International Scenario of Codes for Design and Strengthening of Masonry Structures

Dr. R.K. Jain¹, Deepa A. Joshi²
¹Principal, Dr. DYPIET, Pimpri, Pune, INDIA
²Research Scholar, Sinhgad COE, Pune, INDIA

ABSTRACT

Masonry structures are one of the oldest forms of construction though not obsolete and are still in practice all over the world. Masonry Codes are necessary for design of new masonry structures and codes are also required for a large inventory of existing masonry structures which need strengthening. Very few codes are available for strengthening of masonry structures which do not meet all requirements. The objective of this paper is to study various masonry codes available for above mentioned purposes and to identify the areas where masonry codes are required to be established. In this paper, the review of available masonry codes from number of countries has been presented to understand the global scenario of masonry codes. The Indian scenario of masonry codes is discussed in detail.

Keywords— Codes, FRP, Masonry, Strengthening

I. INTRODUCTION

Masonry structures are one of the oldest forms of construction though not obsolete and are still in practice all over the world. After more than 6000 years, masonry is still used today for construction due to its advantages such as aesthetics, heat and sound insulation, fire resistance and economic considerations. Until 1950’s there were no engineering methods of designing masonry for buildings and thickness of walls was based on Rule-of-Thumb tables given in Building codes and Regulations [1]. Thereafter the intensive research on masonry was conducted in advanced countries and the codes on masonry were established. Unreinforced masonry (URM) buildings, which are also termed as load bearing structures, are very common type of masonry construction and Reinforced Masonry buildings are also used. ‘Confined masonry’ is a new technique, which is being used for construction of masonry buildings. Masonry Codes are necessary for design of new masonry structures and codes are also required for a large inventory of existing masonry structures which need strengthening.

The existing masonry structures need strengthening or retrofitting due to many reasons such as lack of strength, stiffness, ductility and durability. Apart from earthquake requirements, buildings need strengthening due to modifications done in existing structure or change in use of the building. Deterioration of material strength on aging is another significant reason for need of strengthening or retrofitting. Along with loss of human lives and socio-economic problems, damages and collapse of historically important structures takes place due to earthquake. Preservation of Monuments is important as these are identification of culture, region, country and having artistic value. Seismic retrofitting of Historic Monuments is a specialized task because many conventional techniques cannot be applied as prime objective of this type of retrofitting is to preserve aesthetics of these structures. Very few codes are available for strengthening of masonry structures which do not meet all requirements.

Hence the masonry codes are necessary for construction of new masonry buildings of various types such as URM, Reinforced Masonry and Confined Masonry. Also the codes are required for various strengthening techniques for existing masonry structures. The objective of this paper is to study various masonry codes available for above mentioned purposes and to identify the areas where masonry codes are required to be established. In this paper, the review of available masonry codes from number of countries has been presented to understand the global scenario of masonry codes. The Indian scenario of masonry codes is discussed in detail.
II. CODES FOR DESIGN OF MASONRY STRUCTURES

The codes available for design of new masonry construction are studies and the highlights of masonry codes followed by various countries like Europe, America, Canada, New Zealand and India are presented in this section.

- **Eurocode 6 (BS EN 1996) [2]**
  
  This code was published by the European Committee for Standardization (CEN) and is to be used with the National Application Document (NAD) of member countries. It consists of four documents. Part 1-1 is for General rules for reinforced and unreinforced masonry structures, Part 1-2 is for structural fire design, Part 2 discuss about Design considerations, selection of materials and execution of masonry and Part 3 gives simplified calculation methods for unreinforced masonry structures. Seismic design aspects are not covered in Eurocode 6, however Eurocode 8 is for design of structures in seismic regions [2 and 3].

- **Building Code Requirements For Masonry Structures (ACI 530-02/ASCE 5-02/TMS 402-02) [4]**
  
  This code provides minimum requirements for the structural design and construction of masonry elements consisting of masonry units bedded in mortar. The code discuss in detail, ‘Allowable Stress Design’ and ‘Strength Design’ for Unreinforced and Reinforced Masonry. This code has been adopted as standard of the American Concrete Institute (ACI) in 2002, the Structural Engineering Institute of American Society of Civil Engineers in 2001 and The Masonry Society in 2002.

- **International Building Code 2000 [5]**
  
  International Building Code 2000 has been developed by International Code Council, designed to meet need for a modern, up-to-date building code addressing the design and installation of building systems through requirements emphasizing performance. A separate chapter (Chapter 21) has been provided for Masonry. This chapter covers the materials, design, construction and quality of masonry. Masonry design by ‘Working Stress Method’, ‘Strength Design’ and ‘Empirical Design’ has been discussed in this code. Seismic design requirements for masonry are also provided in this code.

