1.3 Research Objectives

The main aim of a structural designer is to prevent the building damages and collapse related with the earthquake accidents to maintain emergency functioning of the facility.

Also it is essential to reduce the severity of losses caused from seismic attacks.

So the main objectives to do this research contain followings:

1. To optimize the behavior of structures especially R.C.C buildings against Seismic attacks using modern techniques.

2. To prevent such deflections that would produce the collapse of elements structures.

3. To become familiar of new and advanced methods and activities performing worldwide.

This can be achieved by:

a. Selecting appropriate materials for construction for optimize earthquake effect.

b. Proportioning of structural members.

c. Having adequate knowledge and safety precautions to optimize its dangers.

So that cost effectiveness and attractive solution can be arrived at. If failure behavior of building structure is known, this objective can be achieved.

II. Methodology

As it obvious that my main reason for this research is to aware and improve the awareness of people toward this really destructive phenomenon which is Earthquake, so concerning this issue I`ve decided to make a research regarding new technologies for constructing Earthquake resistant structures, Which was Started from a simple idea from local building projects, then I started to search and mention new ways which the world is using right now, thus the Methodology process is as following:

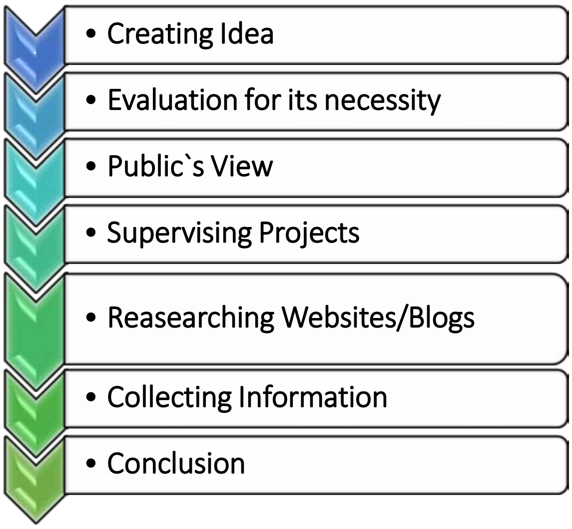

Fig 2.1: *Methodology Chart*

III. Necessity for the Earthquake Resistant Construction

According to the 2011 census of Afghanistan, there are over 30 million housing units in the country, with two-thirds of these being rural houses. The Geological Survey of Afghanistan has classified the country into four seismic zones with varying seismic potential as shown in Fig 2.1.

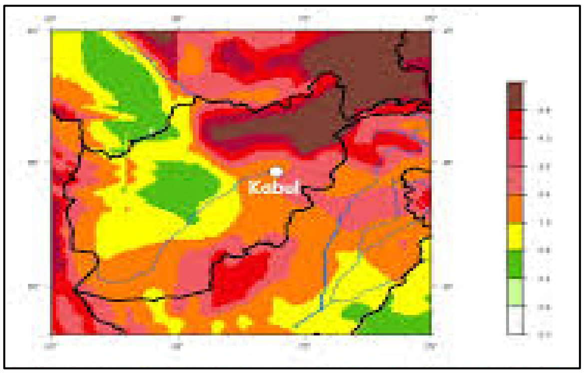

Fig 2.1: *Seismic Zonation Map of Afghanistan (https://nehrpsearch.nist.gov).*

On the other hand, to the larger percentage of housing stock in the rural area, a rapid growth in the urban population has been witnessed over the last decade. The census of India indicates a 32% increase in growth of urban population from 286 million in 2001 to 377 million in 2011.

