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CRITICAL REVIEW ON MECHANICAL ANCHORAGE AS REPLACEMENT OF BENT BAR

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Abstract: In the 21st century, expansion of cities as well as states construction process increase rapidly used in building construction. In reinforced concrete structures, beam-column joint is the most critical region in seismic prone areas. In structural concrete, the provisions for anchorage of straight bars and hooks normally present detailing problems due to conjunction of reinforcement bar. Mechanical anchorage device eliminates detailing problems when conjunction of reinforcement bar. This paper represents the various method of mechanical anchorage and past work carried out on mechanical anchorage which shows the effectiveness of mechanical anchorage method over the most commonly used method.

Keywords: Anchorage Bar, Beam Column Joint, reinforced concrete, T-type anchorage, Mechanical anchorage

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INTRODUCTION

In reinforced concrete structures, thedetailing problems related to the anchorage of reinforcement bars are often of great importance due to the long development lengths and large bend radius required for straight or hooked bars[10]. Alternatives to conventional detailing not so common in ordinary structures but with a long history in heavily reinforced structures have been developed since the middle of the 20th century[10]. Known as mechanical anchorages, they are particularly useful in presence of large bar diameters, because they can achieve the anchorage by a combination of development length and a plate anchor that can be fixed to the rebar contributing to the total anchorage capacity. Therefore, the use of plate-anchored reinforcement bars reduces the development length needed and simplifies the detailing of congested areas, also reducing significantly the placing times.

The requirements for straight bar anchorage and lap splices cannot be provided within the available dimensions of elements. Hooked bars can be use to shorten anchorage length, but in many cases, the bend of the hook will not fit within the dimensions of a member or the hooks create congestion and make an element difficult to construct. Similarly, mechanical anchorage devices can be used, but they frequently require special construction skill and careful attention to tolerances.

Mechanical anchorage, as shown in Fig 1, provide an alternative to hooked bars and assist in alleviating steel congestion. Previous research on mechanical anchorage may be divided into two categories: performance of mechanical anchorage in realistic structural systems, and investigation of the mechanics of the mechanical anchorage under idealized conditions. Previous structural system studies include a number of beam-column joint investigations, where mechanical anchorage were used for longitudinal reinforcement, and slab-column joint investigations, where mechanical anchorage were used for shear reinforcement. The reliability and applicability of the mechanical anchorage were validated in these studies and, consequently, guidelines on the use of mechanical anchorage were introduced in ACI 352R-028[11] and ACI 421.1R-08. These guidelines provide guidance on general application of bars but do not provide direct estimates for the anchorage strength of mechanical anchorage.

Figure 1: Standard hook & Various mechanical anchorage (#8 size)

TYPE OF MECHANICAL ANCHORAGE

Friction-Welded Anchorage

The friction-welded anchorage are manufactured by pressing the end of a deformed reinforcing bar onto a plate spinning at very high speed. The heat produced by the friction between the deformed bar and plate causes the bar material to melt and form a weld between the two. The machinery required for this process is quite large and the anchorage bars can only be created in factory conditions as shown in fig 2. The anchorage bars come in four shapes: square, rectangular, circular, and oval. The circular and oval shaped anchorages are fatigue rated.

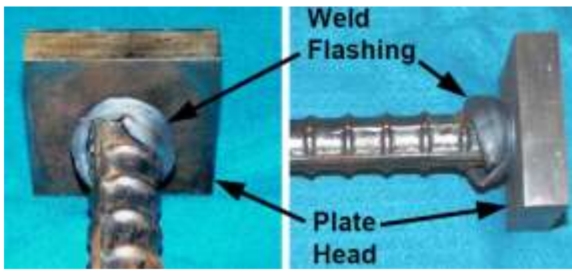

Figure 2: Friction-welded Anchorage **Figure 3: Terminator (Thread) Anchorage**

Thread Anchorage

The tapered thread of the Terminator anchorage allows a more efficient stress transfer than conventional straight thread connections. Terminator anchorages are circular and generally have a relative anchorage area around 3 or 4 as shown in fig 3. Terminator anchorages can be applied in the field provided the bar ends are pre-threaded. Threading may be accomplished in the field. Reinforcing bars may even be tied in place before the anchorage is attached. To attach the anchorage, all that is needed is the Terminator nut and a torque wrench.

