REPORT NUMBER: R1

**A**

**REPORT**

**ON**

**NEEDS OF RETROFITTING**

**SUBMITTED BY:**

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**DEPARTMENT OF EARTHQUAKE ENGINEERING**

**KHWOPA COLLEGE OF ENGINEERING**

**BHAKTAPUR**

**AUGUST 18, 2015**

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# PREFACE

Building construction is a traditional science which deals with the modern methods of sound construction incorporating appropriate use of materials, sufficient strength and performance. Buildings are important structures for human beings, concrete buildings are rapidly increasing. Buildings provide safety but if it is not properly designed then it will be the cause of loss of life and property. Building protects us from every danger so we also have some responsibilities towards its protection. This report deals with how to protect our buildings.

There are different four measures discussed here in our report which we can use to protect our buildings. Our everyday life starts with building and ends with the same. Most of the human activities are performed in building. Buildings saves our life and property so it should be strong enough to carry forces which are acted upon it for this also we need to use protective measures for building protection. Generally every building is strong against compressive force but it does not possess better performance against lateral loads for which we need to be careful. Many buildings where completely collapsed during this recent earthquake with huge loss of life and property.

We mainly discussed about base isolation, tuned mass damper, shock absorber, carbon fiber wraps along with its design and mechanism. We can save many lives as well as properties by applying these protective measures in buildings. These type of measures are not used recently due to lack of skill man power and also due to lack of awareness. It is very essential in our country and it must be concerned while designing phase for the new ones and it may be retrofitted for the old ones. If we will generate skilled manpower and raise awareness then these measures can be beneficial for us.

# ACKNOWLEDGEMENT

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We must acknowledge our deep sense of gratitude towards Er. Shom Nath Shrestha for the orientation classes regarding “Different Measures of Building Protection” from where our team got massive knowledge which is used in this report.

# ABSTRACT

This report is the outcome of one month study, field visit and group discussion as well as consulting with professionals and experts. Different methods and field application were gained up to this phase. Various measures for building protection were determined visiting sites which where destructed by recent earth quake. Condition of building were studied properly and effective measures for the particular building protections where determined. Concepts and ideas of different measures where gained through the experts and special lecture from professionals. There are various measures of building protection which not increases the life of building but it helps building to resist lateral load and show its durability up to designed period. These protective measures are very useful for earth quake prone area to reduce its effect. This report is prepared with great effort and dedications. We are always learning for knowledge and promotions. Therefore, we feel that this report deserves the excuses and tolerances from the reader and professors for any errors and blunders present, despite of the best efforts.

*Keywords: Base isolation, Carbon fiber, Shock absorber, Tuned mass damper*

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# NEEDS OF RETROFITTING BUILDINGS

## Introduction

#### Earthquake:

An earthquake (also known as a quake, tremor) is the perceptible shaking of the surface of the Earth, which can be violent enough to destroy major buildings and kill thousands of people. The severity of the shaking can range from barely felt to violent enough to toss people around.

Seismic Retrofit:

Seismic retrofitting is the modification of existing structures to make them more resistant to seismic activity, ground motion, or soil failure due to earthquakes.

Nepal is an Earthquake prone country and it is very essential to take proper steps to make our buildings and structures resilient so that we may prevent loss of life and property due to earthquakes. In the recent earthquake on 25thApril 2015 many high rise buildings and residential buildings showed vulnerability and most of them either collapsed or were partially damaged. So it is important to adopt various retrofitting techniques for these buildings so that no such damage occurs in the mere future. Retrofitting doesn’t completely prevent damage but it helps to reduce the damage and collapse of structure which in result will save many people in an earthquake.

Our project mainly deals with three components firstly various retrofit methods available, secondly the reasons why retrofitting of buildings are not being put into action, lastly methods of retrofit techniques to adopt. The impacts of retrofit measures vary from measure to measure. Therefore, impact definitions are required for each measure and are made by assigning an impact level to each combination of assessment location and types.

