Manual on

Non-Structural (Falling Hazards) Mitigation for Schools

Towards Safer Schools

DEPARTMENT OF DISASTER MANAGEMENT

MINISTRY OF HOME AND CULTURAL AFFAIRS

ROYAL GOVERNMENT OF BHUTAN

WORLD BANK GROUP

Acronyms:

CPS	**:**	**Community Primary School**
DDM	**:**	**Department of Disaster Management**
DSE	**:**	**Department of School Education**
EVA	**:**	**Ethylene-Vinyl Acetate**
FHM	**:**	**Falling Hazard Mitigation**
GSHAP	**:**	**Global Seismic Hazard Assessment Program**
HSS	**:**	**Higher Secondary School**
LSS	**:**	**Lower Secondary School**
MoE	**:**	**Ministry of Education**
MSS	**:**	**Middle Secondary School**
MoHCA	**:**	**Ministry of Home and Cultural Affairs**
SDMC	**:**	**School Disaster Management Committee**
SDMP	**:**	**School Disaster Management Plan**
UN – ISDR	**:**	**United Nations – International Strategy for Disaster Reduction**

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Executive Summary:

Due to its unique location adjacent to one of the most potent earthquake faults in the world, it is natural that damaging earthquakes will affect Bhutan in the future. These faults, which created the Himalayas, can cause earthquakes that are much more powerful than the 2009 and 2011 earthquakes respectively. We were fortunate that these earthquakes did not cause any casualties to students and teachers, even though it caused much losses and damage to school structures around the country. Since then, we have made reasonable progress in the past few years in preparing our schools for disastrous events. Addressing the effects of falling hazards in schools is a natural progression in our initiatives towards school safety, and this manual is a first step to provide guidance to schools to identify and mitigate the effects of these hazards in schools. Using simple methods, as mentioned in this manual, schools can mitigate the effects of falling objects within school premises. As such, this manual will be an important tool to facilitate the overall 'School Disaster Management Plan' (SDMP) to reduce your school's disaster risk.

Methodology: Experts with several years of experience in the field of Falling Hazards Mitigation conducted a comprehensive assessment of hazards posed by falling objects in many schools across the country to understand common falling hazards in them. The team also assessed external spaces in schools, and visited school hostels to understand specific hazards associated with hostels. Based on experiences in past earthquakes around the world, the manual has identified the effects of these hazards as those that can cause injuries, block exits, cause financial losses, and affect post disaster functioning of schools. For each of these hazards, the manual provides essentially simple methods that can be implemented by school staff members to anchor objects with locally available materials and tools so that the risks posed by these are reduced.

Scope of the Manual: The manual has details about the most common hazards found on school premises and has provided guidance on the mitigation of these hazards. This manual outlines guidance on (a) what can happen during an earthquake, and (b) how we can secure falling hazards. School staff members can adopt most of the mitigation solutions mentioned in the manual using low-cost, readily available parts and tools. These will help your school take positive steps to reduce risks in future earthquakes that will affect your school.

The manual is intended for school administrators and teachers. Mitigation of structural elements such as foundation, columns, beams, and walls as well as attached elements that include stairways, parapets, chimneys, ducts and pipes, wall cladding, and suspended ceilings, etc. is therefore beyond the scope of this manual.

Chapters 1 and 2 cover the earthquake hazards in Bhutan and its possible effects in schools across the country. Chapter 3 covers the common hazards found in various locations in schools, the possible risks posed by these hazards, and the suggested priorities for addressing these hazards. Chapter 4 covers mitigation solutions for common objects found in our schools, and Chapter 5 elaborates the precautions during mitigation actions. Chapter 6 provides guidance to school administrators for ensuring that the mitigation efforts towards safety done today remain sustainable for years to come.

Preface:

Two major earthquakes in 2009 and 2011 have re-confirmed the level of seismic hazards that we are living within Bhutan. A 6.1 Magnitude earthquake struck Mongar on 21 September 2009, killing 12 people and injuring many. On the evening of September 18, 2011, the Sikkim earthquake affected mainly five Dzongkhags in Southwestern Bhutan. These two earthquakes that have affected us after decades of inactivity and caused losses must serve as reminder to enhance preparedness in our schools.

Preparedness activities in schools will include 1) Awareness generation and training; 2) Developing preparedness plans; 3) Assessment and mitigation of falling hazards; 4) Conduct of preparedness drills. Our schools have made much progress in awareness generation, preparedness planning and conduct of preparedness drills. However, even the finest preparedness plans can become irrelevant if objects inside buildings fall down, cause injuries, and block evacuation routes following an earthquake. Thus, it is very important for us to take positive steps towards assessment and mitigation of falling hazards in our schools.

The Department of Disaster Management is pleased to introduce this manual on the "**Non-Structural (Falling Hazards) Mitigation for Schools**" developed along with the Department of School Education under the financial assistance of the World Bank to provide guidance for schools to assess and mitigate falling hazards. The manual provides simple, cost-effective mitigation solutions with locally available materials for common falling hazards in schools. One of the objectives of this manual is also to stimulate the thinking of the users to develop innovative solutions for objects that are not covered in the manual, which may be found in your home or elsewhere. We would welcome feedback on the manual, including new ideas, especially from the practical users of the manual. Please send all feedback to ddm@mohca.gov.bt and we will incorporate these in future revisions after careful consideration. The manual is to be circulated to all schools in the country and made available on the Ministry's portal (www.ddm.gov.bt).

Contents:

Chapter 1: Earthquake Hazard and Schools

Bhutan is located on the Himalayan Arc, which is actually the manifestation of one of the most potent earthquake plate boundaries in the world. As per the Indian Seismic Zone Map (Indian Standard Code 1893:2002), Bhutan borders regions in India, which are in High and Severe hazard zones for earthquakes. The Global Seismic Hazard Assessment Program (GSHAP) also categorizes Bhutan in high to very high hazard regions. Parts of Bhutan have been affected by several earthquakes in history, which include the 1897 Shillong earthquake, the 1934 Bihar-Nepal earthquake, and the 1950 Arunachal-Tibet earthquake. Researchers have also identified that a large earthquake had affected Bhutan close to 1713 AD.

After many decades of inactivity, two earthquakes affected Bhutan in 2009 and in 2011 respectively. On the 21September 2009, a 6.1 Magnitude earthquake struck Mongar, killing 12 people and injuring many. Even though many schools suffered structural and non-structural losses, students had left school early due to the Blessed Rainy Day festival the next day, thereby avoiding loss of lives. The Sikkim earthquake that struck on the evening of September 18, 2011, affected mainly five Dzongkhags in Southwestern Bhutan. School children were again spared because of the timing of the earthquake, late evening on a Sunday. The details of losses of schools in these two earthquakes are given below.

Table 1: Number of schools affected by the Mongar earthquake, September 2009.

No.	Dzongkhag	No. of Secondary schools			Community Primary Schools	Total	Estimated Cost for Reconstruction (Nu. Million)
		Higher (HSS)	Middle (MSS)	Lower (LSS)			
1	Trashiyangtse	0	1	1	16	18	35.53
2	Trashigang	2	1	2	14	19	133.59
3	Lhuentse	1	0	1	4	6	9.32
4	Pemagatshel	0	0	3	4	7	23.80
5	Samdrup Jongkhar	0	0	1	1	2	1.19
6	Mongar	0	2	1	20	23	118.48
Total		117	129	156	114	516	
Total Estimated Cost for Reconstruction (Nu. Million)							**321.89**
Total Approximate Loss and Damage for Education Sector (Nu. Million)							**594.0**

Source: National Recovery and Reconstruction Plan 2009

Table 2: Number of schools affected by the Sikkim earthquake, September 2011.

No.	Dzongkhag	No. of Secondary schools			Community Primary Schools	Total	Estimated Cost for Reconstruction (Nu. Million)
		Higher (HSS)	Middle (MSS)	Lower (LSS)			
1	Chukha	0	0	8	5	13	26.65
2	Dagana	0	0	0	1	1	1.99
3	Gasa	0	0	0	1	1	1.17
4	Haa	0	0	1	0	1	17.74
5	Punakha	0	0	0	1	1	0.25
6	Samtse	0	1	3	0	4	12.60
7	Thimphu	0	0	0	2	2	0.40
8	Trashigang	0	0	0	6	6	4.65
9	Trongsa	0	0	0	4	4	12.20
10	Tsirang	0	0	1	1	2	0.02
11	Wangdue	0	0	1	0	1	5.29
Total Estimated Cost for Reconstruction (Nu. Million)							**82.96**
Total approximate Loss and Damage for Education Sector (Nu. Million)							**50.18**

Source: National Recovery and Reconstruction Plan 2011

These earthquakes reaffirm the study results of several scientists that the Bhutan Himalayas have a large potential for earthquakes. Hence, it is important that we understand the possible effects of future earthquakes and initiate preparedness to reduce the impact of these events. We often note that large damaging earthquakes are rare while less powerful earthquakes are more frequent. Even in damaging earthquakes, a large percentage of the building stock of the region does not collapse completely. However, objects inside buildings may fall down in large, moderate or even mild earthquake shaking and may cause loss of life or injuries, loss (blockage) of exits, loss of functionality and economic losses. Such losses, caused by what we will term 'falling hazards'*, account for a large chunk of the injuries and losses in any earthquake. Rectifying the structural weaknesses of a building by retrofitting will need expert structural engineering advice, but the negative effects of falling hazards can be avoided by taking simple steps to make objects inside buildings safer during earthquake shaking.

Schools also contain many such falling hazards that can injure occupants, hinder smooth evacuation and affect the functional continuity of the school itself. It is important that schools in earthquake-prone regions such as our country take positive steps towards improving safety in our schools.

The following steps are recommended for comprehensive school safety: 1) Awareness generation and training of all staff and students in the school; 2) Developing preparedness plans; 3) Assessment and

mitigation of falling hazards; 4) Regular conduct of preparedness drills and revisions to the plan; and 5) Structural assessment of the building and retrofitting as required.

Our schools have made much progress in developing preparedness plans and the conduct of preparedness drills. However, even the finest preparedness plans can become irrelevant if objects inside school buildings fall down, cause injuries, and block evacuation routes following an earthquake.

This manual aims to provide guidance to school staff members and administrators to a) identify falling hazards within schools, b) understand the effects of these hazards, and c) to take steps to minimize the impacts of these hazards on the occupants of the school. Falling hazards mitigation has to complement all other steps taken towards school safety as mentioned above.

*Hazards posed by the falling of building components which do not form part of the building structure are often called Non-structural Hazards. However, in this manual, we will refer to these as 'Falling Hazards'. This is because, in the larger context of Disaster Risk Reduction, there is a broader meaning to the terms 'Structural' and 'Non-structural Disaster Risk Mitigation'. The United Nations International Strategy for Disaster Risk Reduction (UN-ISDR) defines Structural Risk Reduction measures as, "Any physical construction to reduce or avoid possible impacts of hazards, or application of engineering techniques to achieve hazard-resistance and resilience in structures or systems". Non-Structural risk reduction measures is defined as, "Any measure not involving physical construction that uses knowledge, practice or agreement to reduce risks and impacts, in particular through policies and laws, public awareness raising, training and education".

Chapter 2: Earthquake Effects in Schools

This chapter discusses how the structural and falling hazards (sometimes known as non-structural hazards) of buildings can have adverse effects in an earthquake. Buildings are made up of 'structural elements' and 'non-structural building elements'. The 'structure' is the part of the building that is designed to bear the weight of the building, its contents and people. It also bears the impact of earthquake-induced ground shaking. Structural elements differ in each type of building, but generally, they include the foundation, columns, beams, and walls, if those support the weight from above (called load-bearing walls). All other 'attached' elements in the buildings are generally known as 'non-structural elements'.' The building components 'attached' to the buildings could include stairways, parapets, chimneys, ducts and pipes, wall cladding, and suspended ceilings. As this manual is intended to be used by school administrators and teachers, mitigation of 'attached' elements mentioned above are beyond the scope of this manual. Building contents' include all of those items that occupants bring into a building, such as furniture, equipment, stored items and so on are referred to in this manual as 'falling hazards'.

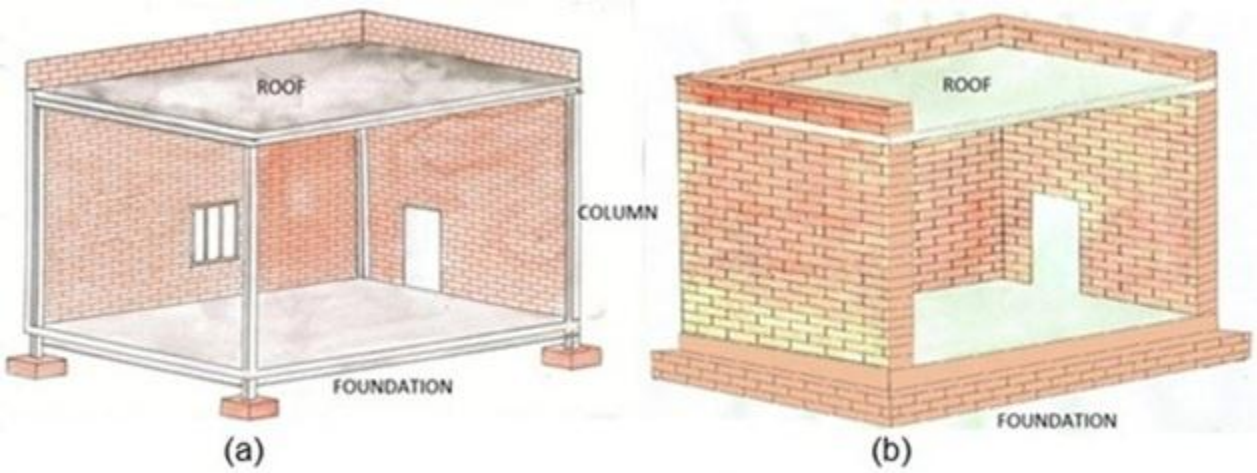


Fig 1. Structural Elements in (a) RCC and (b) load bearing buildings

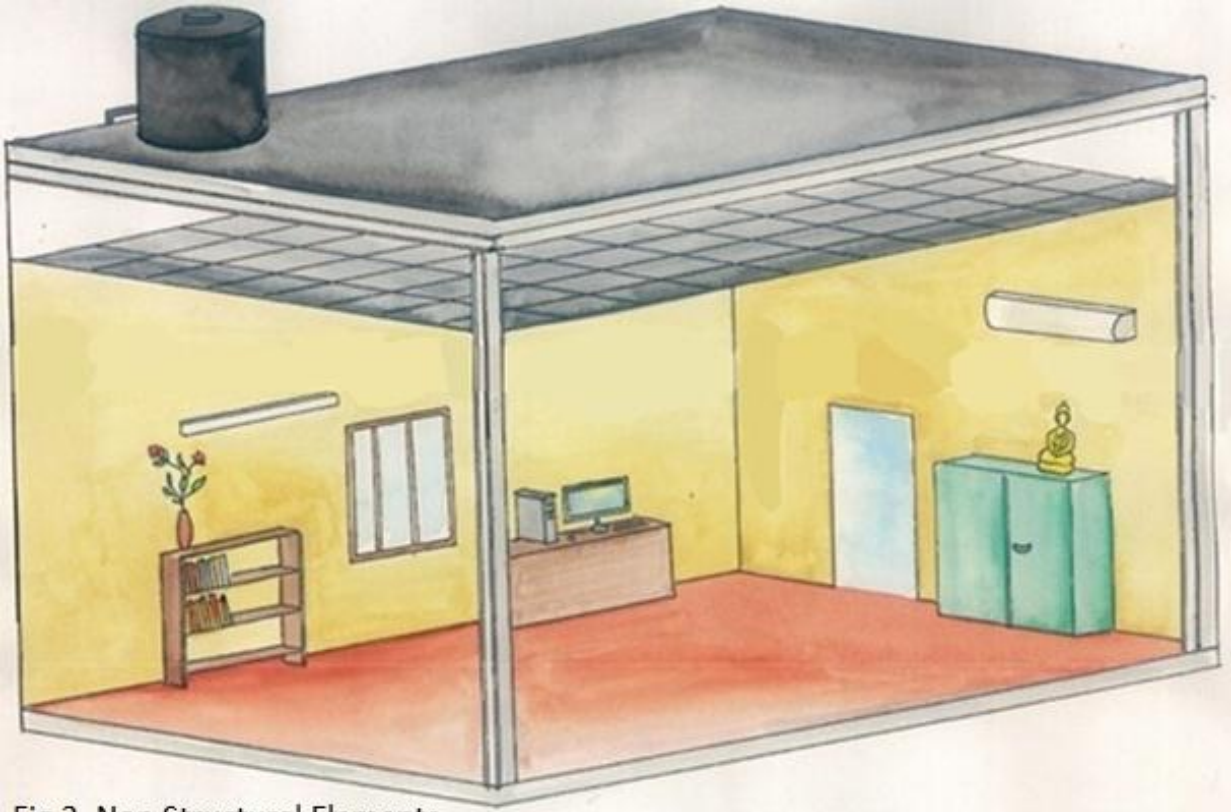


Fig 2. Non Structural Elements

During earthquakes, the biggest danger to people is from buildings that have not been designed and constructed to withstand earthquake shaking. However, in several recent earthquakes, it has been seen that some deaths, most injuries, and a large proportion of the economic losses, and disruption are caused by falling hazards. These may be displaced even in moderate earthquake shaking and cause loss of life, injuries, blockage of exits, loss of functionality and economic losses. Thus, falling hazards could account for a large chunk of the injuries and losses during any earthquake.

