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A Survey on Retrofitting and Repairing of Heavily Cracked Unbonded Post Tensioned Structural System

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ABSTRACT: Recent earthquakes in the Indian subcontinent have led to an increase in the seismic zoning factor over many parts of the country. Also, ductility has become an issue for all those buildings that were designed and detailed using earlier versions of the codes. Under such circumstances, seismic qualification of existing buildings has become extremely important. Seismic qualification eventually leads to retrofitting of the deficient structures. Pushover analysis and evaluation of performance of building using Capacity Spectrum Approach or Displacement Coefficient Method are increasingly used for this purpose. There is a need to look at certain important issues for incorporation in the Indian codes before uniformity of approach can be achieved. This, in turn, needs an in-depth understanding on what has gone into ATC-40 (ATC, 1996) or FEMA -356 (FEMA, 2000), and making appropriate modifications to suit the Indian conditions. It is necessary that the debate on this is started and completed early to achieve the desired results. Pre-disaster preparedness strategies lead to repair/retrofitting of the reinforced concrete structures for ensuring satisfactory performance during earthquakes. Repairs can lead to increased stiffness, strength, and failure-deformation. There is a need to quantify the performance of the structure after the repairs have been carried out. Performance factors have been suggested for such quantification. These are adequate in certain cases but may not be totally satisfactory in others. A large-scale experimental programme undertaken at SERC has shown that if there are inherent weaknesses in the detailing of the original structure, it may not be possible to improve the performance to the desired levels. In these cases, the performance factors may depend on the state of deformation considered for evaluation and may not be unique. There is a need to address this issue, so that suitability of repair measures can be satisfactorily evaluated.

KEYWORDS-Seismic Qualification (SQ), Retrofitting Performance Factors (RPF), Displacement Coefficient Method (DCM), Capacity Spectrum Method (CSM), Reinforced Concrete (RC).

I. INTRODUCTION

1.1 Introduction of the Project Work

Composite materials and high strength adhesives are becoming popular for various structural repair jobs. These materials provide good solutions for repairing, and retrofitting concrete structures. In this system repair work can be done within a short time, without using much labor, and the repair materials generally do not alter the geometric shapes of the original structural member.

a. Motivation

However, the interactive behavior (both short and long term) of un-bonded post-tensioned structural components, when repaired and retrofitted with composite materials is not yet properly understood. The current research was conducted to understand this. Eleven 12'-0" long beams B1 thru B11, were loaded close to their ultimate values. The tests were stopped based on three criteria: excessive cracking, or pre-stressing load reaching over 80%-85% fpu, or deflection reaching twice the allowable deflection. The cracked beams were repaired with varying amount of composite materials

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adhesives, and tested again. The beams were named B1CR, B2CR, B3EgR and so on, where CR represents repair with carbon FRP and EgR represents repair with e-glass FRP. The tests were stopped again based on the above three criteria. Using Carbon and E-glass FRP and adhesives, a very effective repairing and retrofitting system has been developed. The load carrying capacities and deflections of these beams and that of the original un-cracked beams were compared. Various repairing schemes were adopted. Attempts were made to find the minimum usage of the composite materials, prevent diagonal shear cracking, and prevent sudden compression failures. The changes in post-tensioning forces, the effect of having mild steel in the tension zone, and crack propagation at ultimate stage were recorded and discussed here.

b. Retrofitting

Seismic retrofitting is the modification of existing structures to make them more resistant to seismic activity, ground motion, or soil failure due to earthquakes. Presently earthquake-resistant design is being discussed in many forums. If one adopts the provisions of IS:13920-1993 (BIS, 1993), the response reduction factor is 5.0 and for normal frames it is 3.0. This has direct impact on the design forces. The method of analysis and design as described above is the most sophisticated procedure adopted in the design offices. This is the present status, irrespective of what the inconsistencies are in elastic analysis, plastic design for moments and axial forces, and empirical approach for design for shear, bond, etc. It is extremely important to realize that the values obtained in the analysis are at best good indicators for the express purpose of "design". The most essential part, and often the neglected part, is the proper guidance to aid engineers in making the best use of the results available and in providing the reinforcement adequately.

It must be realized at this stage that when one attempts to carry out the seismic evaluation of a building, strictly speaking, the codal provisions at the time of construction, age of the structure, construction practices etc., all become important. It must also be realized that if one is waiting for an exact methodology and rules for the seismic evaluation, one may have to wait for a few more years, if not decades. Presently, there are two nonlinear static analysis procedures available, one termed as the Displacement Coefficient Method (DCM) included in the FEMA-356 document (FEMA, 2000), and the other termed as the Capacity Spectrum Method (CSM) included in the ATC-40 document (ATC, 1996). Both of these methods depend on the lateral load-deformation variation obtained by using the nonlinear static analysis under the gravity loading and idealized lateral loading due to the seismic action. This analysis is generally called as the pushover analysis.