### Methods of Retrofitting

1. Base Isolation
2. Tuned Mass Damper
3. Shock Absorber
4. Carbon Fiber Wrap

### 1.2. Performance Objectives of Retrofitting Buildings

1. Public safety
2. Structure Survivability
3. Structure functionability
4. Structure unaffected

## 2. Different Techniques Available

### 2.1. Base Isolation

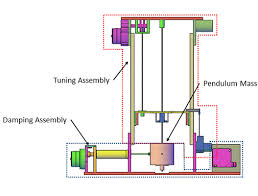
 Base isolation is a collection of structural elements of a building that should substantially decouple the building's structure from the shaking ground thus protecting the building's integrity and enhancing its seismic performance. This earthquake engineering technology, which is a kind of seismic vibration control, can be applied both to a newly designed building and to seismic upgrading of existing structures. Normally, excavations are made around the building and the building is separated from the foundations. Steel or reinforced concrete beams replace the connections to the foundations, while under these, the isolating pads, or base isolators, replace the material removed. While the base isolation tends to restrict transmission of the ground motion to the building, it also keeps the building positioned properly over the foundation. Careful attention to detail is required where the building interfaces with the ground, especially at entrances, stairways and ramps, to ensure sufficient relative motion of those structural elements.

Figure 1: Base Isolation

### 2.2. Tuned Mass Dampers

Tuned mass dampers (TMD) employ movable weights on some sort of springs. These are typically employed to reduce wind sway in very tall, light buildings, bridges. Similar designs may be employed to impart earthquake resistance in eight to ten story buildings that are prone to destructive earthquake induced resonances.

Figure 2: Tuned Mass Damper

### 2.3. Shock Absorbers

Shock absorber absorbs the energy of motion and converts it to heat, thus "damping" resonant effects in structures that are rigidly attached to the ground. In addition to adding energy dissipation capacity to the structure, supplementary damping can reduce the displacement and acceleration demand within the structures. In some cases, the threat of damage does not come from the initial shock itself, but rather from the periodic resonant motion of the structure that repeated ground motion induces.

Figure 3: Shock Absorber

### 2.4. Carbon Fiber Wrap

Carbon fiber is fiber made of carbon. But, these fibers are only a base. What is commonly referred to as carbon fiber is a material consisting of very thin filaments of carbon bound together with plastic polymer resin by heat, pressure or in a vacuum. This resulting composite material is both strong and lightweight.

Figure 4: Carbon Fiber Wrap

## 3. Reasons Why Retrofitting is not Being Conducted

Nepal lies in seismically hazardous region and it is really important to take into account the possibility of occurrence of earthquake at least once in the service life.

So structures should be constructed properly with quality control, proper construction methods and retrofitting the weakened buildings.

### 3.1. Lack of Knowledge and Information

It was found that most of the people are unaware about the adverse effect of earthquake and the need of adopting various measures to make the buildings safe. Thus, no retrofitting techniques are applied while constructing the buildings making it vulnerable during earthquake. This is one of the major factors why our buildings collapse immediately when an earthquake strikes.

So, it is really important to aware people about the importance of installing retrofits to traditionally constructed buildings.

### 3.2. Ignorance of people

Though majority of people are unaware of the need of retrofitting there are some who are ignorant. Lack of moral ethics and misery is the main reason for their ignorance. For example when the owner himself is not using the building the building is constructed with poor quality and in a hurry giving the structure insufficient time to gain strength.

### 3.3. Lack of strict Laws

It will surely make a great difference if strict laws for retrofitting or installing various protective measures in building are put into action. Basic protective measures, constructing structures based on proper design and retrofitting the weakened building will decrease the probable damage that may occur in an earthquake.

## 4. Objectives and Strategies

### 4.1. Objectives of Retrofitting

#### 1. Public Safety

The goal is to protect human life, ensuring that the structure will not collapse upon its occupants or passersby, and that the structure can be safely exited. Under severe seismic conditions the structure may be a total economic write-off, requiring tear-down and replacement.

