International Journal of Engineering Applied Sciences and Technology, 2021
Vol. 6, Issue 4, ISSN No. 2455-2143, Pages 246-249
Published Online August 2021 in IJEAST (http://www.ijeast.com)

APPLICATION OF ULTRA HIGH PERFORMANCE FIBRE REINFORCED CONCRETE ON EARTHQUAKE RESISTING STRUCTURE

Dr. Ajay P. Shelorkar
Department of Civil Engineering
MVPS's KBTCOE, Nashik, Maharashtra, India

Dr. Pradip D. Jadhao
Department of Civil Engineering
KKWIEER, Nashik, Maharashtra, India

Abstract— **Beam column joint is an important component of a reinforced concrete moment resisting frame and should be designed and detailed properly when the frame is subjected to earthquake loading. Failure of beam column joints during earthquake is governed by bond and shear failure mechanism which are brittle in nature. Modern codes provide for reduction of seismic forces through provision of special ductility requirements. A beam column joint has been moulded to the scale of 1:1.5 and the model has been subjected to cyclic loading to find its behavior during earthquake. The earthquake resisting structure is G+11 and has been analyzed using the Seismic Coefficient Method. This paper presents a synthesis of strengthening design of reinforced concrete beam and column by replacing it with Ultra High-Performance Fibre Reinforced Concrete.**

Keywords— **Beam Column joint, UHPFRC, Exterior joint, seismic analysis**

I. INTRODUCTION

In various part of the world, reinforced concrete structures even in seismic zones have been designed only for gravity loads. Such structures though performing well under conventional gravity case, could lead to a questionable structural performance under earthquake. In most cases, those structures are vulnerable to any moderate or major earthquake.

Generally, a three-phase approach is followed to describe a structure under seismic loading,

(i) The structure must have adequate lateral stiffness to control the inter storey drifts such that no damage would occur to non-structural elements during minor and frequently occurring earthquakes,

(ii) During moderate earthquakes, some damage to non-structural elements is permitted, but the structural element must have adequate strength to remain elastic so that no damage would occur,

(iii) During rare and strong earthquakes, the structure must be ductile enough to prevent collapse by aiming for repairable damage which would ascertain economic feasibility.

An earthquake resisting structure dissipate seismic energy through the beam column joints and column ends. The beam column joint is the most critical structural component under seismic loading. The functional requirement of a joint which is the zone of intersection of beams and columns is to enable the adjoining members to develop and sustain their ultimate capacity. The role of these joints becomes more critical under seismic loading.

The seismic design of structures has evolved towards a performance-based design method in recent years. Therefore, there is need for new structural members and systems that possess enhanced deformation capability and damage tolerance without complex reinforcement arrangements. The development of highly damage-tolerant beam-column joints would allow moderate shear distortions in the joint core zone, reduce rotation demands in plastic hinge zone of beam ends, and avoid seismic strengthening of the joint core zone. One option for achieving this goal is to use Ultra High-Performance Fibre Reinforced Concrete to upgrade the deformation capability of beam-column joints. Experimental studies have proved that an improved seismic performance can be achieved, in terms of the shear critical members such as beam-column joints beams and flexural members subjected to high shear stress by using Ultra High Performance Fibre Reinforced Concrete.

II. SIGNIFICANCE AND OBJECTIVE

A. Significance of the Research–

Beam-column joints, which are usually expected to experience greater reversed cyclic action such as an earthquake, need to be properly designed to provide a sufficient deformation capability. If the reinforcements are modified in strengthening the joint, then severe reinforcement congestion and construction difficulties thus may occur. It may either lead to a larger column or beam sections or a greater amount of smaller

International Journal of Engineering Applied Sciences and Technology, 2021
Vol. 6, Issue 4, ISSN No. 2455-2143, Pages 246-249
Published Online August 2021 in IJEAST (http://www.ijeast.com)

diameter bars being used in order to satisfy the minimum anchorage length requirements. So as to overcome this problem, the reinforced concrete is been replaced by ultra-high-performance fibre reinforced concrete and analysed for the seismic forces The main objective of the paper are as follows:

B. Objective of the Research –

i. To examine the behaviour of beam column joint under cyclic loading by providing steel fibres and admixtures.

ii. Strengthening of beam column joint under seismic loading.

iii. To study the seismic effect on the building.