- **Canadian Standards Association (CSA) Standards, Design of masonry structures (S304.1-04) [6]**
  
  This is a limit states design standard. This Standard provides requirements for the structural design of Unreinforced, Reinforced and Prefabricated masonry structures and components in accordance with the limit states design method of the National Building Code of Canada. This Standard also provides requirements for the structural design of prestressed masonry beams, walls and columns. In addition, this Standard provides requirements for the empirical design of Unreinforced masonry.

- **New Zealand Standard – Design of Reinforced Concrete Masonry Structures (NZS 4230: 2004) [7]**
  
  This code has been established by ‘Standards Council’ superseding NZS 4230: Parts 1 and 2:1990 ‘Practice for the Design of Concrete Masonry Structures’. This latest document recognizes the predominant use of reinforced concrete masonry for structural applications in New Zealand and incorporates research findings specifically pertaining to the performance of Reinforced and Prestressed concrete masonry.

- **IS 1905:1987 Code of Practice for Structural Use of Unreinforced Masonry [8]**
  
  IS 1905:1987 is Indian Standard code for structural use of Unreinforced Masonry. This code gives recommendations for structural design aspect of unreinforced load bearing and non-load bearing walls, constructed with solid or perforated burnt clay bricks, sand-lime bricks, stones, concrete blocks, lime based blocks or burnt clay hollow blocks in regard to the materials to be used, maximum permissible stresses and the methods of design.

III. CODES FOR REPAIR / STRENGTHENING / RETROFITTING OF MASONRY STRUCTURES

There are very few codes or guidelines available for repair/ strengthening / retrofitting of Masonry Structures. Various conventional techniques for repair / strengthening of masonry structures are discussed in these codes. However many advanced techniques are not incorporated in these documents. The available codes including Indian code are discussed in brief in this section.

- **FEMA 547: 2006: Techniques for the Seismic Rehabilitation of Existing Building [9]**
  
  This document describes the common seismic rehabilitation techniques used for existing buildings. FEMA 547 [9] supersedes FEMA 172 [10] : NEHRP Handbook for Seismic Rehabilitation of Existing Building ; which was published in 1992. In FEMA 547 [9], various techniques for seismic retrofitting of existing Unreinforced and Reinforced Masonry buildings have been discussed in detail. The techniques covered in this document are ‘Concrete Overlay to Masonry Walls’, ‘Addition of Concrete or Masonry Shear Wall’, ‘Addition of Steel Moment Frame’, ‘Addition or enhancement of cross walls’ and ‘Addition of Veneer Ties in URM Wall’. FEMA 547 [9] has also suggested ‘Fiber Reinforced Polymers Overlay to Masonry Wall’ as one of the strengthening technique. It has been mentioned that improving inadequate in-plane wall strength is the primary purpose of a new fiber-
reinforced polymer (FRP) overlay, but the overlay can also improve out-of-plane bending capacity. It has been also mentioned that there are no code guidelines or FEMA 356 [11] provisions explicitly addressing FRP overlays on unreinforced masonry.

- Indian Standard Codes

IV. CODES FOR STRENGTHENING / RETROFITTING OF MASONRY STRUCTURES USING FIBER REINFORCED POLYMERS (FRP)

Separate codes for Strengthening / Retrofitting of Masonry Structures using FRP are not available, however ACI25, 2003 [15] and CNR DT 200 (2004, R1/2013) [16] discuss about the masonry structures or elements retrofitted with FRP. Highlights of these codes are presented in this section.

  This criterion establishes minimum requirements on fiber-reinforced polymer (FRP) composite systems used to strengthen concrete and masonry structural elements. In this code, qualification tests for various elements of structures have been discussed, for masonry walls Out-of-plane and In-plane load tests are discussed. Minimum acceptance design criteria for flexural strength enhancement, axial load capacity enhancement and shear strength enhancement using FRP has been discussed.

  This document is developed by National Research Council, Advisory Committee on Technical Recommendations for Construction, Italy. This document contains sections on Materials, Basic concepts on FRP strengthening, Strengthening of reinforced and prestressed concrete structures, Strengthening of masonry structures. Design guidelines for use of FRP as strengthening material for masonry columns and walls are provided in detail in this code.

No Indian Standard is available till date for Masonry Structures retrofitted with FRP.

V. CONCLUSION

The codes /guidelines for construction of URM masonry structures are available internationally. The provisions for strengthening / retrofitting of masonry structures are also available in some codes however the codes for innovative techniques such as use of FRP for strengthening / retrofitting of masonry structures are very limited.

In Indian scenario, no code is available for reinforced masonry, confined masonry and strengthening / retrofitting using FRP. In order to use the reinforced masonry and confined masonry for new construction, Indian codes in this context are needed. Also for retrofitting of existing masonry structures; especially the historical monuments of India, Indian codes for retrofitting / strengthening of masonry structures using FRP are required to be established. The work in this context is at research level and in order to use above mentioned techniques in field, lot of research work in this context for Indian condition is needed.

REFERENCES