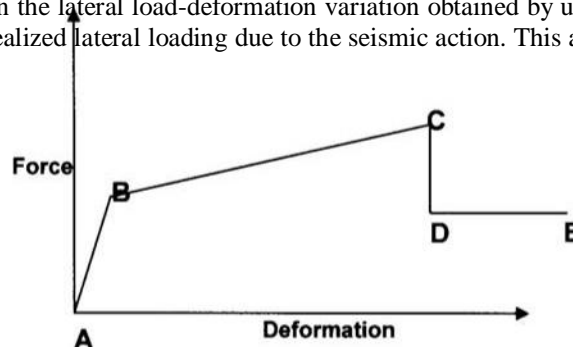


Fig. 1 Idealised force-deformation curve

The pushover analysis may be carried out using force control or deformation control. In the first option, the structure is subjected to an incremental distribution of lateral force, and incremental displacements are calculated. In the second option, the structure is subjected to a deformation profile, and lateral forces needed to generate those displacements are computed. Since the deformation profile is unknown, the first option is commonly used. For the displacement control the user specifies the target maximum displacement at a control point. In certain softwares, displacement control is not the same as applying displacement loading on the structure; displacement control is simply used to measure the displacement that results from the applied loads and to adjust the magnitude of the loading in an attempt to reach certain measured displacement value. The so-called displacement control in this case is essentially a modified form of

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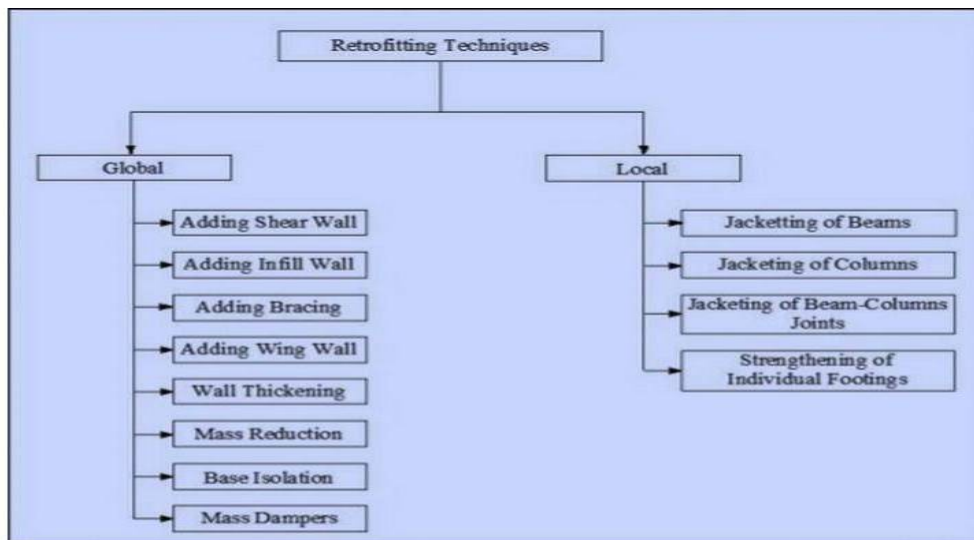
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the force control. The force control strategy can have following options: (i) uniform distribution, (ii) triangular distribution, (iii) generalised power distribution, and (iv) modal adaptive distribution with single or multiple mode participation.

c. Types of Retrofitting Techniques



d. Idealized System Parameters

The multilinear force-displacement curve obtained after the pushover analysis is idealized as bilinear curve, as shown in Figure 4, with a positive or negative post-yield slope.



Fig. 2 Isometric view of the building

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1.2 Objectives

- a. Our aim to find the minimum usage of the composite materials, prevents diagonal shear cracking, and prevents sudden compression failures.
- b. The changes in post-tensioning forces, the effect of having mild steel in the tension zone, and crack propagation at ultimate stage were recorded and discussed here.
- c. Pre-disaster preparedness strategies lead to repair/retrofitting of the reinforced concrete structures forensuring satisfactory performance during earthquakes.
- d. Repairs can lead to increased stiffness, strength, and failure-deformation. There is a need to quantify the performance of the structure after the repairs have been carried out. Performance factors have been suggested for such quantification. These are adequate in certain cases but may not be totally satisfactory in others. A large-scale experimental programme undertaken at SERC has shown that if there are inherent weaknesses in the detailing of the original structure, it may not be possible to improve the performance to the desired levels. In these cases, the performance factors may depend on the state of deformation considered for evaluation and may not be unique.
- e. There is a need to address this issue, so that suitability of repair measures can be satisfactorily evaluated.