#### Structure survivability:

The goal is that the structure, while remaining safe for exit, may require extensive repair (but not replacement) before it is generally useful or considered safe for occupation. This is typically the lowest level of retrofit applied to bridges.

#### Structure functionality:

Primary structure undamaged and the structure are undiminished in utility for its primary application. A high level of retrofit, this ensures that any required repairs are only "cosmetic" - for example, minor cracks in plaster, drywall and stucco. This is the minimum acceptable level of retrofit for hospitals.

#### Structure unaffected:

This level of retrofit is preferred for historic structures of high cultural and national significance.

### 4.2. Strategies of Retrofitting

1. Increasing the capacity and strengthening the structure which is typically done by the addition of cross braces or new structural walls.
2. Reduction of the seismic demand by means of supplementary damping and/or use of base isolation systems.
3. Increasing the local capacity of structural elements. This strategy recognizes the inherent capacity within the existing structures, and therefore adopts a more cost-effective approach to selectively upgrade local capacity (deformation/ductility, strength or stiffness) of individual structural components.
4. Selective weakening retrofit. This is a counter intuitive strategy to change the inelastic mechanism of the structure, while recognizing the inherent capacity of the structure.
5. Allowing sliding connections such as passageway bridges to accommodate additional movement between seismically independent structures.

## Conclusion

Thus, it is important to know the need of retrofitting buildings for better performance of the buildings during an earthquake. By proper awareness to the people about various retrofit methods and by formulating strict laws for various residential, commercial and other high rise buildings we can surely make our towns and cities safer. Therefore, retrofit is necessary to make the building durable and sustain its service life, increase resistance to earthquake damage.

Retrofitting is only considered as a choice if the cost of retrofitting doesn’t go beyond 25% of initial investment. If not then it is advisable to collapse the whole building and build a new structure. But if the structure holds cultural and national importance then retrofit is to be done at all cost.

## 6. Recommendations

1. In residential buildings
2. Improve wall and diaphragm anchorage
3. Improve structural integrity
4. Enhance inplane wall performance
5. Increase out of plane wall capacity
6. In High rise buildings
7. Apply base isolation
8. Use of tuned mass dampers
9. Use shock absorbers
10. Use of Fiber reinforced polymer which are easier to handle and it is very effective method.
11. Concrete Jacketing and using Moment beams
12. Use of buttress and bracings in buildings

## 7. Appendix

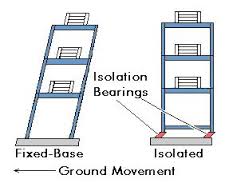




Figure 5: Carbon Fiber Wrap

Figure 6: Working of Base Isolation

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### Base isolation

Figure 8: Tuned Mass Damper of Burj Khalifa

Figure 7: Shock Absorbers

Most structural engineers have at least a little knowledge of what base isolation is – a system of springs installed at the base of a structure to protect against earthquake damage. They know less about the when and why – when to use base isolation and why use it? When it comes to how, they either have too little knowledge or too much knowledge. Conflicting claims from promoters and manufacturers are confusing, contradictory and difficult to fully assess. Then, if a system can be selected from all the choices, there is the final set of how’s – how to design the system, how to connect it to the structure, how to evaluate its performance and how to specify, test and build it. And, of course, the big how, how much does it cost?

#### Brief history:

Although the first patents for base isolation were in the 1800’s, and examples of base isolation were claimed during the early 1900’s (e.g. Tokyo Imperial Hotel) it was the 1970’s before base isolation moved into the mainstream of structural engineering.