2.1. Earthquake Effects on Objects inside the Building:

The way an earthquake affects buildings is similar to what happens to us if we are standing on a stationary bus and the bus moves forward suddenly. Our feet start moving with the bus, but our upper body tends to remain in the same position making us fall backwards. This tendency to remain in the previous position is known as 'inertia' and is well explained in Newton's first law of motion. Similarly, in earthquake shaking, the foundations of the building moves with the ground, but the roof tends to stay in its original position. But, as it is connected to the foundation through the columns and walls, it gets dragged along. Therefore, when the ground moves, the building is thrown backwards as we do in the

bus. How well the building elements are designed and built to resist the effects of this kind of movement will determine whether the building will collapse and the possible effects on various parts of the building. The movement experienced by each element of the building is transferred to the 'non-structural elements' (falling hazards) of the building as well and they tend to slide, fall forwards, backwards, or sideways.

The sliding or falling of objects within buildings can have the following effects:

a. Objects could fall on someone and injure them: A large object such as a cupboard or a heavy flower pot falling on a person's head could be fatal or can cause serious injuries. (Life loss/injury)
b. Objects could fall across exits and trap people or prevent smooth evacuation: A large object such as a wooden cabinet sliding across an exit door will prevent evacuation of the occupants of the room after earthquake shaking. (Exit loss/ blockage)
c. These could result in damage to expensive items: A costly piece of equipment could fall down in earthquake shaking and may be destroyed. (Financial loss)
d. These could result in loss of functionality: A generator falling down and getting damaged in an earthquake can affect the functionality of the building. (Operational loss)

The effects of such hazards can be even more significant in high occupancy buildings such as schools wherein the very purpose of disaster preparedness initiatives is to get all the children out to safe evacuation areas following an earthquake. If falling hazards cause blockage of exits or injuries, school disaster preparedness plans could be rendered useless in the minutes following an earthquake, leading to further losses and trauma. After most earthquakes, it has been observed that medical resources are scarce to meet the needs of the victims, especially children in schools. In the absence of adequate medical resources, minor injuries can aggravate to limb/life-threatening injuries. Hence, it is very important for schools to do the small but essential things that can avoid even the minor injuries. As falling hazards also affect exits and evacuation routes, it is important that schools ensure that all exits are free from potential falling hazards. Schools must also ensure these hazards are mitigated as part of their preparedness and planning efforts. Most falling hazards can be easily and inexpensively avoided and people in different countries have found innovative and simple ways to reduce these hazards.

Schools have several spaces that can be considered more hazard prone than others, especially to falling hazards. Chemistry labs, libraries, cooking areas (if present), staff rooms, and Principal's room are spaces with a comparatively higher hazard than say, classrooms in most of our schools.

The aim of the manual is to introduce you to the importance of securing falling hazards in schools, so that the objects may not slide or fall during an earthquake. In this manual, we will be looking closely at common hazard-prone spaces in schools and try to understand the effects of an earthquake in these areas. It is expected that the following broad objectives can be achieved if the manual is used to initiate falling hazard mitigation measures in all our schools:

- Prevent personal injuries, casualties and economic losses in schools in future earthquakes;
- Keep exit ways safe and clear for evacuation from buildings;
- Protect school equipment and other educational materials;
- Reduce secondary effects of hazards, i.e. chemical spills, fires, gas leaks, explosions, etc.

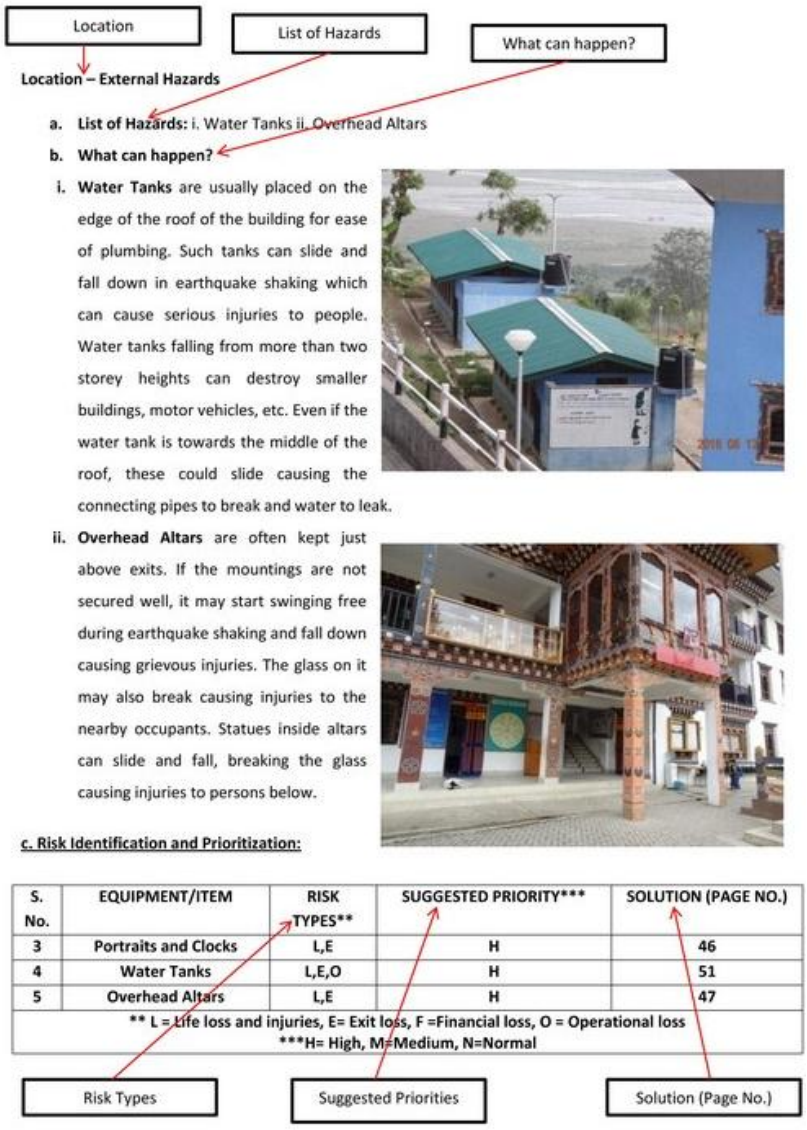
Chapter 3: Falling Hazards in our Schools

As in schools anywhere in the world, our schools also have locations with several falling hazards that can cause injuries or losses in future earthquakes unless these are mitigated. Falling hazards mitigation is a four step process which includes 1.Identification 2. Prioritization 3. Relocation and 4. Securing, as detailed in Chapter 4.

First, we will look for objects in schools that can move in earthquake shaking, use our imagination to think of how these objects will be affected by it, and understand the risk associated with each object (life loss/injury risk or an exit loss risk etc. refer Chapter 2). Once we understand the losses that can be caused due to the effect of an earthquake, we can decide on the priority with which to address the hazards. Now, let us examine various locations in our schools to identify hazards and understand the effect of these hazards.

Here is the key to how the chapter is organized. In each section there will be (a) a list of hazards in that location, (b) what can happen to these hazards in an earthquake, and (c) the mitigation solution table.

The mitigation solution table also mentions the type of risk the hazard poses such as life loss/injuries risk (L), the exit loss risk (E), the financial loss risk (F), and the operational loss (O)risk for the school. The next column gives the suggested priorities in addressing these risks such as High



priority (H), Medium priority (M), and Normal Priority (N) (Please see annexure (a). However, schools can decide on the priorities based on the situation. For example, a flower pot above a cupboard that could fall on someone could be High priority, but a flower pot on the ground in a corner away from exits can be assigned a Normal priority.

The next column gives the page number in the manual where you can find the mitigation solution for the hazard. *Mitigation solution for suspended ceilings is beyond the scope of this manual. However, these have been included as hazards in this chapter for information purpose only.*

3.1. Classrooms:

a. List of the Hazards:

i. Glass Windows ii. Suspended Ceilings iii. Flower Pots iv. Electric Lights v. Tables/Benches/Furniture vi. Ceiling Fans vii. Wall Clocks viii. Classroom Boards ix. Portraits x. Cupboards and Open Rack Shelves

b. What can happen?

i. **Glass Windows** can shatter in moderate to strong earthquake shaking causing injuries to people nearby. Glass on the floor can hinder smooth evacuation.

ii. **Suspended Ceilings** of various types are present in our schools. Almost all types are vulnerable to damage in earthquake shaking. Falling ceiling or its parts can injure people below and block exits.

iii. **Flower Pots** when placed at a height such as on top of cupboards or shelves can fall down injuring someone. If these are kept on the floor, they can slide onto exit ways, hindering smooth evacuation.

iv. **Electric Lights** can fall down in moderate to strong earthquake shaking injuring people nearby, and leaving glass pieces on the floor. Glass pieces on the floor can hinder the smooth evacuation. Fallen electric lights/equipment poses the risk of electric shocks and short-circuits.

v. **Table/Benches/Furniture** present in every classroom can slide or fall down and can hamper smooth evacuation from the classroom.

vi. **Ceiling Fans** if hung on hooks embedded in concrete slab roofs, are normally safe in moderate shaking. (However, wall-fans are normally hung on single/double screws and may fall down, if not anchored properly). A falling fan may injure people below it.

vii. **Wall Clocks** are usually hung on a nail. These can slip and fall down injuring someone and scattering glass on the floor. Glass on the floor can hamper smooth evacuation.

viii. **Classroom Boards** if not anchored properly, could fall down and injure people nearby.

ix. **Portraits** may be heavy and have glass on them. Normally, these are hung on a nail. These can slip and fall down injuring someone badly. Glass on the floor can hinder smooth evacuation.

x. **Cupboards and Open Rack Shelves** can fall down sideways or forwards. It may injure the students nearby or block exit ways. Objects placed in these cupboards or above them can fall down in earthquake shaking and injure people, and impede smooth evacuation from classrooms.

c. Risk Identification and Prioritization:

S. No.	EQUIPMENT/ITEMS	RISK TYPE **	SUGGESTED PRIORITY***	SOLUTION (PAGE NO.)
i.	Glass Windows	L,E	H	43
ii.	Suspended Ceilings	L,E	H	(BEYOND SCOPE)
iii.	Flower Pots	E	M	37, 38
iv.	Electric Lights	L,E	H	50
v.	Tables/Benches/Furniture	E	N	37, 38
vi.	Ceiling Fans	L	H	50
vii.	Wall Clocks	E	H	48
viii.	Classroom Boards	E	M	49
ix.	Portraits	L,E	H	48
x.	Cupboards and Open Rack Shelves	L,E	H	39, 40, 41
** L = Life loss and injuries, E= Exit loss, F =Financial loss, O = Operational loss ***H= High, M=Medium, N=Normal				

3.2. Laboratories

Almost all laboratories of schools have several falling hazards that may pose serious threats in the wake of an earthquake. Chemistry and biology labs have many bottles containing chemicals which can be dangerous if they fall down and break. Loss of computers in computer labs and equipment in physics labs can cause financial losses to schools. The loss of equipment in labs will disrupt the functioning of the schools following any earthquake event.

Biology Laboratory

a. **List of the Hazards:**

   i. Glass Windows/Partitions ii. Suspended Ceilings iii. Electric Lights iv. Specimen Jars.

b. **What can happen?**

i. **Glass Windows/Partitions** can shatter in moderate to strong earthquake shaking, causing injuries to people nearby. Glass on the floor can hinder smooth evacuation.

ii. **Suspended Ceilings** of various types are present in our schools. Almost all types are vulnerable to damage in earthquake shaking. Falling ceiling or ceiling parts can injure people below and also block exits.

iii. **Electric Lights** can fall down in moderate to strong earthquake shaking injuring people nearby, and leaving glass pieces on the floor. Glass pieces on the floor can hinder smooth evacuation. Fallen electric lights/equipment pose the risk of electric short-circuits.

iv. **Specimens Jars** are jars which hold biological specimens in them. In minor shaking, the bottle/ glass containers can fall down and glass containers may break into pieces, causing serious injuries to the nearby occupants and hinder evacuation. Chemicals in which the specimens are stored could spill. The specimen stored in plastic bottles may fall down and be lost or be rendered unusable.

Chemistry Laboratory:

a. List of Hazards:

v. Open Rack Shelves vi. Glassware on Tables vii. Gas Cylinders viii. Physical Balance ix. Titration Apparatus

b. What can happen?

v. **Open Rack Shelves** are used for storing chemicals in glass or plastic bottles. In moderate to strong shaking, unanchored shelves can fall down, spilling contents. Chemicals could mix with each other with serious consequences. Even if the shelves/cupboards do not fall down, the glass/plastic containers may slide and fall down with similar consequences. If glass bottles hit against each other in earthquake shaking, they may break and spill contents. In any of the above eventualities, glass pieces can injure people and hinder evacuation. Acid/strong chemicals spilled on the floor could be serious health hazards.

vi. **Glassware on Tables** can slide and fall down. Glass on the floor may hamper

evacuations.

vii. **Gas Cylinders** are primarily fire hazards and should not be present inside school buildings. Ideally, these should be placed outside the labs with reticulated piped gas supply coming into the labs as required. However, many schools follow the unsafe practice of placing the gas cylinders inside the labs for the convenience of operations, knowing very well that this is unsafe. Should these be unanchored, the cylinders could fall down in earthquake shaking causing the rubber tube connection to come off. This could cause the gas to start leaking which could eventually lead to serious fire and explosion hazards.

viii. **Physical Balances** are sensitive equipment for measuring chemicals by weight. These can slide or tip over, fall down and break. The loss of this equipment may cause financial loss to the school and also functional loss till these are replaced. If these are placed on a height, these can injure someone, and broken glass pieces can impede evacuation.

ix. **Titration Apparatus** include pipettes, burettes chemical flasks, and measuring jars. These can fall down, break and cause injuries and hamper evacuation. While in storage, these are often kept on top of cupboards and can fall down and break, injuring people nearby. Glass on the floor can impede smooth evacuation from the lab.

Note: It may be noted here that students may be advised NOT to do Drop, Cover, Hold during earthquake shaking in Chemistry Labs as glass bottles may fall down and break, spilling dangerous

liquids. The school must identify a safe location within the laboratory for students to assemble before evacuating out to the open assembly area.

Physics Laboratory:

a. List of Hazards:

x. Bench Mounted equipment xi. Glass Cupboards xii. Equipment in/on Cupboards/Open Shelves

b. What can happen?

x. **Bench Mounted Equipment** may slide and fall down and become unusable. These could account for minor injuries. Falling electric equipment poses a serious electric shock and electric short circuit hazard.

xi. **Glass Cupboards**, glass doors on these cupboards can break during earthquake shaking, especially by objects inside it falling against the glass. In addition to the hazards associated with cupboards and shelves, glass pieces will fall around, injuring people and hindering smooth evacuation.

xii. **Equipment in Cupboards/Open Rack Shelves** may fall down in minor or moderate shaking and be rendered unusable. Falling open racks can injure people. Heavy contents on upper shelves of open rack shelves may fall down, causing serious injuries to the people below it. If the rack is located near the exit, it may fall forwards or side wards and may block exits hindering smooth evacuation.