III. ANALYTICAL WORK

Analysis of G+11 building using seismic coefficient method, referring IS 1893(part-1)-2002, and Microsoft excel software. This G+11 building belongs to zone III, resting on hard strata with the Importance Factor of 1. The frame is of SMRF. The overall height of building is 37meter. Lateral force at each storey is calculated using seismic coefficient method and it is compared with experimental data.

Table -1 Building details

Building Details			
Length In X Direction	15 m	Soil Strata	Hard
Length In Y Direction	9 m	Seismic Zone	3
No. of Storey Above Ground	12	Zone Factor(Z)	0.16
Ground Storey Height(M)	4 m	Type of Structure	All other Building
Floor To Floor Height(M)	3 m	Importance Factor(I)	1
External Wall Thickness(M)	0.23 m	Lateral Load Resisting System	SMRF
Internal Wall Thickness(M)	0.23 m	Response Reduction Factor	5
Material	M40 and Fe415	location	Nashik

IV. EXPERIMENTAL WORK

The experimental study dedicated to observe the performance characteristic of beam-column joint when strengthening of critical region of beam and column including joint is done prior to cyclic excitation for testing. Strengthening for specimen done using ultra high-performance fibre reinforced concrete as engineered cementitious composites with hooked end steel fibres.

A. Sectional Details

The critical section of the T section to be analysed is filled with the ultra-high-performance fibre reinforced concrete slurry with combination of

1) Metakaolin + steel fibres + silica fume.
2) GGBFS + steel fibres + silica fume.

The replacement of steel fibres is 2%, 3%, 4% with the combination of 10% of GGBFS and 10 % of metakaolin

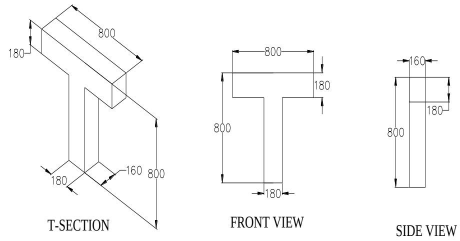

Fig. 1. Sectional details of T Joint

B. Materials and Testing

Ordinary Portland Cement (OPC) 53 grade as cementitious material, coarse aggregate with maximum size of 20mm and 10mm and locally available river sand as fine aggregates are used in construction of concrete specimen. The hooked end steel fibre of size 35mm long and 0.6 mm in diameter (aspect ratio = 60) with nominal tensile strength of 1100 MPa. Silica fume has been recognized as a pozzolanic admixture that is effective in greatly enhancing mechanical properties. The ground granulated blast furnace slag is a by-product of iron manufacturing which when added to concrete improves its properties such as workability, strength and durability. Metakaolin is a thermally available activated alumino silicate material obtained by calcining kaolin clay within the temperature of 700-800 ºC. It contains typically (50-55%) SiO_2 and (40-45%) Al_2O_3 which is highly reactive. In this project, metakaolin used was ordered from Makarpura, Baroda, Gujrat.

C. Beam Column Joint Specimen And Test Setup

There are five beam column joint specimens, out of which two is control specimens with normal steel reinforcement and three with different UHPFRC. The detailed configuration of all joint specimens is as shown above. All joint specimens are tested under compression cyclic loading. All the data were acquired using data acquisition system. Manually semi-automated hydraulic jack bolted to loading frame and connected to computer software, shows the graph between the load and defection. LVDT was also placed under the applied load below the beam and connected to computer. Repeated loading beam was applied with consecutive displacement increment of 5 mm. Also nut- bolt arrangement was prepared to simulate the compressive load on the column of 90 kN, load value verified using load cell.

International Journal of Engineering Applied Sciences and Technology, 2021
Vol. 6, Issue 4, ISSN No. 2455-2143, Pages 246-249
Published Online August 2021 in IJEAST (http://www.ijeast.com)

V. RESULT AND DISCUSSION

The G+11 building is analysing by using seismic coefficient method and Microsoft excel software by referring IS 1893-2002(part-1) the following data is obtained which shows the lateral load distribution along the storey of the building.