In the early 1980’s developments in rubber technology lead to new rubber compounds which were termed “high damping rubber” (HDR). These compounds produced bearings that had a high stiffness at low shear strains but a reduced stiffness at higher strain levels. On unloading, these bearings formed a hysteresis loop that had a significant amount of damping. The first building and bridge applications in the U.S. in the early 1980’s used either LRBs or HDR bearings. Some early projects used sliding bearings in parallel with LRBs or HDR bearings, typically to support light components such as stairs. Sliding bearings were not used alone as the isolation system because, although they have high levels of damping, they do not have a restoring force. A structure on sliding bearings would likely end up in a different location after an earthquake and continue to dislocate under aftershocks.

The development of the friction pendulum system (FPS) shaped the sliding bearing into a spherical surface, overcoming this major disadvantage of sliding bearings. As the bearing moved laterally it was lifted vertically. This provided a restoring force. Although many other systems have been promulgated, based on rollers, cables etc., the market for base isolation now is mainly distributed among variations of LRBs, HDR bearings, flat sliding bearings and FPS.

In terms of supply, the LRB is now out of patent and so there are competing suppliers in most parts of the world. Although specific HDR compounds may be protected, a number of manufacturers have proprietary compounds that provide the same general level of performance. The FPS system is patented but there are licensees in most parts of the world.

#### THE CONCEPT OF BASE ISOLATION:

The term base isolation uses the word isolation in its meaning of the state of being separated and base as a part that supports from beneath or serves as a foundation for an object or structure. As suggested in the literal sense, the structure (a building, bridge or piece of equipment) is separated from its foundation. The original terminology of base isolation is more commonly replaced with seismic isolation nowadays, reflecting that in some cases the separation is somewhere above the base.

Intuitively, the concept of separating the structure from the ground to avoid earthquake damage is quite simple to grasp. After all, in an earthquake the ground moves and it is this ground movement which causes most of the damage to structures. An airplane flying over an earthquake is not affected. So, the principle is simple. Separate the structure from the ground. The ground will move but the building will not move.

Ideal separation would be total. Perhaps an air gap, frictionless rollers, a well-oiled sliding surface, sky hooks, magnetic levitation. These all have practical restraints. An air gap would not provide vertical support; a sky-hook needs to hang from something; frictionless rollers, sliders or magnetic levitation would allow the building to move for blocks under a gust of wind.

Base Isolation falls into general category of Passive Energy Dissipation, which also includes In-Structure Damping. In-structure damping adds damping devices within the structure to dissipate energy but does not permit base movement. This technique for reducing earthquake demand is covered in separate HCG Design Guidelines. The other category of earthquake demand reduction is termed Active Control, where isolation and/or energy dissipation devices are powered to provide optimum performance. This category is the topic of active research but there are no widely available practical systems and our company has no plans to implement this strategy in the short term.

#### THE PURPOSE OF BASE ISOLATION:

A high proportion of the world is subjected to earthquakes and society expects that structural engineers will design our buildings so that they can survive the effects of these earthquakes. As for all the load cases we encounter in the design process, such as gravity and wind, we work to meet a single basic equation: CAPACITY > DEMAND we know that earthquakes happen and are uncontrollable. So, in that sense, we have to accept the demand and make sure that the capacity exceeds it. The earthquake causes inertia forces proportional to the product of the building mass and the earthquake ground accelerations. As the ground accelerations increases, the strength of the building, the capacity, must be increased to avoid structural damage.

Designing for this level of strength is not easy, nor cheap. So most codes allow engineers to use ductility to achieve the capacity. Ductility is a concept of allowing the structural elements to deform beyond their elastic limit in a controlled manner. Beyond this limit, the structural elements soften and the displacements increase with only a small increase in force.

For most structural materials, ductility equals structural damage, in that the effect of both is the same in terms of the definition of damage as that which impairs the usefulness of the object. Ductility will generally cause visible damage. The capacity of a structure to continue to resist loads will be impaired.

Base isolation takes the opposite approach, it attempts to reduce the demand rather than increase the capacity. We cannot control the earthquake itself but we can modify the demand it makes on the structure by preventing the motions being transmitted from the foundation into the structure above.

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