Note: Laboratory equipment such as resistance box, ammeters, meter-bridge etc. which are not used every day are often stored on top of cupboards. These can fall down in earthquake shaking causing injuries and equipment may get damaged.

Computer Laboratory

a. List of Hazards:

xiii. Computer Systems, Monitor and UPS, xiv. Electric wires/Extension Cords

b. What can happen?

xiii. **Computer Systems,** Monitors, and UPS and other electronic equipment are usually placed on the desks or tables without proper anchorage. Computer systems may slide, tip over and fall. In case one item falls, the cords and cables may pull other items down resulting in additional damage. Electrical equipment may suffer internal damage and be rendered inoperable which may affect the functionality of the school, or cause loss of significant data. Electrical equipment on the floor poses the risk of electrical shocks or short circuits.

xiv. **Electrical Wires/Extension Cords** are very common hazards in our computer labs. These can pose the risk of electrical shocks or short-circuits in moderate to strong earthquake shaking. These risks (i.e. electric shocks, glass pieces) are aggravated, as children are not allowed to use footwear in some computer labs.

Note: It may be noted here that students may be advised NOT to do Drop, Cover, Hold during earthquake shaking in Computer Labs due to the presence of loose wires and computer equipment

under tables in the lab. A safe location within the computer labs may be identified in advance for students to assemble before evacuating.

c. Risk Identification and Prioritization:

S. No.	EQUIPMENT/ITEM	RISK TYPE**	SUGGESTED PRIORITY***	SOLUTION (PAGE NO.)
i.	Glass Windows	L,E	H	43
ii.	Suspended Ceilings	L,E	H	(BEYOND SCOPE)
iii.	Electric Lights	L,E	H	50
iv.	Specimen Jars	L,E,O	H	46
v.	Open Rack Shelves	L,E	H	41
vi.	Glassware on the Table	L,E,O	H	46
vii.	Gas Cylinders	L	H	50
viii.	Physical Balance	O	M	45
ix.	Titration Apparatus	L,E	H	46
x.	Bench Mounted Equipment	E,O	M	46
xi.	Glass Cupboards	L,E	H	39, 40, 43
xii.	Equipment in Cupboards/Open Rack Shelves	L,E	H	41
xiii.	Computer Systems, Monitors, and UPS	E, O,	M	44
xiv.	Electrical Wires/Extension Cords	L,E,O	H	(BEYOND SCOPE)
** L = Life loss and injuries, E= Exit loss, F =Financial loss, O = Operational loss ***H= High, M=Medium, N=Normal				

3. 3. Libraries

a. List of Hazards:

i. Magazine Stands ii. Flower Pots iii. Bookshelves iv. Ceiling Fans v. Electric Lights (tube lights, lampshades, etc.) vi. Air conditioners vii. Portraits viii. Glass Windows ix.Wall Clocks

b. What can happen?

i. Even in moderate earthquake shaking, free standing **Magazine Stands** may fall forwards, backwards or sideways, causing injuries to people nearby or blocking the exits. The doors can open, spilling contents which can cause injuries or hinder smooth evacuation. Heavy contents on the shelves of cupboards may knock open doors and fall out.

ii. **Flower Pots** when placed at a height such as on top of cupboards or shelves can fall down injuring someone. If these are kept on the floor, they can slide on to exit ways, hindering smooth evacuation.

iii. **Bookshelves** can be dangerous in moderate shaking, and fall of one bookshelf can cause adjacent shelves to fall onto one another. The books, files, and documents may fall out and get mixed up or damaged.

iv. **Ceiling Fans** if hung on hooks embedded in concrete slab roofs are normally safe in moderate shaking. (However, wall fans are normally hung on single/double screws and may fall down, if not anchored properly). A falling fan may injure people below it.

v. **Electric Lights** can fall down in moderate to strong earthquake shaking injuring people nearby, and leaving glass pieces on the floor. Glass pieces on the floor can hinder smooth evacuation. Fallen electric lights/equipment poses the risk of electric shocks and short-circuits.

vi. Electric Equipment such as **Air Conditioners** can fall down in earthquake shaking injuring people nearby, and hindering evacuation. Fallen electric lights/equipment poses the risk of electric shocks and short-circuits.

vii. **Portraits** may fall down even in moderate shaking, causing injuries. If these contain glass, glass pieces on the floor can hinder smooth evacuation.

viii. **Glass Windows/Partitions** can shatter in moderate to strong earthquake shaking, causing injuries to people nearby. Glass on the floor in exit ways can hinder smooth evacuation.

ix. **Wall Clocks** are usually hung on a nail hammered to the wall. These can slip and fall down injuring someone and scattering glass on the floor. Glass pieces on the floor can hinder smooth evacuation.

c. Risk Identification and Prioritization:

S. No.	EQUIPMENT/ITEMS	RISK TYPE**	SUGGESTED PRIORITY***	SOLUTION (PAGE NO.)
i.	Magazine Stands	L,E	H	43
ii.	Flower Pots	L,E	H	37, 38
iii.	Bookshelves	L,E	H	39, 40, 41
iv.	Ceiling Fans	E	M	50
v.	Electric Lights	E	M	50
vi.	Air Conditioners	L,E	H	51
vii.	Portraits	L,E	H	48
viii.	Glass Windows	L,E, O	H	43
ix.	Wall Clocks	L,E	H	48
** L = Life loss and injuries, E= Exit loss, F =Financial loss, O = Operational loss ***H= High, M=Medium, N=Normal				

3. 4. Staff Rooms

a. List of Hazards:

i. Glass Windows ii. Suspended Ceilings iii. Electric Lights iv. Open Rack Shelves v. Objects on the Top of the Cupboards/Tables vi. Cupboards vii. Glass on Notice Boards

b. What can happen?

i. **Glass Windows** can shatter in moderate to strong earthquake shaking, causing injuries to people nearby. Glass on the floor can hinder smooth evacuation aftermath of an earthquake.

ii. **Suspended Ceilings** of various types are present in our schools. Almost all types are vulnerable to damage in earthquake shaking. Falling ceiling or ceiling parts can injure persons below and also block exits.

iii. **Electric Lights** can fall down in moderate to strong earthquake shaking injuring people nearby, and leaving glass pieces on the floor. Glass pieces on the floor can hinder smooth evacuation. Fallen electric lights/equipment pose the risk of electric short-circuit.

iv. **Open Rack Shelves** can fall forwards or sideways, spilling contents such as books, files, etc. Falling racks can injure people around and may also block exits hindering smooth evacuation.

v. **Objects on top of the Cupboards** can fall down in earthquake shaking injuring people nearby, and may also hinder smooth evacuation.

vi. In moderate earthquake shaking, the free standing **Cupboards** may fall forwards or sideways, causing injuries to people nearby or blocking the exits. The doors can open, spilling contents, which can cause injuries or hinder smooth evacuation. Heavy contents on upper shelves of cupboards may knock open doors and fall out. If cupboards have glass doors, this may become glass hazards as well.

vii. **Glass on the Notice Board** can break and fall in earthquake shaking causing injuries to nearby persons. Glass pieces on the floor can hinder smooth evacuation.

c. Risk Identification and Prioritization:

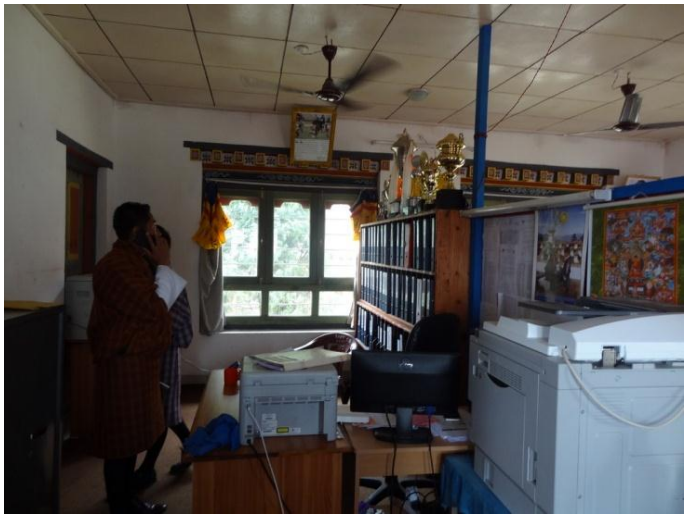
S. No.	EQUIPMENT/ITEMS	RISK TYPE**	SUGGESTED PRIORITY***	SOLUTION (PAGE NO.)
i.	Glass Window	L,E	H	43
ii.	Suspended Ceilings	L,E	H	(BEYOND SCOPE)
iii.	Electric Lights	L,E	H	50
iv.	Open Rack Shelves	L,E	H	41
v.	Objects on top of Cupboards	L,E	H	41
vi.	Cupboards	L,E	H	39, 40, 41
vii.	Glass Notice Boards	L,E	H	43
	** L = Life loss and injuries, E= Exit loss, F =Financial loss, O = Operational loss ***H= High, M=Medium, N=Normal			

3. 5. Principal's Room:

a. List of Hazards:

i. Cupboards ii. Flower Pots iii. Wall Clocks iv. Electric Lights (tube lights) v. Computers and Printers vi. Ceiling Fans vii. Suspended Ceilings viii. Trophies and Small Statues ix. Portraits x.Glass Windows

b. What can happen?



i. In moderate to heavy shaking, **Cupboards** can fall forwards or sideways, injuring people nearby or blocking exits. Objects placed above cupboards can also fall, even in minor shaking.

ii. **Flower Pots** when placed at a height such as on top of cupboards or shelves can fall down injuring someone. If these are kept on the floor, they can slide on to exit ways, hindering smooth evacuation.

iii. **Wall Clocks** are usually hung on nails. These can slip and fall down injuring someone and scattering glass on the floor. Glass on the floor can hinder smooth evacuation.

iv. **Electric Lights** can fall down in moderate to strong earthquake shaking injuring people nearby, and leaving glass pieces on the floor. Glass pieces on the floor can hinder smooth evacuation. Fallen electric lights/equipment poses the risk of electric shocks and short-circuits.

v. **Computers and Printers** can also fall down and be damaged. The computers in the principal's office may contain important data which if lost may affect the functioning of the school. Falling electronic items may also injure people or hinder evacuation.

vi. **Ceiling Fans** if hung on hooks embedded in concrete slab roofs are normally safe in moderate shaking. (However, wall fans are normally hung on single/double screws and may fall down, if not anchored properly). A falling fan may injure people below it.

vii. **Suspended Ceilings** of various types are present in our schools. Almost all types are vulnerable to damage in earthquake shaking. Falling ceiling or ceiling parts can injure people below and also block exits.

viii. **Trophies and Small Statues** are normally kept on the top of cupboards, tables, or shelves. They may fall injuring people nearby or prevent smooth evacuation.

ix. **Portraits** may be heavy and have glass on them. Normally, these are hung on a nail. These can slip and fall down injuring someone badly. Glass on the floor can hinder smooth evacuation.

x. **Glass Windows/Partitions** can shatter in moderate to strong earthquake shaking, causing injuries to people nearby. Glass on the floor can hinder smooth evacuation.

c. Risk Identification and Prioritization:

S. No.	EQUIPMENT/ITEM	RISK TYPE**	SUGGESTED PRIORITY***	SOLUTION (PAGE NO.)
i.	Cupboards	L,E	H	39, 40, 41
ii.	Flower Pots	L,E	M	37, 38
iii.	Wall Clocks	L,E	H	48
iv.	Electric Lights	L,E	H	50
v.	Computers and Printers	E,O	M	44
vi.	Ceiling Fans	L,E	H	50
vii.	Suspended Ceilings	L,E	H	(BEYOND SCOPE)
viii.	Trophies and Small Statues	L,E	H	47
ix.	Portraits	L,E	H	48
x.	Glass windows and Glass Partitions	L,E	H	43
** L = Life loss and injuries, E= Exit loss, F =Financial loss, O = Operational loss ***H= High, M=Medium, N=Normal				

3.6. Store Rooms:

a. List of Hazards:

Many schools have a significant amount of ongoing storage space for equipment, supplies, furniture, and academic records. In schools, these rooms store academic and extra/co-curricular activity materials. The lists of hazards in storage rooms are as follows:

i. Cupboards ii. Open Rack Shelves iii. Ceiling Fans iv. Objects on Top of Cupboards v. Glass Windows vi. Suspended Ceilings and vii. Computer Systems

b. What can happen?

i. In moderate earthquake shaking, the free standing **Cupboards** may fall forwards or sideways, causing injuries persons nearby or blocking the exits. The doors may open, spilling contents, which can cause injuries or hinder smooth evacuation. Heavy contents on upper shelves of cupboards may knock open doors and fall out. If cupboards have glass doors, this may become glass hazards as well.

ii. **Open Rack Shelves** can fall forwards or sideways, spilling contents such as books, files, etc. Falling racks can injure people around and may also block exits, hindering smooth evacuation.

iii. **Ceiling Fans,** if hung on hooks embedded in concrete slab roofs, are normally safe in moderate shaking. (However, wall fans are normally hung on single/double screws and may fall down, if not anchored properly). A falling fan may injure people below it.

iv. **Objects on top of Cupboards** can fall down in earthquake shaking injuring people nearby and may also hinder smooth evacuation.

v. **Glass Windows** can shatter in moderate to strong earthquake shaking, causing injuries to people nearby. Glass on the floor can hinder smooth evacuation.

vi. **Suspended Ceilings** of various types are present in our schools. Almost all types are vulnerable to damage in earthquake shaking. Falling ceiling or ceiling parts can injure people below and also block exits.

vii. **Computer Systems** can also fall down and be damaged. Computers sometime may contain important data which if lost may affect the functioning of the school. Falling electronic items may also injure people or hinder evacuation.

c. Risk Identification and Prioritization:

S. No.	EQUIPMENT/ITEMS	RISK TYPE**	SUGGESTED PRIORITY***	SOLUTION (PAGE NO.)
i.	Cupboards	L,E	H	39, 40, 41
ii.	Open Rack Shelves	L,E	H	41
iii.	Ceiling Fans	L,E	H	50
iv.	Objects on top of Cupboards	L,E	H	41
v.	Glass Windows	L,E	H	43
vi.	Suspended Ceilings	L,E	H	(BEYOND SCOPE)
vii.	Computer Systems	E,O	M	44
** L = Life loss and injuries, E= Exit loss, F =Financial loss, O = Operational loss ***H= High, M=Medium, N=Normal				

3. 7. Corridors:

a. List of Hazards

Corridors across schools have many items kept on the floor for decoration (such as potted plants) or for storage (old/extra furniture).The list of things which school corridors have commonly are as follows:

i. Cupboards ii. Flower Pots, iii. Benches iv. Wall-Clocks v. Notice boards and vi. Other objects near exits

b. What can happen?

i. In moderate to high shaking, free standing **Cupboards** may fall down, the glass door on cupboards may break especially by objects inside it falling against the glass. Objects inside glass cabinets may fall on to the glass breaking it and creating an additional hazard that can injure people nearby and hamper evacuation.

ii. **Flower Pots** may fall over and break, causing hindrance to the exit ways. In large earthquakes, the water pots can rock on its base or slide sideways. Also, it is common to water the plants kept on corridors and staircases. If water spills from these pots, it may cause slippery surfaces on the staircases, hindering smooth evacuation.

iii. **Benches** may shift from its position in earthquakes and block exit ways.

iv. **Wall Clocks** are generally hung on a single nail and may fall down in moderate earthquake shaking. The glass on the clock may break, causing injuries to nearby occupants and hinder smooth evacuation.

v. **Notice Boards** are normally hung on nails. If not anchored properly, these could fall down and injure people nearby or may hinder smooth evacuation.

vi. Many Objects such as **loudspeakers** and **flowerpots** are normally kept near the exits. In earthquake shaking, these objects may fall down or sideways, blocking exits.

c. Risk Identification and Prioritization:

S. No.	EQUIPMENT/ITEM	RISK TYPES**	SUGGESTED PRIORITY ***	SOLUTION (PAGE NO.)
i.	Cupboards	L,E	H	39, 40, 41
ii.	Flower Pots	E	M	37, 38
iii.	Clocks	L,E	H	48
iv.	Benches	E	M	37, 38
v.	Notice Boards	E	M	49, 43
vi.	Objects Near Exits	E	M	37, 38
** L = Life loss and injuries, E= Exit loss, F =Financial loss, O = Operational loss ***H= High, M=Medium, N=Normal				

