**RETROFITTING TECHNIQUES AND METHODS USED TO ANALYSIS OF EARTHQUAKE DAMAGED RCC BUILDING**

**Submitted in partial fulfillment of the requirements for the degree of master of technology**

**Submitted By**

**NISHANT**

**(Roll No. - )**

**Under the Supervision**

**Mr. NISHANT SHARMA**

**(A.P. IN CE Dept.)**

**Civil Engineering Department**

**CANDIDATE’S DECLARATION**

I ………. bearing roll number: ( )a student of B.Tech (Civil Engineering) hereby declared that I own the full responsibility for the information, result etc. provided in this thesis titled “**RETROFITTING TECHNIQUES AND METHODS USED TO ANALYSIS OF EARTHQUAKE DAMAGED RCC BUILDING** ” submitted to Maharshi Dayanand (M D) University, Rohtak for award of Master of Technology (Civil Engg.) degree. I have taken care all respect to honor the intellectual property right and have acknowledged the contributions of other for using them in this academic purpose. I further declared that in case of any violation of intellectual property right or copyright I as the candidate would be fully responsible for the same. My supervisor and institute should not be held for full or partial violation of copyright if found at any stage of my degree.

Nishant

Civil Engineering 4th sem.

**CERTIFICATE BY THE SUPERVISOR**

It is certified that this thesis report titled “**RETROFITTING TECHNIQUES AND METHODS USED TO ANALYSIS OF EARTHQUAKE DAMAGED RCC BUILDING** ” by Nishant in the partial fulfillment of requirement for the award of Master of Technology (Civil Engg.) submitted to Maharshi Dayanand (M D) University, Rohtak is a record of student’s own work carried out under my supervision and guidance. This thesis has not been submitted to any other University or Institution for award of degree.

The work contained in this dissertation is at per university standards. I wish him/her good success in life.

Mr. Nishant sharma

(AP in CE Deptt.)

Civil Engineering Department

BRCM College of Engineering & Technology

**ABSTRACT**

Earthquakes are one of nature’s greatest hazards to life on this planet. The impact of this phenomenon is sudden with little or no warning to make preparations against damages and collapse of buildings/structures. The hazards to life in case of earthquake are almost entirely associated with manmade structures such as buildings, dams, bridges etc. Prevention of disasters caused by earthquake has become increasingly important in recent years. Disaster prevention includes the reduction of seismic risk through retrofitting existing buildings in order to meet seismic safety requirements. The planning of alterations to existing buildings differs from new planning through an important condition; the existing construction must be taken as the basis for all planning and building actions. The new structure can be built sufficiently earthquake resistant by adoption proper design methodology and construction quality control. But the existing old structures which have mostly been planned without considering this important aspect, pose enormous seismic risk, in particular to human life and historical monuments.

India is one of the most earthquake prone countries in the world and has experienced several major/moderate earthquakes during the last 15 years. About 50-60% of the total area of the country is vulnerable to seismic activity intensities. In India, almost 85% of the total buildings are non engineered buildings made up of earthen walls, stone walls, brick masonry walls, etc. These buildings are more vulnerable and in the event of a major earthquake, there is likely to be substantial loss of lives and property.

The recent earthquakes have posed a serious threat to many existing Indian RC buildings which are designed mainly for gravity loads. Hence focusing on the damage and collapse of RC buildings, it is important to estimate the response of existing buildings under earthquakes from the viewpoint of life reservation and risk management. Different retrofitting methods and materials are studied in this dissertation like use of steel braces, fiber reinforced polymers, inter storey drift and storey shear have been carried out using equivalent static analysis to investigate the influence of these parameter on the behavior of buildings with soft storey. The plan area considered for all configurations of buildings is 16.0m16.0m.

From the result it is observed that the earthquake damaged structure can be retrofitted using different material and using various techniques. From the analysis it is observed that the retrofitted model shows lesser displacement as compared to the earthquake damaged model, and also decreases the storey drift. All these analysis is done with the help of software STAAD Pro v8i. Effects of dead load, live load and earthquake load are also considered as per IS 456, are 13920-1984, and ARE 1893-2002.