The urban population by the end of 2030 is projected to be nearly 590 million. As per the statistics, 50% of the demand for construction activity in India comes from the infrastructure sector; the rest comes from industrial activities, residential and commercial development. Due to this rapid urbanization, there is an increased demand for infrastructure, essential basic amenities, residential layouts and community development *(Abarkane, C., 2017).*

The time of occurrence (day or night) of an earthquake plays a major role as they have a direct impact on the occupancy of buildings. For example, Latur earthquake (1993) occurred in the early hours around 3:53AM when the majority of the population in the affected area were asleep. On the contrary Bhuj earthquake (2001) occurred in the morning around 8.46AM, with the majority of the people awake and minimum occupancy of the building. These two earthquakes exhibited the poor performance of non-engineered building units such as random rubble masonry in mud mortar with heavy roofs as well as modern multistory RC framed buildings (*BMTPC, 2006*) Fig 2.2.

The past earthquake experience has demonstrated the lack of seismic design in modern residential buildings. At the same time, the importance of incorporation of seismic principles in structural design for a building to perform as a single unit during an earthquake has become clearer. It is necessary to empower rural communities in ensuring seismic safety of the building stock by creating awareness about earthquakes and importance of earthquake-resistant buildings. The built environment in urban sectors has to be planned and designed carefully in the initial stages so that the building configuration is favorable for good seismic performance.

Fig 2.2: *Apartment collapse in 2001 Bhuj earthquake with separation of the lift shaft (www.bbcnews.com/exlusive_photage)*

IV. Building Typologies

Ideally, the classification based on construction type should be based on the knowledge of the structural system, load transfer mechanism, the predominant construction material used, and the performance during past earthquakes. Buildings are classified based on the material type as follows *(MacGREGOR, J., 2009)*:

- Masonry and Mortar type
- Structural Concrete
- Steel
- Wooden Structures

Figure 3.1 depicts various types of buildings categorized under Masonry type in our country.

Similarly, the classification of various building units under Structural Concrete, Steel, and Wooden Structures category are presented in the subsequent Figures 3.2, and 3.3.

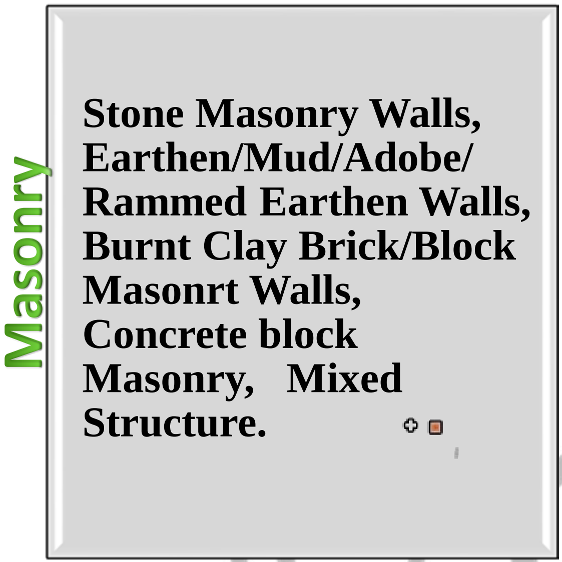

Fig 3.1: *Classification of various masonry units.*

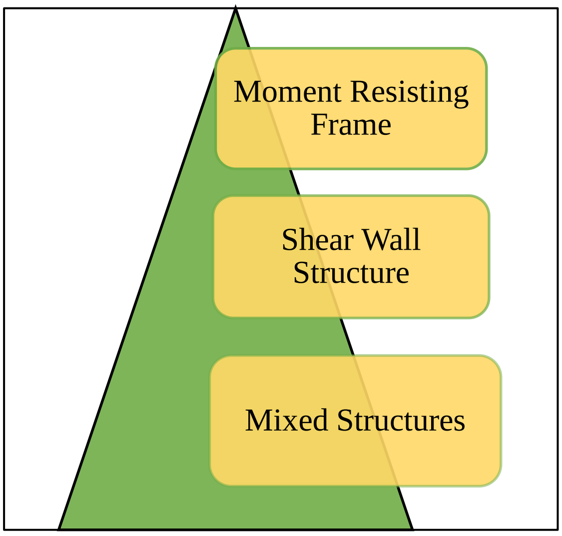

Fig 3.2: *Classification of various load bearing units under Structural Concrete.*