3. 8. Common Areas of Schools:

a. List of Hazards:

i. Suspended Ceilings ii. Fans (Ceiling and Wall) iii.Cupboards iv. Electric Lights v. Glass windows and Partitions and vi. Altars

b. What can happen?

i. **Suspended Ceilings** of various types are present in our schools. Almost all types are vulnerable to damage in earthquake shaking. Falling ceiling or ceiling parts can injure people below and also block exits. Ceiling failures may result in loss of functionality until the ceiling and utilities are repaired.

ii. **Ceiling Fans** if hung on hooks embedded in concrete slab roofs are normally safe in moderate shaking. (However, wall fans are normally hung on single/double screws and may fall down, if not anchored properly). A falling fan may injure people below it.

iii. In moderate earthquake shaking, the free standing **Cupboards** may fall forwards or sideways, causing injuries to people nearby, or blocking the exits. The doors can open, spilling contents which can cause injuries or hinder smooth evacuation. Heavy contents on upper shelves of cupboards may knock open doors and fall out. If cupboards have glass doors, this may become glass hazards as well.

iv. **Electric Lights** can fall down in moderate to strong earthquake shaking injuring people nearby, and leaving glass pieces on the floor. Glass pieces on the floor can hinder smooth evacuation. Fallen electric equipment pose the risk of electric short-circuit.

v. **Glass Windows/Partitions** can shatter in moderate to strong earthquake shaking, causing injuries to people nearby. Glass on the floor can hinder smooth evacuation.

vi. **Altars (Internal Unit)** are usually made up of two separate parts, and the top part is more likely to fall down in moderate shaking than the bottom part. In stronger shaking, the top and bottom parts of altars can fall down injuring people nearby. Almost always, altars have a butter lamp which can be a fire hazard if it falls down, especially if it is near combustible items such as cloth, wood, etc. Statues in the altar may also fall down.

c. Risk Identification and Prioritization:

S. No.	EQUIPMENT/ITEM	RISK TYPES**	SUGGESTED PRIORITY ***	SOLUTION (PAGE NO.)
i.	Suspended Ceilings	L.E	H	(BEYOND SCOPE)
ii.	Ceiling Fans	L,E	H	50
iii.	Cupboards	L,E	H	39, 40, 41
iv.	Electric Lights	L,E	H	50
v.	Glass Windows/Partitions	L,E	H	43
vi.	Altars (Internal Unit)	L,E	H	48
** L = Life loss and injuries, E= Exit loss, F =Financial loss, O = Operational loss ***H= High, M=Medium, N=Normal				

3. 9. Hostels:

In the coming years, many more of our schools will be having hostel facilities, which pose a different challenge in preparedness and planning. Falling mitigation hazards in hostels must be given high priority as these hazards can cause death, injuries, loss of exit and financial and operational loss**.**

a. List of Hazards:

i. Cupboards/Lockers ii. Suspended Ceilings iii. Glass Windows iv. Electric Lights

b. What can happen?

i. **Cupboards/Lockers** are almost always kept near exit ways due to lack of adequate space in hostels. The doors can open, spilling contents, which can cause injuries/trapping people or hinder smooth evacuation. Heavy items kept on the top of cupboards/lockers may fall down with similar effects.

ii. **Suspended Ceilings** of various types are commonly found in our schools. Almost all types are susceptible to damage in earthquake shaking. Falling ceiling or ceiling parts can injure people below and also block exits.

iii. **Glass Windows** can shatter in moderate to strong earthquake shaking, causing injuries to people nearby. Glass on the floor can hinder smooth evacuation in the aftermath of an earthquake.

iv. **Electric Lights** can fall down in moderate to strong earthquake shaking injuring people nearby, and leaving glass pieces on the floor. Glass pieces on the floor can hinder smooth evacuation.

Electrical wiring along suspended ceilings can be dangerous, posing electrical shock and short-circuit hazards.

c. Risk Identification and Prioritization:

S. No.	EQUIPMENT/ITEM	RISK TYPE**	SUGGESTED PRIORITY***	SOLUTION (PAGE NO.)
i.	Cupboards/ Lockers	L,E	H	39, 40, 41
ii.	Suspended Ceilings	L,E	H	(BEYOND SCOPE)
iii.	Glass Windows	L,E	H	43
iv.	Electric Lights	L,E	H	50
** L = Life loss and injuries, E= Exit loss, F =Financial loss, O = Operational loss ***H= High, M=Medium, N=Normal				

3. 10. External Falling Hazards

Schools have a large number of hazards outside its buildings. These can slide, fall or topple in moderate to severe earthquake shaking and cause injuries to staff and students. Past earthquakes have shown that external falling hazards have caused death and injuries just outside of the buildings. These hazards include water tank, solar panels, electric panel boards, overhead altars, air conditioners, glass windows, etc. Addressing these hazards is as important as addressing hazards within schools as these can cause loss of life and loss of exits.

External Part of the School Buildings:

a. List of Hazards: Hazards found on the exterior of school buildings includes;

i. Electric Boards ii. Air-Conditioners iii. Glass on Notice Boards iv. Portraits and Clocks v. Water Tanks vi. Overhead Altars

b. What can happen?

i. **Electric Boards** are usually placed outside the building close to the entrance or under staircases. If these are not anchored properly, they could get dislodged causing short circuits, sparking and fires. Being located close to the exits, such fires can prevent evacuation and lead to undesirable consequences.

ii. **Air Conditioners** can fall outwards in moderate to severe earthquake shaking causing injuries to people nearby. If these are placed above exits, these are a serious threat to evacuees. Fallen air conditioners on/near exit routes will hamper smooth evacuation.

iii. **Glass on Notice Boards** can break during earthquake shaking. In addition to the hazards associated with falling notice boards, glass pieces may fall around, injuring persons and hindering smooth evacuation.

iv. **Portraits and Clocks** are sometimes displayed in the assembly areas of the school and are normally hung on a nail. They may be heavy and have glass on them. In moderate to strong earthquake shaking, these can slip and fall down injuring someone badly. Glass on the floor can hinder smooth evacuation.

v. **Water Tanks** are usually placed on the edge of the roof of the building for ease of plumbing. Such tanks can slide and fall down in earthquake shaking which can cause serious injuries to people. Water tanks falling from more than two storey heights can destroy smaller buildings, motor vehicles, etc. Even if the water tank is towards the middle of the roof, these could slide causing the connecting pipes to break and water to leak.

vi. **Overhead Altars** are often kept just above exits. If the mountings are not secured well, it may start swinging free during earthquake shaking and fall down causing grievous injuries. The glass on it may also break causing injuries to the nearby occupants. Statues inside altars can

slide and fall, breaking the glass causing injuries to persons below. Almost always, altars have butter lamps which can be a fire hazard if it falls down, especially if it is near combustible items such as cloth, wood, etc.

c. Risk Identification and Prioritization:

S. No.	EQUIPMENT/ITEM	RISK TYPES**	SUGGESTED PRIORITY***	SOLUTION (PAGE NO.)
i.	Electric Boards	L,E	H	53
ii.	Air Conditioners	L	H	51
iii.	Glass on Notice Boards	E	H, M	43, 50
iv.	Portraits and Clocks	L,E	H	48
v.	Water Tanks	L,E,O	H	53
vi.	Overhead Altars (External Unit)	L,E	H	49
** L = Life loss and injuries, E= Exit loss, F =Financial loss, O = Operational loss ***H= High, M=Medium, N=Normal				

Note: Some school buildings have stones kept on sloping Corrugated Galvanized Iron (CGI) sheet roofing to prevent wind damage. These may fall down in moderate to heavy shaking and kill/injure people around. These must be avoided.

Chapter 4: Mitigation Solutions

This chapter provides guidance on proposed mitigation actions that can be taken in our schools based on the impact of falling hazards in schools during and after an earthquake. There are four important steps to reduce risk caused by falling hazards in your school.

1. Identification
2. Prioritisation
3. Relocation
4. Securing

4.1. Identification:

Falling hazards can be identified in a school in a systematic way. We will look for objects that can move in earthquake shaking, and try to understand if they will slide, topple or fall down. You will have to use your imagination and think of how the objects will be affected by earthquake shaking. In the example

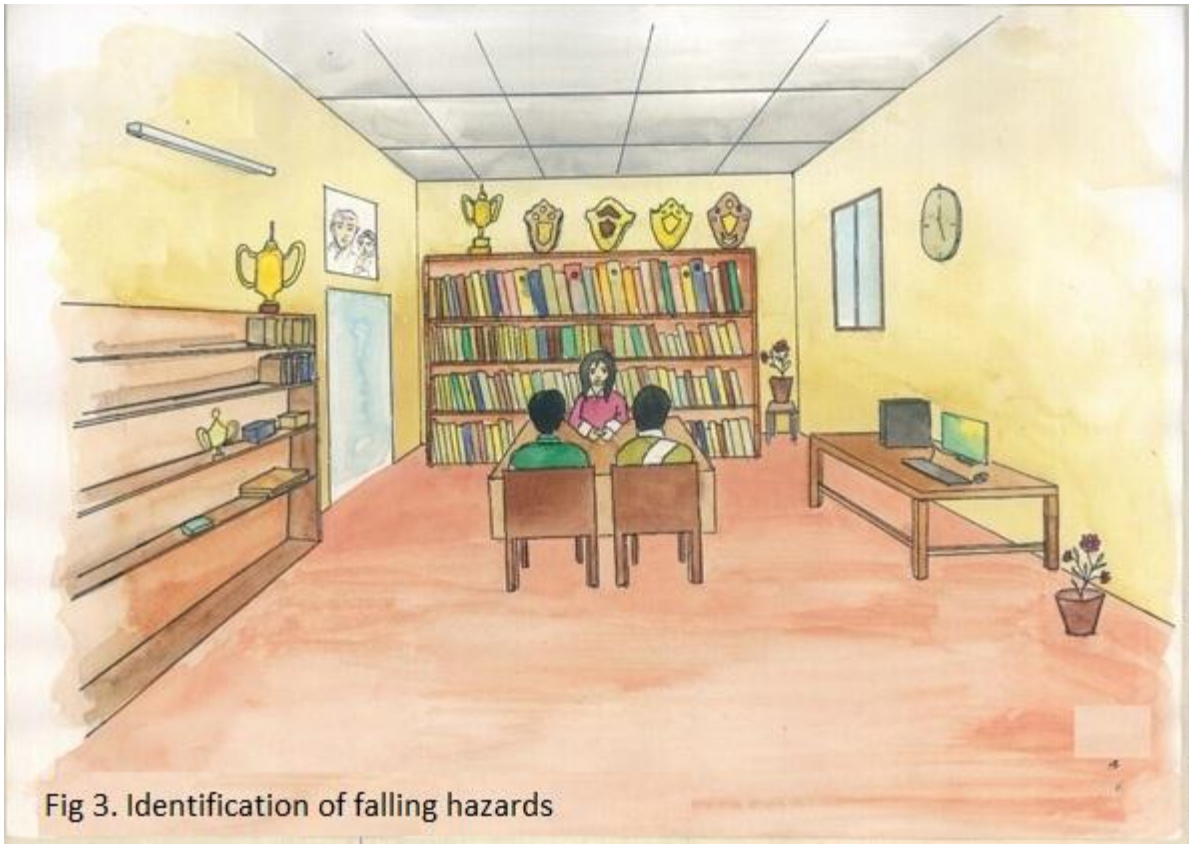


Fig 3. Identification of falling hazards

picture below a Principal's office in a school, try to identify as many hazards as possible in the room. In the next page we will try to understand the potential losses associated with each object, whether it is a life loss or injury or an exit loss, etc.

Remember to look at each object from the perspective of the shortest occupant of the room. For example, in a kindergarten classroom, look at objects from a small child's perspective and you will see that even a mug on a table can be a hazard. Identifying objects that can move in earthquake shaking is among the first steps in mitigating falling hazards. You can involve children also in the exercise by calling it a 'hazard hunt' and taking their help in spotting hazards. Once you have identified the hazards, you will understand the kind of losses that can be caused due to the movement of each object as described in detail in chapter 2.

a. **Life loss / injuries (L)**
b. **Exit blockage/ loss (E)**
c. **Financial loss (F)**
d. **Operational loss (O)**

When we plan to mitigate falling hazards, we must consider these losses, and decide on the priority with which to address the hazards.

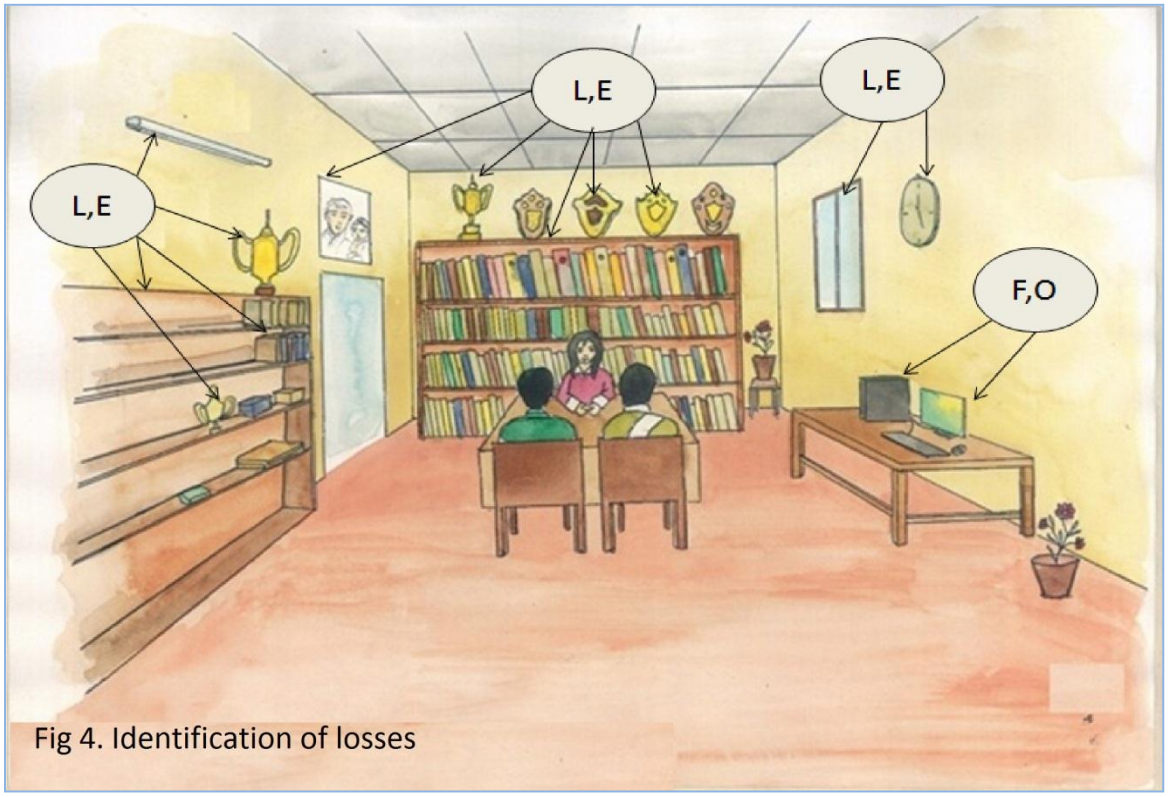


Fig 4. Identification of losses

4.2. Prioritization

Once you understand the losses that can be caused due to the effects of an earthquake, you can decide which of the hazards to address first and which can be done later. The final decision on the best way and the priorities with which to implement falling hazards mitigation in schools must be taken in consultation with the school safety committee. However, we list below some suggested priorities for addressing falling hazards.

High (H) = Every object that poses a threat to life should be deemed as high priority. Likewise, every object that can block the exit and can hamper the evacuation of large number of persons must also be high priority.

Medium (M) = The loss of certain objects such as office computers, academic/attendance records, etc. can cause operational loss to the school. These can be given a medium (or even high) priority in mitigation as decided by the school.

Normal (N) = When the objects are not expected to cause loss of life or injuries, loss of exits or operational continuity and may cause only some financial losses, it may be given a normal priority.

A sample form has been given below that can be used when we finish identification and prioritization.