**ACKNOWLEDGEMENTS**

I am highly grateful to the Hon’ble Vice-Chancellor, M.D. University for providing me this opportunity to carry out the present dissertation work. The constant guidance and encouragement received from HOD, Civil Engineering Dept. of BRCM COLLEGE OF ENGINEERING BAHAL, (Haryana) has been of great help in carrying out the present work and is acknowledged with reverential thanks.

I would like to express a deep sense of gratitude and thanks profusely to my Dissertation Supervisors, Mr. NISHANT SHARMA, Assistant Professor, Dept. of Civil Engineering BRCM COLLEGE OF ENGINEERING BAHAL (Haryana). Without their wise counsel and able guidance, it would have been impossible to complete the dissertation in this manner.

The copious help received from the Technician Staff of the department of Civil Engineering BRCM COLLEGE OF ENGINEERING BAHAL (Haryana) for the excellent Laboratory support is also acknowledged. Finally, I am indebted to thanks to all whosoever have contributed in this dissertation work.

NISHANT

Roll No. -

CONTENTS

[Title page](#_Toc419726006) i

[Candidate’s Declaration](#_Toc419726007) ii

[Certificate by the supervisor](#_Toc419726008) iii

[Abstract](#_Toc419726009) iv

[Acknowledgments](#_Toc419726010) vi

[Contents](#_Toc419726011) vii

[List of Figures](#_Toc419726012) ix

[List of Tables](#_Toc419726013) x

[Chapter 1: INTRODUCTION](#_Toc419726014) 1-4

1.1 [Introduction 1](#_Toc419726015)

1.2 [Requirement to determine the retrofitting method 2](#_Toc419726016)

1.2.1 [Socio economic constraints for changes 2](#_Toc419726017)

1.3 [Objective of Dissertation 2](#_Toc419726018)

1.4 [Organization of dissertation 3](#_Toc419726019)

1.5 [Summary 3](#_Toc419726020)

[Chapter 2: LITERATURE REVIEW 5-11](#_Toc419726021)

2.1 [Introduction 5](#_Toc419726022)

2.2 [Application and research of FRP in India as compared to China 7](#_Toc419726023)

2.3 [Summary of literature review 11](#_Toc419726024)

[Chapter 3: ESTIMATION OF DAMAGEABILITY 12-17](#_Toc419726025)

3.1 [Data collection, rapid visual screening and condition assessment of buildings 12](#_Toc419726026)

3.2 [Reinforced concrete buildings 12](#_Toc419726027)

3.3 [Condition evaluation of building after earthquake 14](#_Toc419726028)

3.4 [Visual inspection 14](#_Toc419726029)

3.5 [Items of inspection 14](#_Toc419726030)

3.5.1 [Detailed investigation 15](#_Toc419726031)

3.6 [Summary 17](#_Toc419726032)

[Chapter 4: RETROFITTING 18-29](#_Toc419726033)

4.1 [Goals of retrofit 18](#_Toc419726034)

4.2 [Building deficiencies 18](#_Toc419726035)

4.2.1 [Local deficiencies 18](#_Toc419726036)

4.2.2 [Global deficiencies 20](#_Toc419726037)

4.3 [Retrofit strategies 21](#_Toc419726038)

4.3.1 [Local retrofit strategies 21](#_Toc419726039)

4.3.2 [Global retrofit strategies 24](#_Toc419726040)

4.4 [Retrofitting steps 26](#_Toc419726041)

4.5 [To retrofit or not 27](#_Toc419726042)

4.6 [Extent of seismic retrofit 2](#_Toc419726043)9

4.7 [Summary 29](#_Toc419726044)

[Chapter 5: PARAMETRIC STUDY 30-4](#_Toc419726045)4

5.1 [Introduction 30](#_Toc419726046)

5.2 [Details of structure 31](#_Toc419726047)

5.2.1 [Detail of model “A” 31](#_Toc419726048)

5.2.2 [Detail of model “B” 3](#_Toc419726049)7

5.2.3 [Detail of model “C” 3](#_Toc419726050)9

5.2.4 [Detail of model “D” 39](#_Toc419726051)