1.4 Scope of the Project Work

The cracked beams were repaired with varying amount of composite materials adhesives, and tested again. The beams were named B1CR, B2CR, B3EgR and so on, where CR represents repair with carbon FRP and EgR represents repair with e-glass FRP. The tests were stopped again based on the above three criteria. Using Carbon and E-glass FRP and adhesives, a very effective repairing and retrofitting system has been developed.

II. LITERATURE REVIEW

1. PERFORMANCE OF UNREINFORCED STONE MASONRY BUILDINGS DURING THE 2010/2011 CANTERBURY EARTHQUAKE SWARM AND RETROFIT TECHNIQUES FOR THEIR SEISMIC IMPROVEMENT

From this Paper I Refer-

The sequence of earthquakes that has greatly affected Christchurch and Canterbury since September 2010 has again demonstrated the need for seismic retrofit of heritage unreinforced masonry buildings commencing in April 2011, the damage to unreinforced stone masonry buildings in Christchurch was assessed and recorded with the primary objective being to document the seismic performance of these structures, recognizing that they constitute an important component of New Zealand's heritage architecture. A damage statistics database was compiled by combining the results of safety evaluation placarding and post-earthquake inspections, and it was determined that the damage observed was consistent with observations previously made on the seismic performance of stone masonry structures in large earthquakes. Details are also given on typical building characteristics and on failure modes observed. Suggestions on appropriate seismic retrofit and remediation techniques are presented, in relation also to strengthening interventions that are typical for similar unreinforced stone masonry structures in Europe.

2. SIMULATION OF HIGHLY DUCTILE FIBER-REINFORCED CEMENT-BASED COMPOSITE COMPONENTS UNDER CYCLIC LOADING.

From this Paper I Refer-

Ductile fiber-reinforced cement-based composites (DFRCCs) are being investigated for new design as well as retrofitting of structures in seismic regions. DFRCC is highly ductile and is characterized by strain-hardening in tension to strains over 3% and by unique cyclic loading behavior. To accurately predict the structural performance of DFRCC components under cyclic and seismic loading, a robust constitutive model is needed for structural scale simulations. In this paper, a constitutive model based on total strain is proposed and applied to simulate structural component tests. The

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model in particular captures DFRCC's unique reversed cyclic loading behavior. The simulation results show that the implemented model is robust and reasonably accurate in simulating DFRCC structural components reinforced with steel and fiber-reinforced polymer bars.

3. CONTROVERSIAL ASPECTS IN SEISMIC ASSESSMENT AND RETROFIT OF STRUCTURES IN MODERN TIMES: UNDERSTANDING AND IMPLEMENTING LESSONS FROM ANCIENT HERITAGE.

From this Paper I Refer-

Several alternative seismic retrofit and strengthening solutions have been studied in the past and adopted in practical applications ranging from conventional techniques, utilizing braces, jacketing or infill, to more recent approaches such as supplemental damping devices or advanced materials (e.g. Fibre Reinforced Polymers, FRP, or Shape Memory Alloys, SMA). A series of controversial issues are implicit in the complex decision-making process of seismic retrofit, where both rational and counter-intuitive solutions can satisfy some of the most critical aspects of multi-level performance-based seismic retrofit criteria. Interesting and fascinating suggestions and lessons can be obtained by reviewing the current trends in new design (i.e. innovative solutions for the future generation of buildings systems) as well as the architectural solutions used by the ancients. While walking this "bridge of knowledge" of our cultural heritage with the critical eyes of a curious and passionate observer, we can observe surprising commonality in engineering problems and their successful (and recently attempted) solutions. Understanding and implementing this heritage could lead to a uniquely stable platform for major breakthroughs in the development of "new solutions" in seismic design and retrofit.