Locations	Objects and descriptions	Risk Types (Check all that apply)				Priority High Medium Normal
		Life Loss and injuries	Exit loss	Financial loss	Operational loss	
Principal's office	Cupboards, tables	✓	✓	-	-	H
	Computer systems	-	-	✓	✓	H/M
	Flowerpots	-	-	-	-	N

4.3. Relocation:

When objects pose a threat to life/injury or may block an exit in earthquake shaking, the best mitigation option is to move it away from where it can cause losses. In many schools, objects such as old furniture are kept along the corridors. This practice has to stop completely. Corridors have to be seen as emergency exits and nothing should hamper smooth evacuation in emergencies. Even in rooms such as the library, cupboards, magazine racks, etc. are kept near exit ways and these will hamper evacuation

following an earthquake. As mentioned above, these have to be relocated and anchored away from exit ways. Objects that can fall on someone and injure them should also be moved away from where it can cause harm. Relocation is the first and simplest step in getting schools started towards falling hazards mitigation. Please see the 'before and after' pictures below a school office where the hazards that could cause life loss or blockage of exits have been moved away from where it can do harm.

Fig 5. Before Relocation

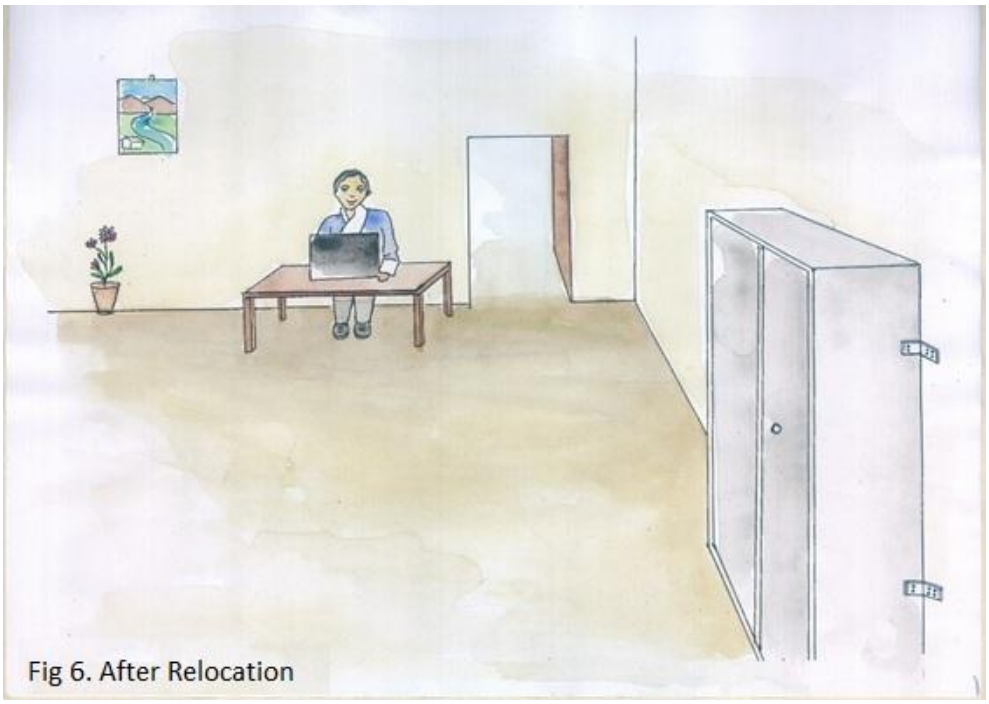


Fig 6. After Relocation

4.4. Securing Objects:

Relocating objects can eliminate many hazards, but some objects present a hazard regardless of their location and must be secured, in order to prevent damage. To fix these objects, please see the solutions given for each item that were identified in the previous chapter. This section of the chapter provides guidance about the mitigation actions needed for securing these falling objects.

4.4.1. Cupboards/Lockers:

Steel or wooden cupboards can be easily anchored to the wall using L- clamps (also called L-brackets), plastic wall anchors, screws, and a drill machine. You can use the clamps each at the left and right sides as shown in figure 7 (a). If there is limited space on the side of the cupboard, the legs of the clamps can be tucked in as shown in the figure 7 (b).The size and the bolts required to anchor cupboards may vary

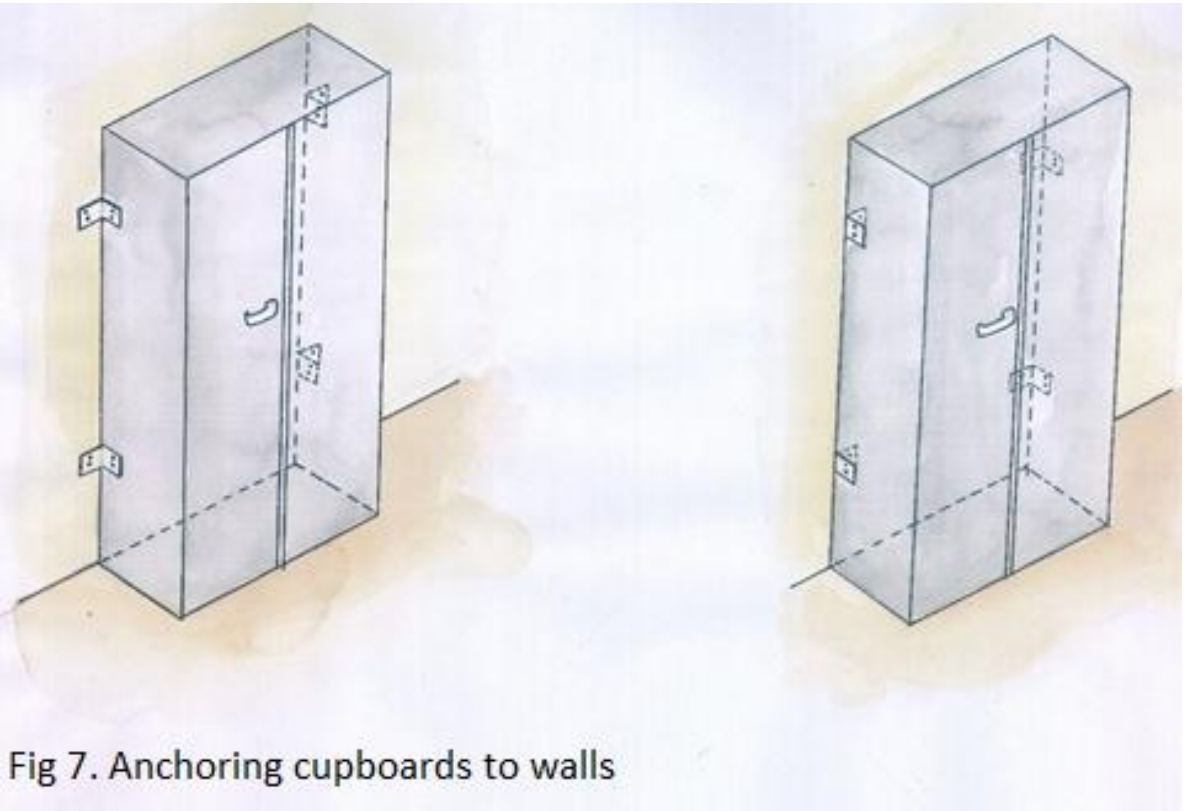


Fig 7. Anchoring cupboards to walls

as per the height and weight of the cupboard. Also, in rooms with thick floor skirting, longer clamps may be required to be used. Longer clamps may also be required for anchoring old cupboards which lean forward due to worn out front legs. Details of the clamps to be used in various circumstances are given in the following pages.

If cupboards are placed in the corner of the room, a clamp will have to be fixed on top of the cupboard as shown in figure 8 below.

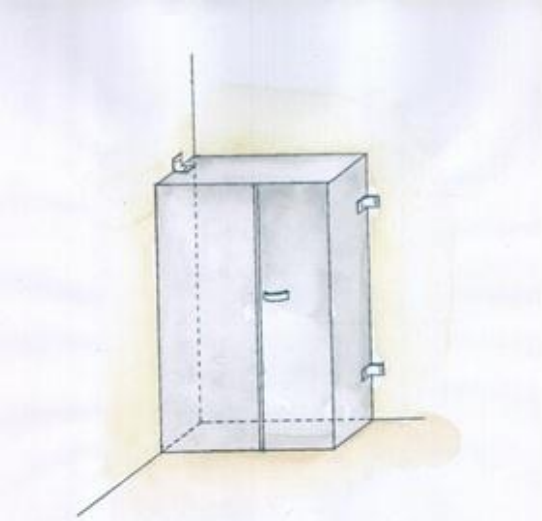


Fig 8. Anchoring cupboard in corner

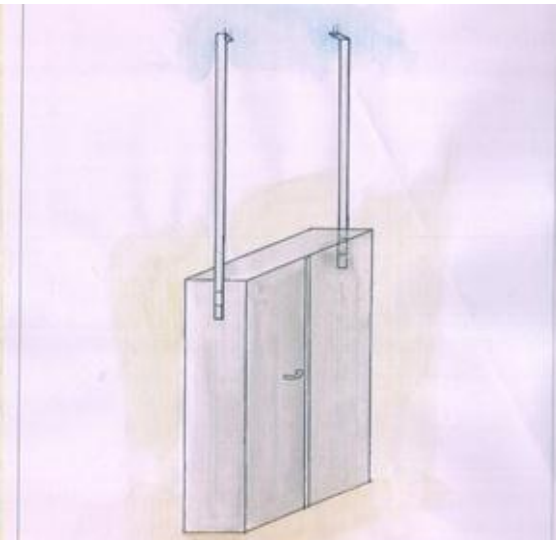


Fig 9. Anchoring free-standing cupboard

Many school libraries and storage rooms have freestanding cupboards, which are not placed against walls. In such cases, the first option will be to relocate these cupboards to where it can be anchored to a wall. However, if this is not possible, these will have to be anchored to the concrete roof using long L-clamps as shown in the figure 9. L clamps are to be used for both sides of the cupboard. For additional safety, these can also be anchored at the base to the floor. However, please remember that the legs of the L clamp on the floor can be a trip-hazard for students and teachers using the room if these are not tucked under the cupboards.

If there are rows of cupboards, such as in a library, these can be connected to each other at the top with two slotted flat bars as shown in the figure 10 and every fourth/fifth cupboard connected to the roof with long L clamps. Here also, additional safety can be obtained by anchoring the middle cupboard to the floor with L clamps as mentioned above. The

Fig 10. Anchoring rows of free-standing cupboards

key is to connect all cupboards together so that they support each other during earthquake shaking.

(**Note: Lockers also can be anchored similar to cupboards but if lockers have openable drawers, care should be taken to ensure that the bolts do not obstruct free movement of the drawers.**)

4.4.2. Closed/Open (slotted angle) Rack Shelves:

Open slotted angle racks can be directly anchored to walls without L clamps as shown in the image. Adjacent racks can be connected to each other.

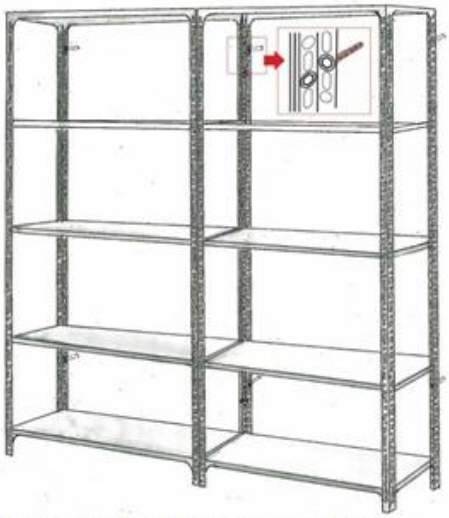


Fig 11. Anchoring open rack shelves

Closed (slotted angle) rack shelves, however, should be treated as cupboards, and must be anchored using L clamps as discussed above.

It is also easy to connect these racks with each other using nuts and bolts as shown in the image. Free standing racks will have to be anchored to the concrete ceiling similar to the cupboards.

4.4.3. Objects on Closed/Open (slotted angle) Rack Shelves:

Objects on open rack shelves must be restrained from falling down in earthquake shaking. Provide shelf-restraints such as plywood or plexiglass lip as shown in the drawing to keep bottles in shelves. Spring (normally used to hang curtains) can also be used to keep items from falling off. A combination of the lip and the spring will strengthen effectiveness of the restraints.

Always keep heavy items in the bottom shelves of the racks. It has been seen many items are also kept on top of rack and shelves. This practice must not be encouraged.

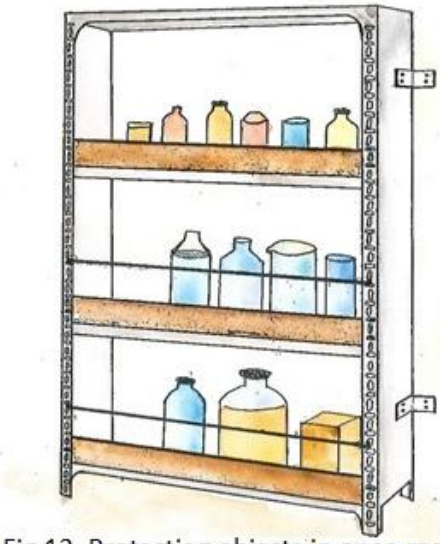


Fig 12. Protecting objects in open rack shelf

Supplies required:

i. For Anchoring Short Cupboards/Lockers (below 1.5 m height):

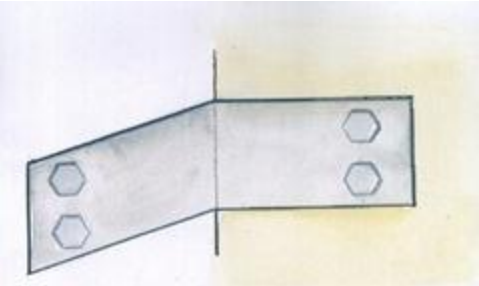


Fig 13. Clamp for short cupboard

- 2 mm thick L-Clamps with two 8 mm diameter holes vertically aligned in each leg with 8 cm length of the clamp on cupboard side, 8 cm length of the clamp on the wall side and 4 cm width of the clamp will be required.
- 8mm (dia) ×60 (length) mm plastic wall anchor
- 60 mm Hex Screw with washers for plastic wall anchor
- 8 mm (dia) hexagonal bolt (2 cm long) with washers and lock nuts.

ii. For Anchoring Tall Cupboards/Lockers (above 1.5 m height):

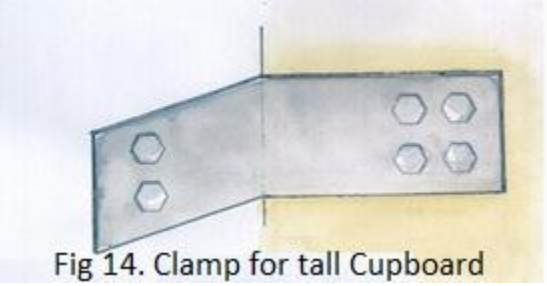


Fig 14. Clamp for tall Cupboard

- 2 mm thick L-Clamps with 8 cm length of the clamp on cupboard side, 10 cm length of the clamp on the wall side and 5 cm width of the clamp will be required. Clamps will have 8 mm diameter holes vertically aligned for each side (four 8 mm dia holes on the clamp on wall side, two 8 mm dia holes on the clamp on cupboard side)
- 8 mm (dia) ×60 (length) mm plastic wall anchor
- 60 mm Hex Screw with washers for plastic wall anchor.
- 8 mm (dia) hexagonal bolt (2 cm long) with washers and lock nuts.

iii. For Anchoring Tall Cupboards/Lockers leaning forward.

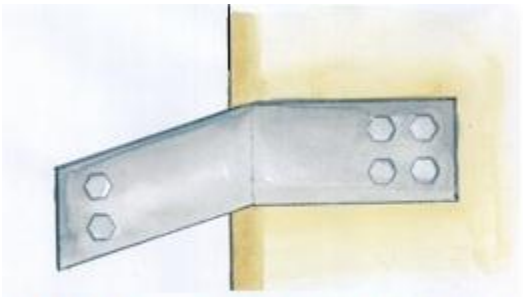


Fig 15. Clamp for cupboard leaning forward

- Longer L clamps are required when old steel cupboards have wear and tear in the front legs or when the wall has thick skirting
- 2 mm thick L-Clamps with 10 cm length of the clamp on cupboard side, 10 cm length of the clamp on the wall side and 5 cm width of the clamp will be required. The clamps will have 8 mm diameter holes vertically aligned in each leg (four 8 mm dia holes on the clamp on wall side, two 8 mm dia holes on the clamp on cupboard side)
- 8 (dia) × 60 (length) mm plastic wall anchors.