Table -2 Lateral load distribution

Storey	**Height(h_i)**	**Weight(w_i)**	$w_i h_i^2$	$\frac{w_i h_j^2}{\sum W_i h_i^2}$	**Q_i (kN)**	
					Q_{ix}	**Q_{iy}**
12	37	613.00125	839198.71	0.177410747	13.536	10.4849
11	34	784.32975	906685.19	0.191677722	14.6245	11.3281
10	31	784.32975	753740.89	0.159344542	12.1576	9.41723
9	28	784.32975	614914.52	0.129995963	9.91836	7.68273
8	25	784.32975	490206.09	0.103631986	7.90686	6.12463
7	22	784.32975	379615.6	0.080252610	6.12307	4.74291
6	19	784.32975	283143.04	0.059857835	4.567	3.53758
5	16	784.32975	200788.42	0.042447662	3.23865	2.50865
4	13	784.32975	132551.73	0.028022089	2.13801	1.6561
3	10	784.32975	78432.975	0.016581118	1.2651	0.97994
2	7	784.32975	38432.158	0.008124748	0.6199	0.48017
1	4	784.32975	12549.276	0.002652979	0.20242	0.15679
		∑	4730258.6	1	76.2975	59.0998

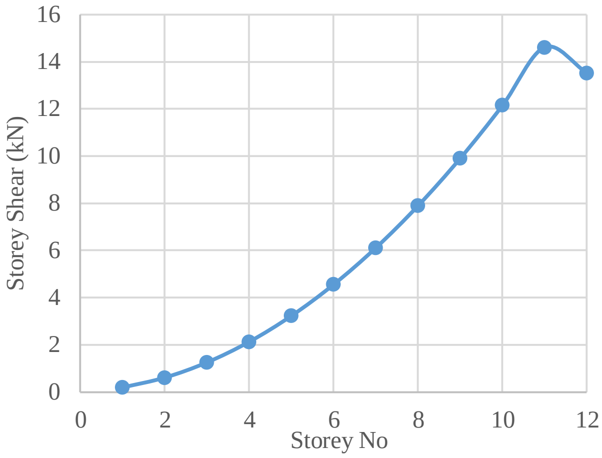

Fig. 2. Story Shear – Static Analysis in X- Direction

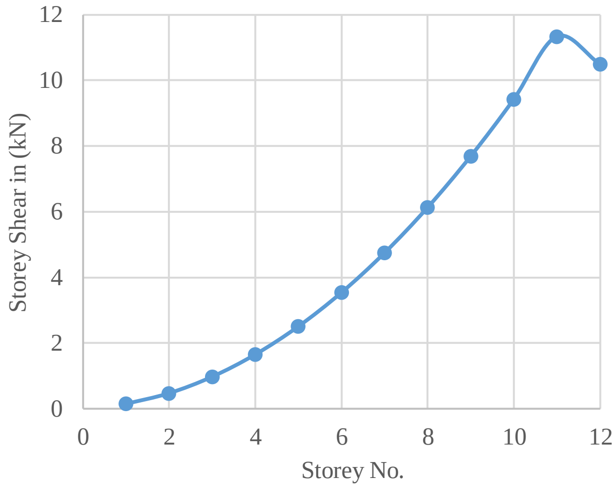

Fig. 3. Story Shear – Static Analysis inY- Direction

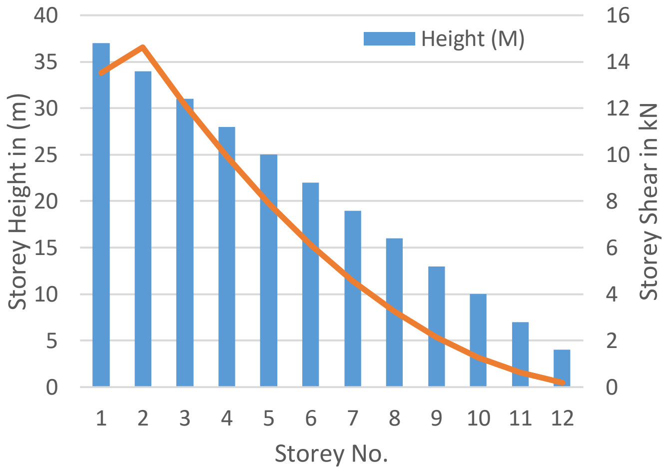

Fig.4. Storey height and Storey Shear – Static Analysis in X-Direction

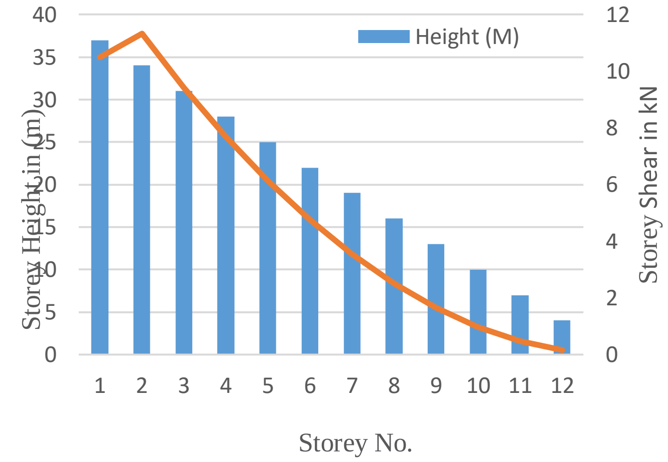

Fig.5. Storey height and Storey Shear – Static Analysis inY-Direction

VI. CONCLUSION

This paper presents a combination of experimental and analytical study on the application of ultra-high performance fibre reinforced concrete to replace the normal concrete casted in beam column joint in order to improve seismic performance. The findings from the presented well conducted experimental study has proved that ultra-high-performance fibre reinforced concrete as an advanced alternative can effectively promote the seismic performance of beam column joint. The proposed experimental study consisted of five beam column joints at exterior end of building and investigated the influences on the seismic performance from the different proportion of the steel fibres, Ground granulated blast furnace slag and metakaolin. The data obtained from the data acquisition system is then compared with the seismic coefficient analysis using Microsoft excel software. Comparing the data obtained from the experimental and analytical work, it was observed that the beam column joints replaced with ultra-high performance fibre reinforced concrete can sustain more lateral load than the conventional beam column joint.