4. INCREASING THE CAPACITY OF EXISTING BRIDGES BY USING UNBONDED PRESTRESSING TECHNOLOGY: A CASE STUDY ANTONINO RECUPERO,¹ NINO SPINELLA,¹ PIERO COLAJANNI,² AND COSIMO D. SCILIPOTI³

From this Paper I Refer-

This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. External posttensioning or unbonded prestressing was found to be a powerful tool for retrofitting and for increasing the life extension of existing structures. Since the 1950s, this technique of reinforcement was applied with success to bridge structures in many countries, and was found to provide an efficient and economic solution for a wide range of bridge types and conditions. Unbonded prestressing is defined as a system in which the post-tensioning tendons or bars are located outside the concrete cross-section and the prestressing forces are transmitted to the girder through the end anchorages, deviators, or saddles. In response to the demand for a faster and more efficient transportation system, there was a steady increase in the weight and volume of traffic throughout the world. Besides increases in legal vehicle loads, the overloading of vehicles is a common problem and it must also be considered when designing or assessing bridges. As a result, many bridges are now required to carry loads significantly greater than their original design loads; and their deck results still deteriorated by cracking of concrete, corrosion of rebars, snapping of tendons, and so forth. In the following, a case study about a railway bridge retrofitted by external posttensioning technique will be illustrated.

5. FIBER-REINFORCED POLYMER COMPOSITES FOR CONSTRUCTION—STATE-OF-THE-ART REVIEW C. E. BAKIS¹; L. C. BANK, F.ASCE²; V. L. BROWN, M.ASCE; E. COSENZA⁴; J. F. DAVALOS, A.M.ASCE; J. J. LESKO; A. MACHIDA; S. H. RIZKALLA, F.ASCE AND T. C. TRIANTAFILLOU, M.ASCE

From this Paper I Refer-

A concise state-of-the-art survey of fiber-reinforced polymer also known as fiber-reinforced plastic! composites for construction applications in civil engineering is presented. The paper is organized into separate sections on structural shapes, bridge decks, internal reinforcements, externally bonded reinforcements, and standards and codes. Each section includes a historical review, the current state of the art, and future challenges.

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6.FINITE ELEMENT ANALYSIS OF CFRP WRAPPED BONDED AND UNBONDED POST TENSIONED BEAMS ANJALI GUPTA¹, DR.M.S.KULKARNI²

From this Paper I Refer-

Four Finite Element (FEM) models has been developed using Ansys 15 for Bonded and Unbonded Post tensioned prestressed concrete beams retrofitted with frp designed based on American guidelines ACI and AASHTO. In this research comparison of two guidelines AASHTO and ACI by formulating excel sheets for generalized solution and validation of results by finite element modeling in ANSYS software is done. This work gives the comparison of total stresses, flexure capacity increase, deflection reduction, crack control, displacement curves and the check for shear on the same model from both the methods ACI and AASHTO for bonded and unbonded PT beams. Although a great amount of work has been done on retrofitting of concrete and prestressed concrete bridge girders but comparison of these two design procedures for prestressed beams with bonded and unbonded strands for residential is really beneficial to design professionals. The results showed that FRP strength was effectively utilized in the section selected herein, which could be addressed through economy for the amount of FRP and prestressing steel used, thereby increasing the section ductility. The ACI and AASHTO approach produced comparable results to the FEM and can be effectively and conveniently used in design.

7.STUDY ON RETROFITTED R.C.C. BUILDING BY DIFFERENT NDT METHODS NIKHIL L. JAGTAP, PROF. P.R. MEHETRE.

From this Paper I Refer-

In this project, condition of the existing structure is assessed using NDT'S and it is proposed to extend the structure. The building was designed according to the state of the art over 40 years ago, it did not meet the present day requirement. The project study deals with strengthening and enhancement of performance of existing structure by means of Retrofitting, so that structure can perform well when it would be subjected to additional loads over it. Building is residential community building having G+2 storey. Utility or purpose of building is for society gatherings. Number of floors proposed to extend are three. The present work deals with NDT on existing structural elements, determination of load and moment carrying capacity of structural elements before and after extension, method applied for strengthening of structure and design of the existing structural elements such as R.C.C. beams and columns according to the load carrying capacity required. Keywords - Confinement, jacketing, NDT test, strengthening.

III. METHODOLOGY

A. OUTLINE OF RETROFITTING METHOD USING ELASTO-PLASTIC DAMPERS

The proposed retrofitting method achieves a high level of structural safety through dampers installed in an existing seismically vulnerable building more efficiently than conventional retrofitting methods. There are many ways of installing dampers in an existing building, including (1) installing steel-framed braces that incorporate dampers into an existing open frame and (2) installing damper-embedded studs into existing frame so that existing openings are maintained. The latter method can be used in cases where the building is to be strengthened internally. Dampers used in this retrofitting method are elasto-plastic steel dampers that have honeycomb openings. The damper used in the experimental study reported in this paper is shown in Figure 1(a). The damper is designed to concentrate story drifts in its plastic deformation region and efficiently absorb earthquake energy by cyclic plastic deformations. The load-deformation relationship, as shown in Figure 1(b), plot as spindle-shaped hysteresis loops and indicate a high energy absorbing capacity.

