double-deck Bridge Structures

A research program of field and laboratory tests to study the seismic response of reinforced concrete double-deck freeway structures has been concluded at the University of California, Berkeley. The program had three phases of testing. This report describes the research findings of the third phase of the program, which focused on the design criteria for beam-column joints in new ductile double-deck freeways. Two one-third scale test specimens representing the lower-level beam-column joint in a double-deck bridge structure were built and tested in the laboratory. The test specimens were designed according to current design criteria. The two test specimens differed in the strength of the members framing into the joints. The scope of the tests was to determine the response of the joints when subjected to unidirectional and bidirectional load cycles and compare the response to the different levels of maximum joint shear stress demands.

Beam-Column Joints

Existing reinforced concrete (RC) structures are often vulnerable to seismic events. The reports of damage observed pointed out the key importance of beam-to-column joints on the global performance of RC frames. Several theoretical and analytical formulations have been proposed for evaluating the shear strength of beam-to-column joints. The present work deals with the formulations for evaluating the shear strength of exterior and interior connections currently available in both the scientific literature and the main seismic codes. The comparison between the experimental results collected in a wide database and the theoretical shear strength is made for assessing the presented models. The models have been recalibrated and the

relevant coefficients describing the average error and the dispersion of the models have been evaluated. Furthermore, the behaviour of reinforced concrete beam-to-column joints under cyclic loading is analysed and a simple model for dynamic non-linear analyses is proposed.

Reinforced Concrete Beam-column Joints for Seismic Loading

Semi-Rigid Joints in Structural Steelwork

The Behavior of Fiber Reinforced Concrete Beam-column Joints Subjected to Earthquake-type Loading

Influence of lateral beams on the behavior of beam-column joints

Strengthening of Reinforced Concrete Beam-column Joints to Increase Seismic Resistance

Externally Reinforced Concrete Beams and Beam-column Joints

Seismic Resistance of Reinforced Concrete Beam-column Joints

Recent Studies on Reinforced Concrete Beam-column Joints in Japan

The shear strength of reinforced concrete beam-column joints subjected to reverse load

Recommendations for Design of Beam-column Joints in Monolithic Reinforced Concrete Structures