- 60 mm Hex Screw with washers for plastic wall anchor.
- 8 mm (dia) hexagonal bolt (2 cm long) with washers and lock nuts (cupboard side).

iv. For Anchoring Open and Closed Rack Shelves :

- 8 mm (dia) × 60 (length) mm plastic wall anchors.
- 60 mm Hex Screw with washers for plastic wall anchor.
- 8 mm (dia) hexagonal bolt (2 cm long) with washers and lock nuts (for connecting racks together).
- Curtain springs (or plastic cords) as per requirement
- Plywood with holes/plexiglas as per requirement.
- Slotted flat bars, thickness 3 mm with 2 or 2.5 cm width (for connecting rows of cupboards).

4.4.4. Glass Windows and Glass Partitions

There are several types of glass used in windows, doors and other glazing. Plain glass shatters into sharp shards that can fall from the frame. It is very expensive to replace all plain glass with tempered, annealed, or safety glass in our schools. Thin films such as sun control films that are commonly used for car windows can be used to prevent shattered glass from falling down. However, these films are also expensive and not commonly available. For wooden window panes, a chicken wire mesh layer can be provided on the inside to prevent broken glass pieces from falling onto children in class. For large panes of glass on the exterior of the building, you can provide landscaping that discourages people from loitering or congregating where glass shards could fall.

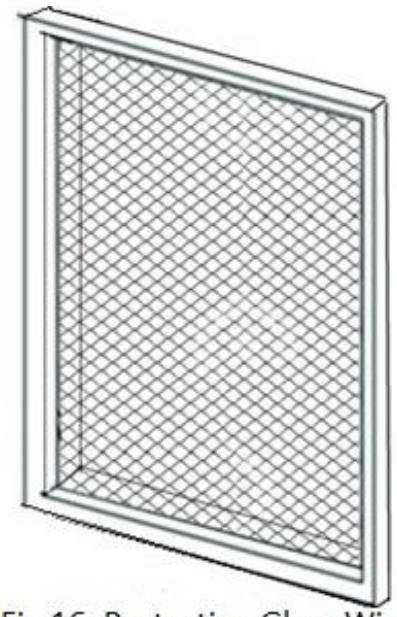


Fig 16. Protecting Glass Window

4.4.5. Magazine Stands:

Magazine stands are short and narrow. These should be kept away from exit ways. As these cannot be kept against the walls due to the display on both sides, these should be placed at right angles to the wall and attached on that side to the wall using L clamps. Long L clamps tucked inside can be used to anchor these to the floor as shown in the picture.

Fig 17. Anchoring Magazine Stand

4.4.6. Computer Systems and Printers:

Computers, printers, monitors, projectors, scanners, and other electronic equipment are commonly kept on desks and tables without proper anchorage. These items have to be prevented from falling down in earthquake shaking. First and foremost, the table should be prevented from falling by anchoring to walls or floor.

Computer Monitors : Monitors can be anchored to the table using nylon straps as shown in the figure 18. The base of the computer monitor is prevented from sliding with a friction inducing rubber sheet (EVA sheet is preferred). Then the monitor is attached to the table with nylon straps, which goes around in loops/bows around the neck of the monitor. Two such bows on either side can give more stability. The straps can be provided with adjustable side release buckles or hook and loop tape (such as Velcro) so that computer monitors can be moved as required.

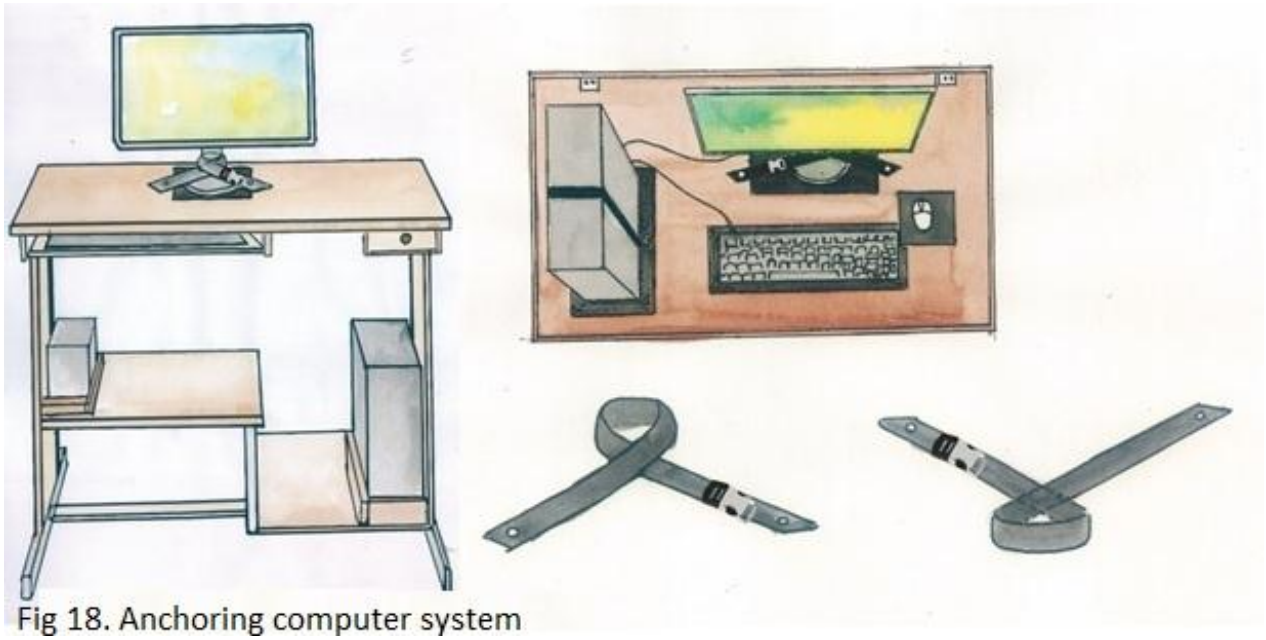


Fig 18. Anchoring computer system

For old type CRT Monitor : The combination of both EVA sheets and strap at the back can prevent the monitor from falling down.

Central Processing Unit (CPU) : CPU is preferably kept in the horizontal position on the table. They can be kept in place with EVA sheets and straps as shown in the pictures. If these have to be kept vertical, it is advised that these be kept on the lower shelf and kept in place using nylon straps and adjustable side release buckles.

Uninterrupted Power Supply (UPS) : An UPS or a CPU kept on the lower shelf can also be anchored by creating a small wooden lip border around and keeping it in place with a strap. Self-adhesive hook and loop can be used effectively to keep computer items in place. Two 10 cm long strips of the hook side glued to either side of the CPU to paste it and use 10 cm loop sides on the table (if the tape is not self-adhesive one can use instant epoxy adhesive, for example, Fevikwik). Allow the glue to set and place the CPU onto the table so that the hook and loops attach well to each other. Clean all surfaces before attaching.

EVA sheets below keyboards will prevent these from sliding.

Supplies Required:

a. Hook and Loop (Velcro) tape along with instant glue.
b. Nylon strap belt 1" or 1.5" wide; and length has to be as per requirement.
c. Side release buckles used with Nylon strap for fastening.
d. Rubberized mats (EVA sheets)

4.4.7. Physical Balances:

Physical balances are sensitive instruments that have to be kept from sliding and also toppling over. To prevent the legs from sliding in any direction, use thin (4mm or 6mm) plywood pieces of 8cm x 8 cm with holes drilled through slightly larger than the diameter of the pointed end of the legs nailed/screwed onto the table. The balance may be kept from toppling by connecting it to the wall using a chain as shown in the figure below.

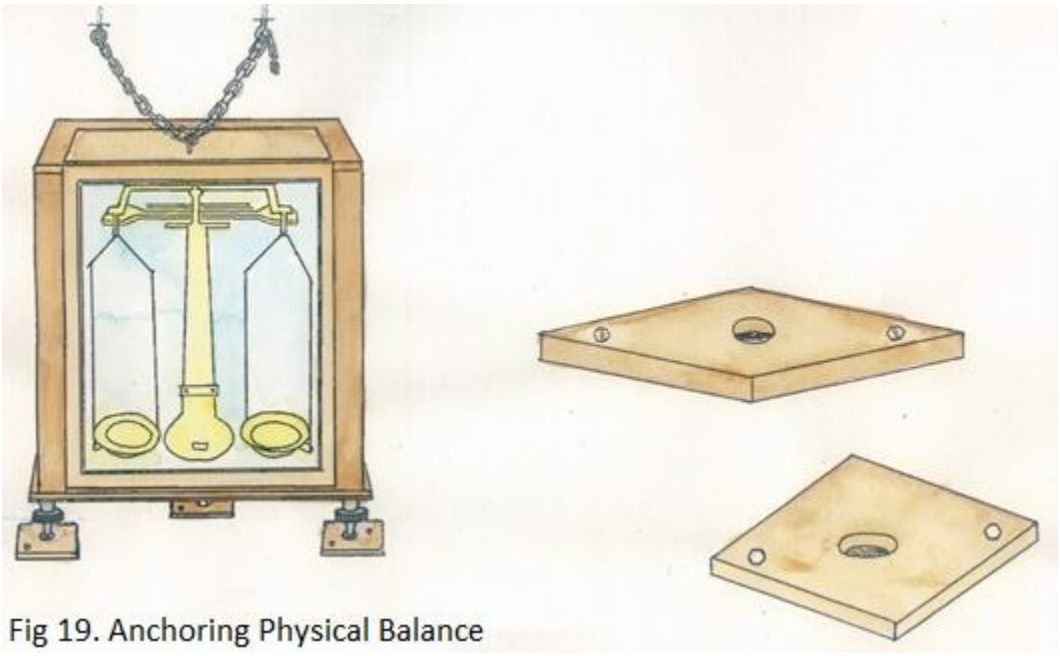


Fig 19. Anchoring Physical Balance

4.4.8. Glass Beakers/Specimen Bottles:

Glass beakers/specimen bottles, beakers, etc. have not only to be prevented from falling down during an earthquake shaking, but also kept from hitting each other. While in storage, these should be kept in boxes with bin/partitions as shown in the figures below. These bins should have separators as per the diameter of the glassware. If these are kept in open shelves, they should be prevented from falling with a glass/plywood lipping and a spring above. These can also be kept in place by customized plywood base with circular holes as per the sizes of the beakers.

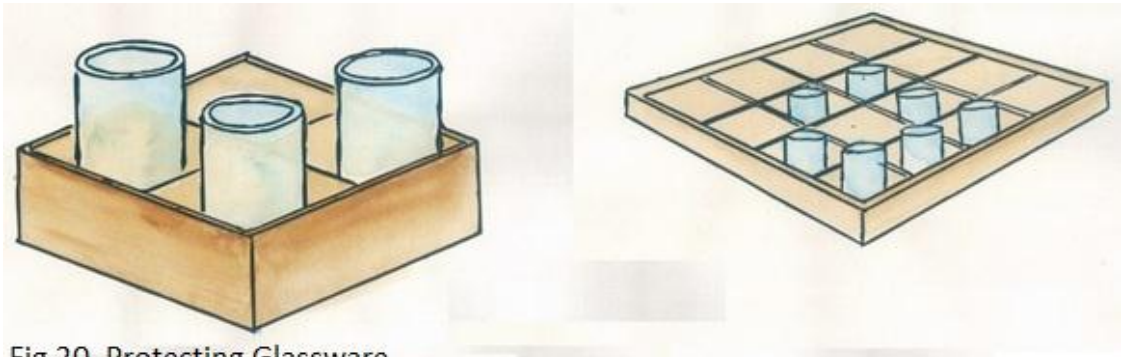


Fig 20. Protecting Glassware

4.4.9. Titration Apparatus:

These should always be boxed while in storage and kept in the lower shelves of the cupboards.

4.4.10. Common-bench Mounted Equipment:

Common bench mounted equipment such as Ammeters, resistance boxes, microscope, optical benches, while in storage should be protected from falling down from cupboards by providing wooden lipping and curtain spring at height appropriate to the stored items in the shelves. These objects can be prevented from moving by placing a friction-increasing rubber sheet such as EVA sheet on the shelves before placing the equipment.

Fig 21. Protecting bench mounted items

All work benches in physics lab must have sheets of EVA glued to the surface to prevent such equipment from sliding in earthquake shaking.

4.4.11. Display Shelves:

Display shelves should be kept away from where it can fall down and injure someone or block exits. Shelves should be anchored to walls or roof as discussed in the mitigation option for cupboards. If the display shelves have glass doors, use mitigation solutions for glass as given above page 48.

Objects on display should be anchored to the (anchored) shelves or to walls. In most schools, the displayed objects include trophies, sports shields and statues. It is again advised to keep these away from places where they can cause losses. If these cannot be avoided, please use the following solutions.

4.4.12. Statues/Trophies:

Many trophies are made up of two or three pieces. Glue/attach all pieces together.

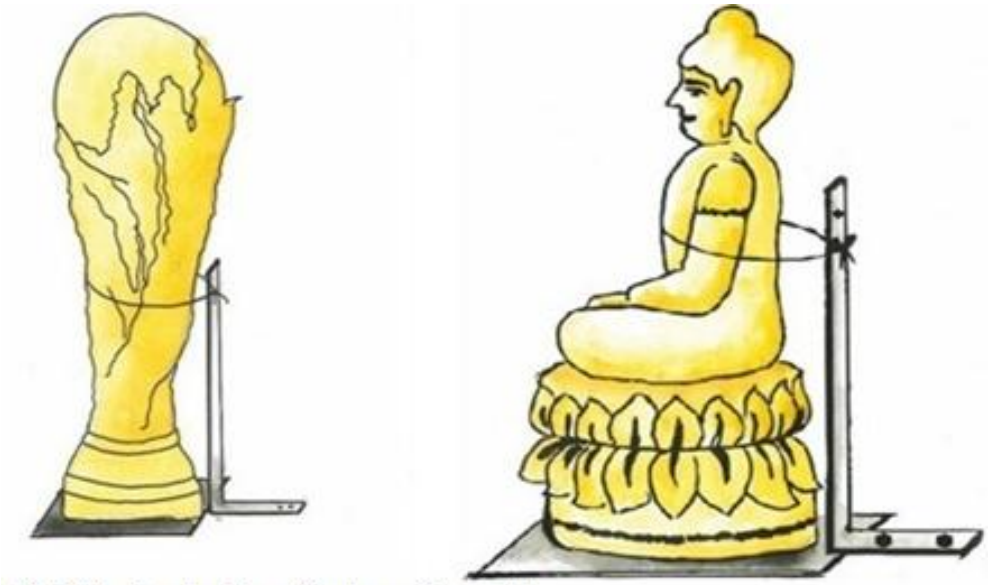


Fig 22. Protecting Statues/Trophies

Trophies/Statues can be prevented from falling by tying them to a long L clamp behind them on the shelf or to a J hook attached to the wall behind them (if available). Use fishing wire (Nylon 1 mm diameter) to tie trophies and statues. Use intertwined nylon thread for heavier trophies. The height of the longer leg of the L clamp depends on the height of the trophy or statues.

4.4.13. Sports Shields:

Ideally these should not be kept at a height as these are heavy objects that can injure people nearby if these fall

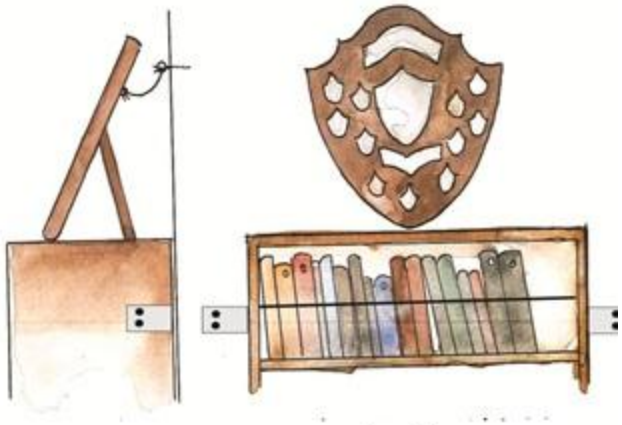


Fig 23. Protecting Sports Shields

down. These can be tied using fishing wire at the back to the shelf using 'O' ring hook at both ends or to a 'J' hook on the wall as available. If sports shields are kept in glass cupboard, use mitigation solutions for glass and a spring to prevent it from falling on to the glass as given in previous page.