laboratory based testing setup

The Joint assemblage was subjected to monolithic loading using Hydraulic jack of 25 Toncapacity. The specimen column is kept in horizontal direction and beam is kept vertical as illustrated in Fig 4. Both ends of the RCC columns are restrained in vertical and in both horizontal directions by using strong built up steel boxes which in turn are connected to the reaction floor using holding down anchor bolts. To facilitate the application of monolithic load on either side of the RCC beam, hydraulic jacks are used which are connected to the strong steel frame using mechanical fasteners and the RCC beam was loaded as shown in Fig 4. The Linear Variable Differential Transducer (LVDT) was connected on either side of the specimen to monitor the displacements. To record the loads accurately, the specimenwas tested to reach its maximum failure load.

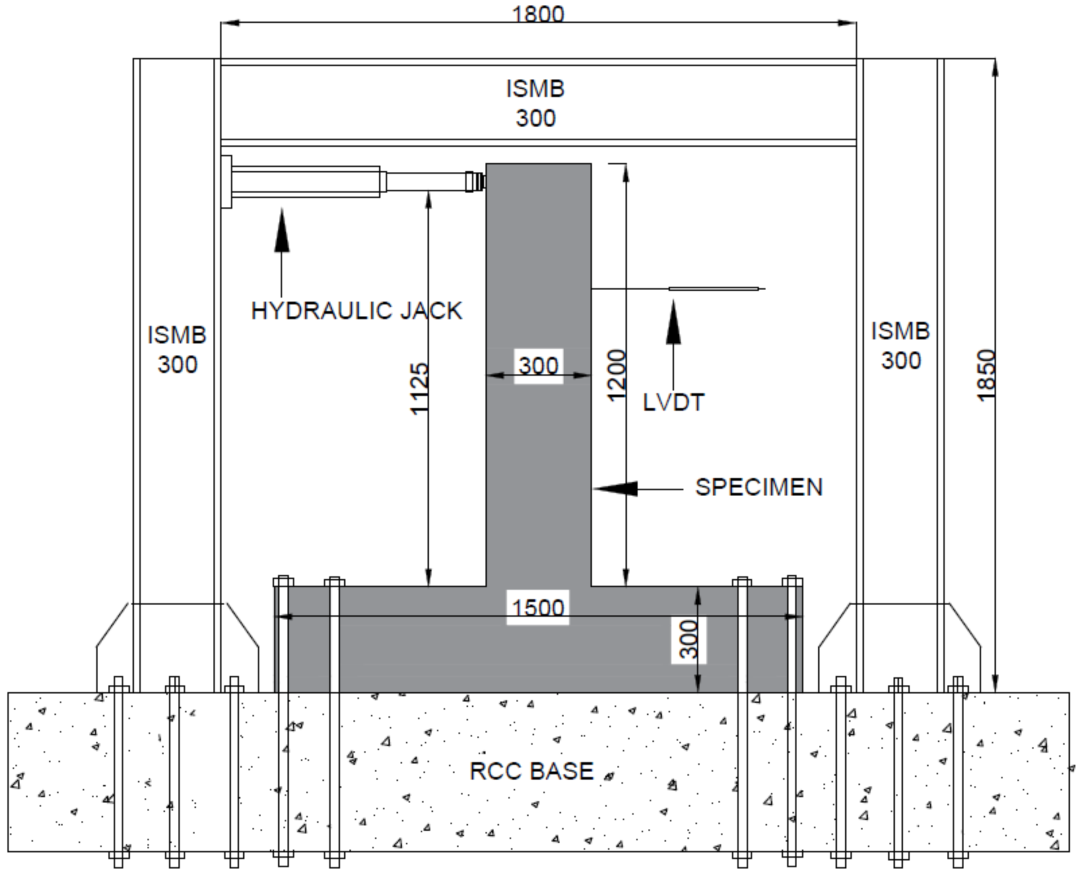

Figure 4: Schematic diagram of test setup

REVIEW OF LITERATURE

John w. Wallace, Scott w. McConnell (1997)[1]To evaluate the applicability of mechanically anchored bars with diminutive anchorages in exterior beam-column joints. The research program consisted of testing two, full-scale, exterior beam-column joint sub assemblages. One of the specimens was subjected to cyclic load whereas the other specimen was subjected to essentially monotonic load. The objective of this paper is to provide a brief overview of the results.The utilization of mechanically anchored bar in place of standard hooks within an exterior beam-column joints is a viable option and presents no consequential design quandaries. A minimum anchorage length of 12db is recommended for reinforcement terminated within a beam-column joint provide the anchorage bearing area in tension is at least four times the bar area.