5.2.5 [Detail of model “E” 40](#_Toc419726052)

5.2.6 [Detail of model “F” 44](#_Toc419726053)

[Chapter 6: RESULTS AND DISCUSSION 45-4](#_Toc419726054)6

6.1 [Introduction 4](#_Toc419726055)5

6.2 [Comparison of average displacement of various model 45](#_Toc419726056)

6.3 [Comparison of soft storey with height of various model 4](#_Toc419726057)6

6.4 [Conclusion 4](#_Toc419726058)6

CHAPTER 7: [CASE STUDY AND FUTURE SCOPE 47-5](#_Toc419726060)1

7.1 [Structural retrofitting case study 4](#_Toc419726061)7

7.1.1 [Detail of the Structure 4](#_Toc419726062)7

7.1.2 [Approach to problem](#_Toc419726063) 48

7.1.3 [Diagnosis](#_Toc419726064) 48

7.1.4 [Remedial measures 5](#_Toc419726065)0

7.2 [Future scope 5](#_Toc419726066)1

[REFERENCES 52-5](#_Toc419726067)4

**LIST OF FIGURES**

|  |  |  |
| --- | --- | --- |
| **Figure** |  | **Page no.** |
| Figure 3.1 | Equipment for rebound hammer test(Seismic retrofit handbook) | 16 |
| Figure 3.2 | use of Schmidt rebound hammer in a slab of building damaged by earthquake(Seismic retrofit handbook) | 17 |
| Figure 4.1 | principles of base isolation technology(Aritra Banerjee BB070543CE) | 26 |
| Figure 4.2 | seismic load capacity versus risk of building collapse(Seismic retrofit handbook) | 28 |
| Figure 4.3 | design seismic load as a function of remaining usable life(Seismic retrofit handbook) | 28 |
| Figure 5.1 | typical column failure of C type building(world housing) | 31 |
| Figure 5.2 | typical wall failures in case of C type building(buildings 2013, 3(1), 173-190) | 31 |
| Figure 5.3 | typical joint failures in case C type building(secure penn state) | 31 |
| Figure 5.4 | Front elevation of building i.e. model A | 32 |
| Figure 5.5 | Front plan of building i.e. model A | 32 |
| Figure 5.6 | 5 storey frame without bracing of model A | 33 |
| Figure 5.7 | Columns in building | 34 |
| Figure 5.8 | Beams in building | 34 |
| Figure 5.9 | STAAD model showing eq. load in x-direction | 36 |
| Figure 5.10 | STAAD model showing eq. load in z-direction | 36 |
| Figure 5.11 | Dead load in STAAD model | 36 |
| Figure 5.12 | Live load in STAAD model | 37 |
| Figure 5.13 | 3-dimension rendered view of model A | 37 |
| Figure 5.14 | Diagonal bracing for model B | 38 |
| Figure 5.15 | Diagonal bracing for model C | 38 |
| Figure 5.16 | Diagonal bracing for model D | 40 |
| Figure 5.17 | STAAD showing retrofitted model E | 40 |
| Figure 5.18 | STAAD showing retrofitted model F | 44 |
| Figure 6.1 | Bar chart showing avg. displacement of different model | 45 |
| Figure 6.2 | Bar chart showing storey drift | 46 |
| Figure 7.1 | Column after jacketing | 51 |

**LIST OF TABLES**

|  |  |  |
| --- | --- | --- |
| **Table** |  | **Page no.** |
| Table 3.1 | Damageability of R.C./steel buildings | 14 |
| Table 5.1 | Height details of the structure (same for all models) | 33 |
| Table 5.2 | General considerations | 33 |
| Table 5.3 | Loads used in analysis of frame | 34 |
| Table 5.4 | For different load cases applied is given below | 35 |
| Table 5.5 | For model B | 38 |
| Table 5.6 | For model C | 39 |
| Table 5.7 | For model D | 39 |
| Table 5.8 | For model E | 43 |
| Table 5.9 | For model F | 44 |