4.4.14. Wall-Mounted Items:

Items should be hung using small J hook or big headed screws rather than nails. For additional stability, use a small hook and loop tape glued to the clock and the wall as shown in the below figure.

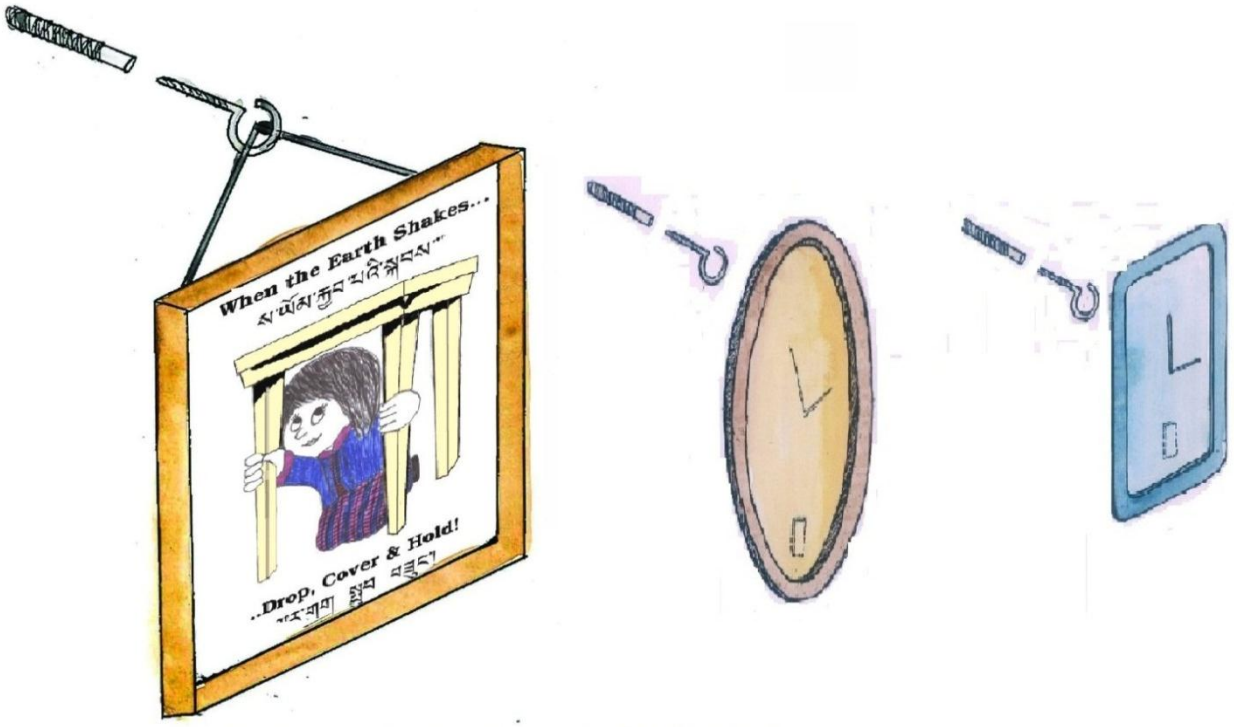


Fig 24. Anchoring Portraits/Wall-Clock

4.4.15. Altars (Internal):

Altars are often made up of two or more parts. It is important to get the altar to move as one unit in earthquake shaking. This can be done with L clamps as shown in the drawing. It must also be connected to the wall using L clamps similar to the solution for cupboard.

The statues in the altar should be prevented from falling using L clamps and fishing wire as shown above page. Butter lamps in altar are a major hazard and must be prevented from falling by placing them in metal boxes with bin to hold the butter lamps in

Fig 25. Anchoring Altar (Internal)

place without allowing these to slide in earthquake shaking as shown above.

4.4.16. Altars (external)

Often it is seen that these altars are over exits of the school. These must be moved away from exits and anchored well to the school building so that it does not hamper evacuation in any manner. Care should be taken to ensure that the statues are anchored as per solutions given above. Glass on the altar should be prevented from breaking and falling by using transparent film as mentioned above. Butter lamps should be kept from sliding by placing them in a metal bin with partition as shown.

Fig 26. Anchoring Altar (External)

4.4.17. Classroom Boards:

Classroom boards are normally fixed well to walls. These should be rechecked. If additional anchoring is required, use Z clamps as shown in figure. Boards can also be fixed directly to the walls by drilling through it and anchoring using plastic/metal anchors with washers.

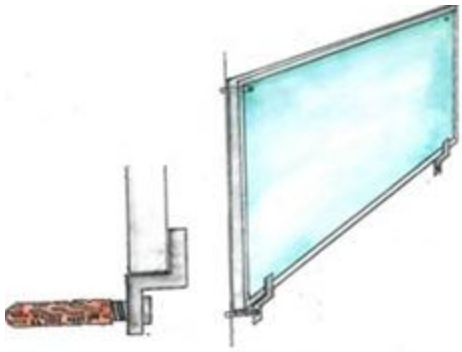


Fig 27. Anchoring Class-room Board

4.4.18. Tube lights:

Tube lights can be attached to the wall/roof by using fishing wire tied to two J hooks on either side of the tube light. Two wires are required near the ends of the tube light.

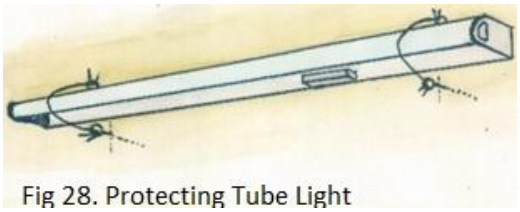


Fig 28. Protecting Tube Light

4.4.19. Fans:

Ceiling fans are normally hung on U clamps embedded in the concrete roof. The connecting nuts and bolts may be checked for stability. A check-nut should be tightened beside the primary nut to secure it. As an additional measure, a chain may be connected to a ring welded on to the stem of the fan and attached to a J hook anchor bolted into the roof slab.

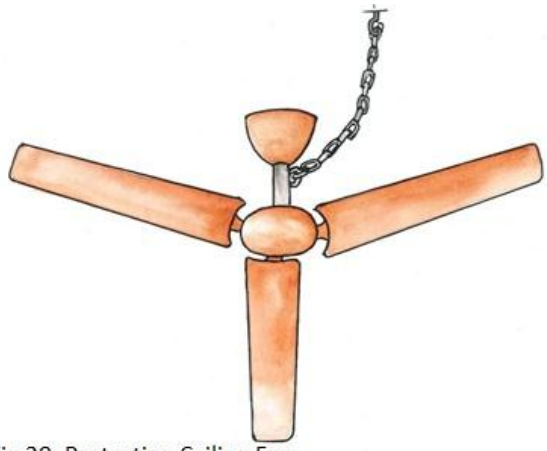


Fig 29. Protecting Ceiling Fan

4.4.20. Wall Fans

Wall fans have to be checked for stability. The base of the fan may be secured with a strap across it as shown in the figure. A chain should connect the handle behind the fan to a J hook on the wall with enough slack that it allows free rotation of the fan.

Fig 30. Protecting Wall Fan

4.4.21. Gas Cylinders:

If Gas Cylinders fall down, the connecting tube may come out, resulting in a gas leak and fires. Hence, it is important that these cylinders are not allowed to fall. The simplest way of anchoring cylinders is to chain them to a hook on the wall. If a chain is unavailable, it can even be tied with a rope to the hook.

Fig 31. Anchoring Gas Cylinder

4.4.22. Air Conditioner: Split (Internal Unit):

While installing it is important to use anchors and both that are sized to resist the horizontal forces caused by earthquake shaking. This can be reinforced with restraint straps on either side that do not affect the louvers of the AC.

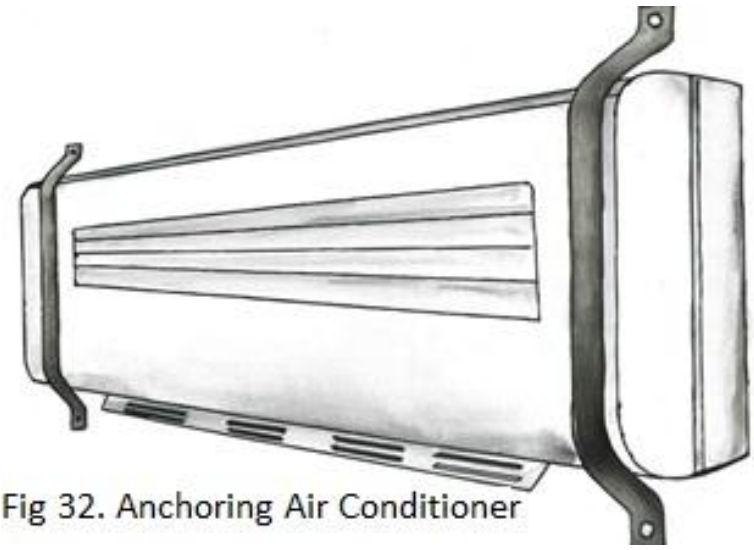


Fig 32. Anchoring Air Conditioner

4.4.23. Split AC (External Unit)

These normally come with stands and anchors for anchoring to the floor/walls. Double check that these have been anchored well.

4.4.24. Window AC:

Window-units normally can only be removed inward and cannot fall outward if installed well. However, these must be double-checked and to ensure safety of external bystanders, these must be attached to the external walls with metals straps as shown in the figure alongside.

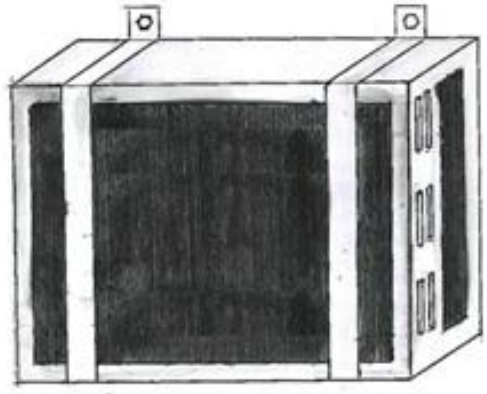


Fig 33. Anchoring Air Conditioner

4.4.25. Refrigerators/ Incubators:

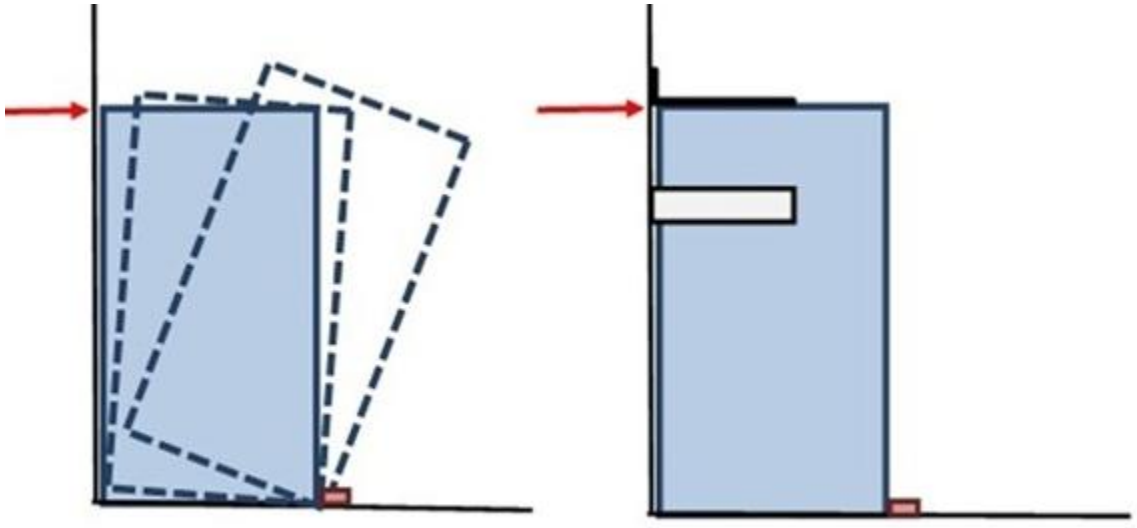


Fig 34. Anchoring Electric/Electronic Objects

While mitigating falling hazards, it must be noted that one cannot drill into electric/electronic equipment such as incubators, fridges, etc. Our solutions have to be managed without making holes in these objects. As can be seen in the above drawing here, when an object falls forward, the back corner of the object has to rise up before it can fall down. We will prevent the object from falling down by preventing the back corner from rising. To prevent it, align the object against the wall where it is to be anchored. Use the pencil to mark the left, top and right side lines on the wall.

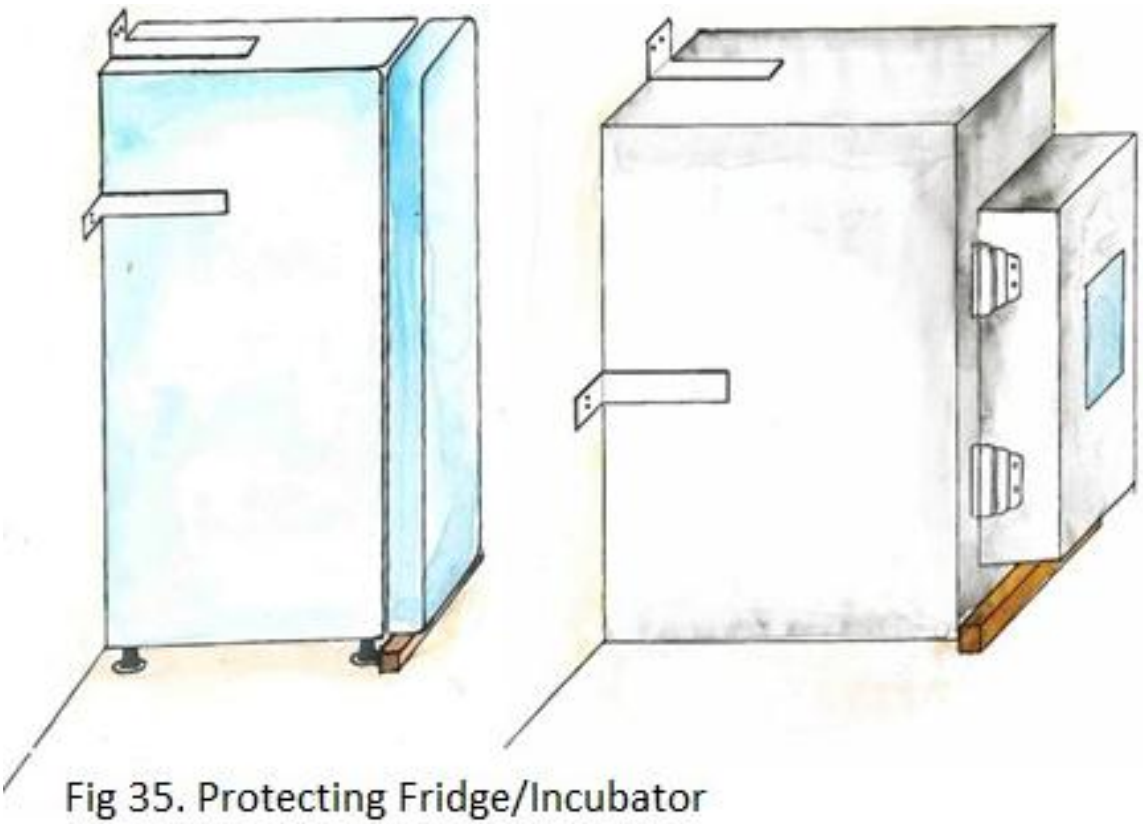


Fig 35. Protecting Fridge/Incubator

Fix long L clamps with 10 cm length on wall side with two holes, and 20 cm long on the object side with no hole. The clamp on the sides should be about 2/3rdthe height of the object from the bottom. Now, push the object into the space between the three clamps. Now it cannot fall forward or to the side as it is held by the clamps touching it on three sides. However, it can slide forward in earthquake shaking and we have to prevent the legs from moving forward. This can be done by screwing a wooden reaper (3 cm x 2 cm) on the floor in front of the legs of the object.

4.4.26. Electric Panel Board:

It can be anchored to the wall using L clamps to ensure that these do not fall out and cause electrical short circuits during earthquake shaking. Care should be taken to avoid electric shocks while working around electrical panel boxes.