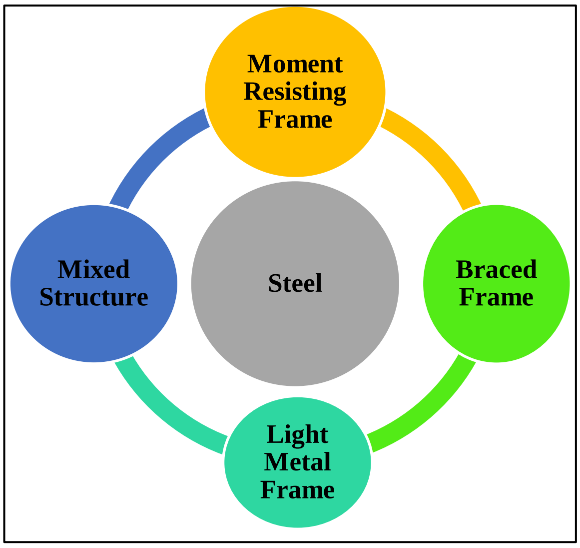

Fig 3.3: *Classification of various load bearing units of steel.*

V. Modern Construction Techniques for Earthquake Resistant Buildings

5.1 Pre Stressed Concrete

Members in earthquake-resistant construction this ensures proper connection between various components of a structure. Further, this technology has been widely adopted in New Zealand.

5.2 Shape-Memory Alloys

Exhibit unique characteristics are desirable in an earthquake resistant building. They have the ability to dissipate significant energy without significant degradation or permanent deformation. The most common shape memory alloys are made of metal mixtures containing copper-zinc-aluminum-nickel, copper-aluminum-nickel or nickel titanium. This specific smart material is being widely researched to explore its extensive applications (Jain, S.K., 2015).

The important structures such as hospitals, fire stations, and other public buildings need to remain functional after an earthquake. In order to make this possible, the response of the building to seismic load must be controlled using suitable control devices such as:

5.3 Base Isolation

It's one of the widely accepted and adopted approaches for protecting the building from seismic forces. It is a collection of structural elements responsible for decoupling superstructure from the substructure. When the ground supporting the foundation of the building shakes, this component undergoes lateral displacement while keeping the structure intact.

There is considerable interest now in base-isolated systems among earthquake engineers – especially in countries like Japan, USA, and New Zealand – with an eye towards developing cheaper systems with broader applications.

5.4 Seismic Dampers

Diagonal braces in a moment resisting frame were used as an effective lateral load resisting system. However, recent developments in the area of structural seismic response control have led to the replacement of these bracings with seismic dampers as shown in Figure 4.1.

These dampers act like the hydraulic shock absorbers in cars – much of the sudden jerks are absorbed in the hydraulic fluids and only little is transmitted above to the chassis of the car. When seismic energy is transmitted through them, dampers absorb part of it and reduce the magnitude of the force acting on a structure. Commonly used types of seismic dampers include viscous dampers (energy is absorbed by silicone-based fluid passing between piston-cylinder arrangement), friction dampers (energy is absorbed by surfaces with friction between them rubbing against each other), and yielding dampers (energy is absorbed by metallic components that yield). In India, friction dampers have been provided in an 18-story RC frame structure in Gurgaon, India