John w. Wallace, Scott w. McConnell, Piush gupta, Paul a. cote (1998)[2]The demeanor and load deformation replication of reinforced concrete exterior and corner beam-column joints constructed with anchorage reinforcement is evaluated. The research program consisted of testing two exterior and five corner joint specimen. And observed demeanor of specimen. demonstrated that the of avail of anchorage reinforcement had facilitated specimen fabrication, concrete placement and the demeanor was as good as than similarly constructed specimens with standard 90◦ hooks for beam-column corner joint.

Thomas H.-K. Kang, Sang-Su Ha, Dong-Uk Choi (2008)[3]Predicated on twelve pull-out tests of single-mechanical anchorage, the anchorage size of at least 2.6 was efficacious to achieve adequate anchorage or bearing, provided that the development length was 10db. The loading condition (monotonic vs. reiterated), anchorage shape (circular vs. square), and anchorage-annexing technique (threading vs. welding) did not impact the anchorage deportment substantially during pull-out. The test results of the joint subassemblies support the applicability of mechanical anchorage with minuscule anchorages (2.6) in exterior beam-column joints, and the incipient ACI 318-08[10] provision on mechanical anchorage. The exterior joint containing mechanical anchorage with a development length of 15db and with anchorage size of approximately 3 was capable of transferring probable moments and forces in the members without loss up to 3.5% drift, and additionally met ACI T1.1R-01 acceptance criteria. The aforementioned results were achieved even with moderate joint confinement. This denotes that reduced joint confinement does not impact adversely on the anchorage bar anchorage in inter-story joints, likely due to the bearing stress acting against the concrete above the joint. This implicatively insinuates a possibility that transverse reinforcement in the exterior inter-story joint can be reduced when mechanical anchorages are utilized.

Hung-Jen Lee and Si-Ying Yu (2009)[4]The cyclic replication of six exterior beam-column joints with or without eccentricity to evaluate the utilization of mechanical anchorages in place of hooked bar anchorages.Thepresented experimental program demonstrates that eccentricbeam-column joints with mechanical anchorages can exhibitsatisfactory performance and adequate anchorage capacity for alimiting drift ratio. Elongating ACI design methods to cover the utilization of mechanical anchorages for eccentric beam column joints is an felicitous code modification. Test results also indicate that the cyclic behaviour of exterior beam-column joints can be significantly improved by attaching double mechanical devices on each beam bar within the joint.

Thomas H.-K. Kang, Myoungsu Shin, Nilanjan Mitra, John F. Bonacci (2009)[5]presents a detailed review of anterior research on the utilization of mechanical anchorage in reinforced concrete beam-column joints subjected to quasi-static inverted cyclic loading is presented in this paper. The investigated database comprises most available experimental tests on this subject around the world, including those conducted in the U.S., Korea, Japan, and Taiwan. The test database was assessed to evaluate the incipient ACI 318-08[10], Section 12.6, requisites for applications in beam-column joints and to supplement the current ACI 352R-02[11] report.BothACI 318-08[10] and 352R-02[11] are predicated on quite constrained experimental research. Given this concern, these ACI standardsand recommendations were evaluated utilizing an extensive database encompassing most available test data for reinforced concrete beam-column joints with mechanical anchorage subjected to inverted cyclicloading. The primary objectives of this study are to document the experimental investigations in a uniform format; provide a detailed review for the test data; and, conclusively,propose design guidelines tosupplement ACI 352R-02[11] and 318-08[10] on the subject of mechanical anchorage in beam-column joints.