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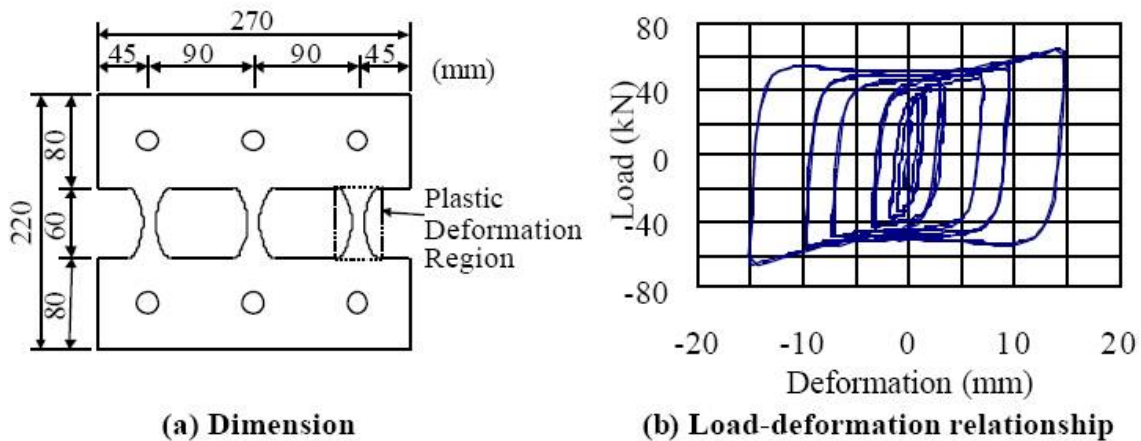


Fig.1: Elasto-plastic damper

IV. CONCLUSION

This paper attempts to gather the available information particularly on the nonlinear behaviour, and the various approaches available to evaluate the seismic safety of buildings. It is emphasized that the existing procedure is grossly approximate, and hence improving sections of the approach to high levels of accuracy would not necessarily lead to a better result. The need of the present hour is to see what needs to be done in the Indian context. The basic inputs are earthquake spectrum, nonlinear load-deformation behaviour under monotonic cyclic and random loadings, acceptable levels of damage under various performance levels etc., and these have a lot of grey areas. There needs to be a wider discussion among the researchers to evolve a good standard for use by the profession. The need for evaluating the various repair strategies for use in the improvement of the seismic performance of reinforced concrete structures has been highlighted. The behaviour of repaired beams and beam-column joints has been discussed. It is observed that inherent deficiencies in the detailing of the beam-column joints get reflected even after repair, though the performance factors indicate significant improvement. There is a need to evolve suitable performance factors when the system shows a negative stiffness. Two of the logical extensions show that the repair would not be as effective in these cases.

REFERENCES

- [1] Tong-Seok Han "Simulation of Highly Ductile Fiber-Reinforced Cement-Based Composite Components Under Cyclic Loading" ACI Structural Journal/November-December 2003
- [2] MISS. SHITAL PARDESHI "REPAIR, RESTORATION AND STRENGTHENING OF BUILDING" NOVATEUR PUBLICATIONS INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY [IJIERT] ISSN: 2394-3696 VOLUME 4, ISSUE 3, Mar.-2017
- [3] AntoninoRecupero, "Increasing the Capacity of Existing Bridges by Using Unbonded Prestressing Technology: A Case Study" Published 23 July 2014
- [4] Stefano Pampanin "Controversial aspects in seismic assessment and retrofit of structures in modern times:Understanding and implementing" BULLETIN OF THE NEW ZEALAND SOCIETY FOR EARTHQUAKE ENGINEERING, Vol. 39, No. 2, June 2006
- [5] Shri. Pravin B. Waghmare " MATERIALS AND JACKETING TECHNIQUE FOR RETROFITTING OF STRUCTURES" IJAERS/Vol. I/ Issue I/October-December, 2011/15-19
- [6] Finite Element Analysis Of Cfrp Wrapped Bonded And Unbonded Post Tensioned Beams Anjali Gupta1, Dr.M.S.Kulkarni2
- [7] Study On Retrofitted R.C.C. Building By Different Ndt Methods Nikhil L. Jagtap, Prof. P.R. Mehetre.