VII. REFERENCE

[1] Aminul Laskar,Biswajit Roy. (2016). Cyclic behavior of in situ exterior beam column subassemblies with cold joint in column. Engineering structures , 822-833.

[2] Amir Mirmiran, Pedram Zohrevand. (2012). Cyclic behavior of hybrid columns made of ultra high performance concrete and fiber reinforced polymers. American Society of Civil Engineers , 91-99.

[3] Dr. S. Sundararaman, S. Azhagarsamy. (2015). Performance of Ultra High Performnce Concrete Containing Mineral Admixture. International Journal of Civil Engineering , 336-342.

[4] Guo Lin Wang, J. G. Teng. (2012). Shear strength model for RC beam column joints under seismic loading. Engineering Structures , 350-360.

[5] Hamdolah Behnam, J. K. (2017). Exterior RC wide beam column connections. Engineering Structures , 27-44.

[6] Pooya Alaee, Bing Li. (2017). Highh strength concrete exterior beam column joints with high yield strength steel reinforcements. Engineering Structures , 305-321.

[7] Raman Bharti, R. Siva Chidambaram, Naveen Kwatra. (2017). Influence of fibre reinforced concrete on plastic behavior on exterior beam column joint under cyclic loaing. Procedia Engineering , 1122-1129.

[8] Rohit Nimse, D. J. (2014). Behviour of wet precast beam column connections under progressive collapse scenario. 149-159.

[9] Venkatesh Kaka. (2016). Seismic Behavior of ultra High Performance Fiber Reinforced Concrete Moment Frame Members. first international interactive symposium , 56-66.

[10] Xing wen Liang,Ying jun Wang, Ming ke Deng. (2016). Seimic performance of fibre reinforced concrete interior beam column joints. Engineering Structures , 432-445.

[11] Y. Sun,. (2012). Earthquake resistng properties and evolution of high performance concrete columns. Engineering Structures , 55-65.