Thomas H.-K. Kang, Nilanjan Mitra(2012)[6]Given that both ACI 318-08[10] provisions and 352R-02[11]recommendations have been developed predicated on quite constrained experimental data, an extensive database was assembled by Kang, which contains most of the available test data of reinforced concrete exterior beam-column connections with mechanical anchorage subject to load reversal. The recent data focusing on the investigation of design parameters of clear bar spacing and anchorage size, and re-evaluated utilizing a variety of statistical and empirical techniques. An effort has been made to find a statistical model linking quantitative design parameters and qualitative connection replication. In this study, binomial logistic regression methodology has been applied. The statistical methodology quantifies the effect of each design parameter in determining the performance of the connection. A reliable and robust goodness-of-fit test, the loglikelihood ratio test, was performed to evaluate the developed logistic regression model.In the cessation, the statistical methodology was evaluated by utilizing two robust goodness-of-fit tests and genuine experimental data.

S. Rajagopal , S. Prabavathy (2013)[7]presents In reinforced concrete structures, it is essential to enhance the performance of beam–column joints in moderate and astringent seismic susceptibility areas. An endeavor has been made to study and evaluate the performance of exterior beam–column joint utilizing opportune reinforcement anchorage and joint core detail. The anchorages are detailed as per ACI-352[11] (Mechanical anchorage), ACI-318[10] (90º Standard bent anchorages) and IS-456[14] (Full anchorage) along with confinement as per IS-13920[13]. Consequential amendments were observed in seismic performance, ductility and vigor while utilizing proposed hair-clip bar plus X-cross bar in amalgamation with mechanical anchorage detail for higher seismic prone areas, apart from resolution to reducing congestion of reinforcement in joint core. To assess the performances of anchorages and joint details, two groups of three specimens each were tested under reversal loading.

Vaibhav R. Pawar, Dr. Y.D.Patil, Dr. H.S.Patil (2017)[8]present detailing quandaries due to the long development lengths and astronomically immense bend diameters that are required, concretely when immensely colossal diameter reinforcing bars are utilized. In many cases, the requisites for straight bar anchorage and lap splices cannot be provided within the available dimensions of elements. Hooked bars can be acclimated to abbreviate anchorage length, but in many cases, the bend of the hook will not fit within the dimensions of a member or the hooks engender congestion and make an element arduous to construct. Experimental work was conducted on exterior beam-column joint specimens with T-type mechanical anchorage.

Welded and threaded anchorage reinforcement bars were utilized as T-type anchorage with short development length. The seismic tests were conducted to investigate the applicability of mechanical anchorage with threaded and welded type. The test data were assessed to examine the effect of the anchorage size, shape and anchorage affixing techniques on the anchorage comportment under cyclic loads. The result from 1/3 scale seismic testing of a joint with mechanical anchorage were evaluated by compression with a companion specimen with hooked bars and by utilizing the acceptance criteria of ACI 374.1-05. No brittle concrete brake out occurred for any mechanical anchorage in pullout, provided that the anchorage size was at least 2.5 and embedment depth was 11db. This implicatively insinuates a possibility that the amount of transverses reinforcement in the exterior inter-story joint may be reduced when mechanical anchorages are utilized.

SUMMARY OF FINDINGS

A detailed review of past research paper covered in this paperbased on the use of mechanical anchorage in reinforced concrete beam-column joint. Out of there all literature for the detailing of exterior beam-column joint of reinforced concrete structures in seismic prone areas are made from the knowledge gathered through the results ofthe experimental test data base.Based on the review of the previous data,

- The net bearing area of ananchorage is suggested to be at least three times the bar area for the design of beam-column joints. The data of beam column joints subject to cyclic loading provide a means toupdate both ACI code [11][10].
- The transverse reinforcement within the joint region should be positioned essentially in-line with the mechanically anchored bars to restrain the heads from pushing off the cover concrete as well as to provide lateral stability to the column vertical bars.
- Mechanical anchorage joint detail offers a better moment carrying capacity thereby improving the seismic performance without compromising the ductility and stiffness.
- Arrangement of reinforcement detail in the exterior beam-column joint core reduces congestion of reinforcement, easier placement of concrete and aids in faster construction at site.
- Combination of anchorage and joint detailing may be used in locations demanding low and moderate ductility situation.

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