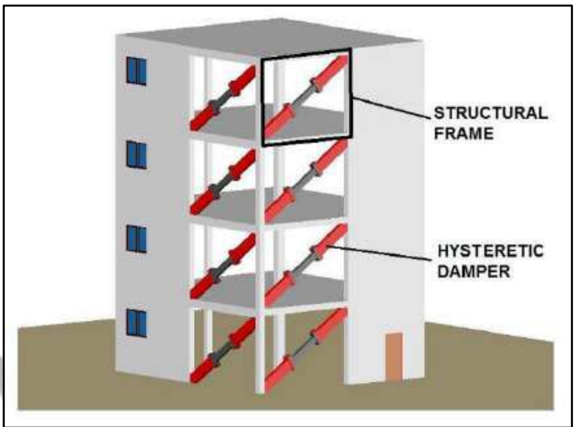

Fig 4.1: *Seismic Energy Dissipation Devices (www.reasearchgate.net).*

5.4 Steel Plate Shear Walls

Shear walls are considered as an essential component of a lateral load resisting systems and steel is well known for its ductile behavior. Combining these two desirable properties, an effective load resisting system was developed and has found wide applications in Japan and North America. These walls are designed in such a way that they bend instead of buckling under the action of lateral loads. These walls are significantly thinner and lighter, thereby reducing the building weight. Further, these walls need not be cured and hence, speeding up the construction process.

5.5 Carbon Fibers

The tensile characteristics and the stable nature of a spider web were studied by various researchers in Japan. An Earthquake-Resistant Building Made with Carbon Fabric - resembling a giant spider web has been constructed in Nomi City of Ishikawa Prefecture in Japan. This is the world's first seismic reinforcement structure made of carbon fiber material.

VI. Recommendations

After evaluation of several ways and alternatives for earthquake structures design, I recommend all designers and architectures to use these useful and important techniques during their projects to save either assets or people's lives.

These alternatives can be low budged ones or the method with better efficiency and little bit more expense. For example, steel plate shear walls can be better but it's a bit costly. On the other hand using dampers and base insulation have both better resistance and better adequate safety.

Also many more other technologies are yet to discover and new ways will be available in a very near future. As the arena of knowledge is exceeding day by day, so it's important to be up to date.

VII. Conclusions

The researchers all over the world are attempting to produce cost-effective and efficient construction technology by making use of the locally available materials. For example, in Peru, researchers have made traditional adobe structures much stronger by reinforcing walls with plastic mesh. In India, engineers have successfully used bamboo to strengthen concrete. And in Indonesia, some homes now stand on easy-to-make bearings fashioned from old tires filled with sand or stone. It was also found that even the no engineered constructions sometimes possess the required resistance to earthquake ground motions.

The earthquake safe construction technology should mainly involve usage of materials of ductile nature, earthquake resilient building configuration, lightweight structural components to reduce the seismic forces and robust architectural forms.

References

[1]. Abarkane, C., Galé-Lamuela, D., Benavent, A., Suárez, E., Gallego, A. (2017). *Ultrasonic Pulse-Echo Signal Analysis for Damage Evaluation of Metallic Slit-Plate Hysteretic Dampers.* Ammor Books, New York.

[2]. BMTPC (2006). *Vulnerability Atlas of India*. Building materials and technology promotion council, Ministry of Urban Development, Government of India, New Delhi.

[3]. Duggal, S. (2007). *Earthquake Resistant design of Structures*. Oxford University Press, USA.

[4] IS 13828–1993. *Indian standard guidelines for improving earthquake resistance of low strength masonry buildings*. Bureau of Indian Standards, New Delhi.

[5]. Jain, S. K., Brzev, S., Bhargava, L. K., Basu, D., Ghosh, I., Rai, D. C., & Ghaisas, K. V. (2015). *Confined masonry for residential construction, campus on the*

Sabarmati monograph. Indian Institute of Technology, Gandhinagar.

[6]. Make India Statistics. (2015). makeindia.com/sector/construction.

[7]. MacGREGOR, J., Wight, J.K. (2009). *Reinforced Concrete: Mechanics and Design*, Pearson Publisher, 5th Edition, New York.

[8]. NDMA (2013*). Seismic Vulnerability Assessment of Building Types in India*, Technical Document (Tech-Doc) on Typology of Buildings in India.

[9]. Segui, W. (2013). *Steel Design*. Cengage Learning, 5th Ed, LA.

[10]. Sinha, R., Goyal, A. (2004).*A national policy for seismic vulnerability assessment of buildings and procedure for rapid visual screening of buildings for potential seismic vulnerability*. Report to Disaster Management Division, Ministry of Home Affairs, Government of India.

* * *