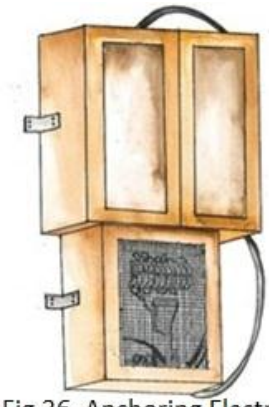


Fig 36. Anchoring Electric Board

4.4.27. Water Tanks:

Water tanks are almost always kept on the roof edge and can be affected by earthquake shaking. To prevent these from moving, the tanks should be anchored by braced L clamps of 1/3rd the height of the tank as shown in the figure above. The top of the clamp may be welded with a curved flat steel plate to prevent the clamp from damaging the tank in earthquake shaking. The connecting water pipe may be provided with a flexible joint to prevent breakages to the pipe in earthquake shaking.

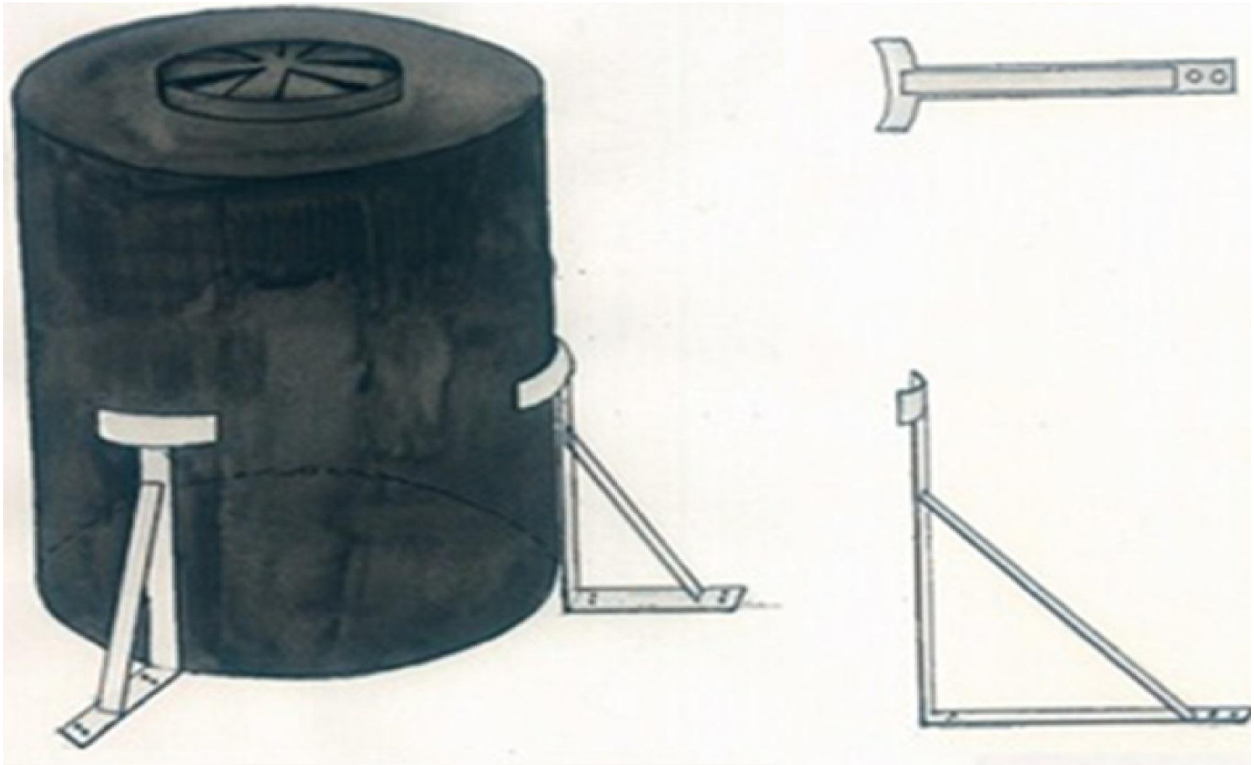


Fig 37. Protecting Water Tank

Chapter V: Precautions to be taken during Mitigation Actions – A must to follow

As we have seen in the preceding chapters, falling hazards mitigation is simple, but because we may be new to working with such tools, it is important to take all precautions we can in the interest of safety. We have listed a few points to be taken care of while carrying out the mitigation activities in schools.

1. You will have to use a drilling machine for fixing many of the hazards found in schools, and it is important to understand the material on to which we are drilling. This will help us choose the correct drill bit depending on to whether we are drilling on to a brick wall, concrete pillar, steel cupboard or wooden cupboard. Using the wrong drill bit could lead to accidents and also damage the drill machine as well as the object being drilled into.
2. Before starting drilling operations, it is necessary to 'test-run' it and get a feel of its performance before actually using it.
3. It is important to take extreme care while handling drills or sharp objects. Wear safety glass, work gloves, thick jacket and other protective equipment. These will help you to protect from dust, debris or any other hazardous objects. Do not wear loose clothes.
4. While using drill machines, it is important to inspect if the electric cords are not passing through the walls into which drilling is to be done. This will help you avoid electrical shocks.
5. When you are anchoring a cupboard or rack, it will be important to check inside to ensure you will not damage items inside the cupboard while drilling into it. Some cupboards have movable drawers whose movement should not be restricted due to the bolts.
6. When objects such as cupboards or rack shelves are to be drilled into, it is important to mark it position of the clamp and of the holes to be drilled. Marking exact points will help ensure correct drilling of the holes. The L clamps are not machine manufactured and hence the holes in one clamp may not match another. Thus, it is important to use the same clamp for marking the holes and also for anchoring as well.
7. Weight of such cupboards should be reduced by removing stored items such as books from inside them before moving these or drilling.
8. When drilling into anything, make sure that drill bits are set straight and tight in the jaws of the drill machine. Start the drilling at right angles to the wall and keep it straight during the drilling. If a drill is not held correctly, the drill bit may bend or break causing flying metal pieces.

9. Clean debris and dust from the holes you have made in the walls using small air blower or brush before inserting anchors and the screw.
10. Never hammer the anchor or the screws as they are not designed to be hit.
11. Some objects such as fridges or incubators should NEVER be drilled into. For solutions for these objects please see on page 56.
12. Chemistry labs contain a variety of hazardous materials that are chemically reactive, or toxic. Please discuss with the lab in-charge before choosing materials for mitigation purposes. This is to ensure that these materials do not react with these chemicals. Always keep those chemical bottles separate that may lead to hazardous reactions.
13. A Gas Cylinder is primarily a fire hazard and should not be present inside chemistry labs. Ideally, these should be placed outside the labs. If a gas cylinder is to be anchored, it should be shut off first and moved away from where the drilling is taking place.
14. When cutting a piece of wood by handsaw, make sure the saw blade is sharp and no nails or other imbedded objects are there in the wood. Mark the place where you are going to cut and then secure the wood firmly in place before cutting.
15. When working at a height to fix external hazards such as water tanks, overhead altars, air conditioners, etc. for which you may have to use ladders, it is extremely necessary to wear safety gear which include head protection, safety belts etc. to avoid injuries.
16. Before using ladders, inspect whether all rivets and joints, nuts and bolts are tight; feet steps and rungs are secure; spreader and pail shelf function properly. Also, keep ladders clean, free from grease, oil, mud, snow, wet paint, and other slippery material.
17. Prior to anchoring objects, a 'general safety check' for many other objects such as ceiling fans etc. is required to be done to ensure that they are properly anchored. To do that, a quick inspection of them should be undertaken.
18. When using tools and hardware for anchoring objects, it is also important to read instructional guides and specific details about the product features. Reading the manufacturer's guidelines will help ensure the product operates as intended.

Chapter VI: Ensuring Sustainability

This chapter will provides guidance to schools to take up the mitigation options and ensure that these are sustained so that any new items brought into the premises will be anchored.

1. It is important for all schools to implement mitigation options as recommended in this manual. However, this cannot be a one-time activity; all efforts must be made to ensure sustainability and continuity of Falling Hazards Mitigation (FHM) in schools.
2. FHM should be part of overall school safety efforts in schools, and schools should conduct falling hazards assessments annually to ensure that the updated mitigation and risk reduction actions are included in their school disaster management plans.
3. Teachers and students should be aware of the importance of mitigating these hazards and should be part of both the risk identification and mitigation process.
4. The following steps may be carried out annually to ensure the continuity of FHM in schools:
    a. The SDMC (School Disaster Management Committee) will add a section on Falling hazards to the existing School Disaster Management Plan. The risk assessments will become part of the updated school DM plan. There will be a separate section on 'Additions to School Inventory' showing the new items acquired by the school.
    b. The disaster focal teacher, the multi-skilled teacher, the class teachers and the relevant school Disaster Risk Management teams (Awareness Generation team) should carry out the non-structural assessments at the beginning of an academic year. It is important to involve as many students as possible as it contributes to raising their awareness and knowledge on DRM. The disaster risk management focal teachers should present the findings to the School Disaster Management Committee (SDMC).
    c. The SDMC will decide on the priority of the mitigation actions and get the budget approved for the mitigation actions. The multi-skilled teachers trained in the Falling Hazards Mitigation will lead and complete the mitigation efforts within the school academic year, with monitoring by the SDMC.

This manual has covered solutions for almost all falling hazards found in our schools with materials that are available locally in every dzongkhag. One of the objectives of this manual is also to stimulate your thinking to develop innovative solutions for items that are not covered in the manual, which may be found in your home or elsewhere.

References:

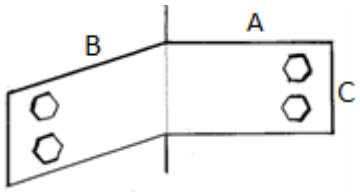
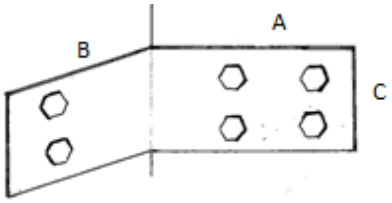
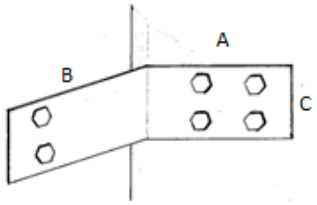
1. Non-Structural Risk Reduction Handbook for schools, Delhi Disaster Management Authority, Delhi, 2007, India. (http://www.geohaz.in/upload/files/Non-Structural_Risk_Book.pdf).
2. Reducing Earthquake Risk in Hospitals from equipment, contents, architectural elements, and building utility systems. (http://www.geohaz.in/upload/files/hospitalsafetymanual.pdf).
3. Reducing the Risks of Nonstructural Earthquake Damage – A Practical Guide, FEMA – 74, 2011. (http://mitigation.eeri.org/files/FEMA74_FieldManual.pdf).
4. National Recovery and Reconstruction Plan 2009. (http://www.adrc.asia/documents/dm_information/Bhutan_National_Recovery_and_Reconstruction_Plan.pdf).
5. National Recovery and Reconstruction Plan 2011.

Annexures:

Annexure A: Explanation of terminologies.

Sr No.	Terminologies	Explanation
1.	Life Loss/Injury risk	The risk that the object can cause injury or loss of life due to its movement induced by earthquake shaking. Example: A large object such as a cupboard or a heavy flower pot falling on a person's head could be fatal or can cause serious injuries.
2.	Exit Loss/ Blockage risk	The risk that the object can cause an exit to be partially or fully blocked due to its movement induced by earthquake shaking. Example: A large object such as a wooden cabinet sliding across an exit door will prevent evacuation of the occupants of the room after earthquake shaking.
3.	Financial loss risk	The risk that the object can cause significant financial losses due to its movement induced by earthquake shaking. Please note that '*significant*' is used here as a relative term. What could be a negligible loss to a well-equipped school could be a significant loss to a school with limited resources. Example: These could result in damage to expensive items- A costly piece of equipment could fall down in earthquake shaking and may be destroyed.
4.	Operational loss risk	The risk that the object can cause an interruption to the functioning of the school or a part of the school due to its movement induced by earthquake shaking. Example: If equipment such as computers, projectors fall down and get damaged in earthquake shaking the functionality of the computer lab will be lost.
5.	High priority objects	Every object that poses a threat to life should be deemed as high priority. Likewise, every object that can block the exit and can hamper the evacuation of large number of persons must also be high priority
6.	Medium priority objects	The loss of certain objects such as office computers, academic/attendance records, etc. can cause operational loss to the school. These can be given a medium (or even high) priority in mitigation as decided by the school.
7.	Normal priority objects	When the objects are not expected to cause loss of life or injuries, loss of exits or operational continuity and may cause only some financial losses, it may be given a normal priority.

Annexure B: Selection of Materials, Methods and Devices:

Sr No.	Name of the items	Dimensions	Usages
1.	2 mm thick L-Clamps with two 8 mm diameter holes vertically aligned in each leg.	(A × B × C)* 8×8×4 (cm)	Short cupboards (below 1.5 m height):  A – Length of the clamp cupboard side. B – Length of the clamp wall side. C – Width of the clamp For fixing short light cupboards, one clamp on each side near the top will be enough.
2.	2 mm thick L-Clamps with four 8 mm diameter holes vertically aligned in each leg. 1. Four 8 mm dia holes on 'B' side 2. Two 8 mm dia holes on 'A' side.	8×10×5 (cm)	Tall cupboards (above 1.5 m height):  For fixing tall heavy cupboard, use two clamps near the top and bottom on each side.
3.	2 mm thick L-Clamps with 8 mm diameter holes vertically aligned in each leg. **Note:** 1. Four 8 mm dia holes on 'B' side. 2. Two 8 mm dia holes on 'A' side.	10×10×5 (cm)	Tall cupboard(above 1.5 m height) leaning towards front. 
4.	Plastic wall anchor sleeves for fixing L clamps to walls	8 (dia) ×60 (Length) mm	For use with L clamps on *wall-side* to keep cupboards in place.
5.	Hex Screw with washers for plastic wall anchor	60 mm Hex Screw with washers	For use with L clamps on *wall-side* to keep cupboards in place.

Sr No.	Name of the Items	Dimensions	Usages
6.	Hexagonal nut and bolt	8 mm (dia) hexagonal bolt (2 cm long) with washers and lock nuts.	To be used on the *cupboard-side* with L Clamps to fix cupboard.
7.	Nylon strap belt	2.5 cm or 4 cm wide as per requirement	For strapping computers, TV monitors, etc.
8.	Steel or plastic side release buckles	As per requirement	Used with Nylon strap for fastening.
9.	Adjustable belt buckles	As per requirement	Adjustable clips for tightening nylon straps.
10.	Curtain stretch spring	Standard size	Curtain spring for keeping shelf contents (books, bottles, and other items from falling). Two hooks will be required for each piece of spring.
11.	2 mm thick EVA (Ethylene-Vinyl-Acetate) foam	As per requirement	For preventing objects such as computers, T.V monitors and other small equipment from sliding. EVA sheets come in large rolls and can be cut as per base dimensions of the equipment.
12.	Hook and loop tape	As per requirement	For preventing objects such as computers, T.V monitors and other small equipment from sliding.
13.	Metal Chain	As per requirement	For attaching items on wheels to prevent them from rolling away (or for keeping a gas cylinder from falling)
14.	Steel Carabineer Clips	As per requirement	Carabineer clips for hooking with metal chain.
15.	Sleeve anchor with open and closed eyebolt	6 mm to 12 mm	For attaching heavy items to be used along with metal chain and carabineer hook
16.	Hooks	2.5 cm	Hooks for hanging small portraits, wall clocks, etc.
17.	Hooks	5 cm	Hooks for hanging large portraits, wall-clocks etc.
18.	Sun Film	As per requirement	For preventing glass shards from falling if large glass panes break in earthquake.
19.	Chicken Mesh	As per requirement	For preventing glass shards from falling if large glass panes break in earthquake.

Annexure C: Selection of anchors based on Wall Materials.

Weight of the object (including contents)	**Brick Masonry**	**Concrete Block Masonry**	**Stone Masonry**	**Timber** (Wood Screws)
0-5 kg	**For light objects use size 6 Standard Wall Plugs**			4 mm x 60 mm
5-50 kg	Size 6 mm dia	Size 6 mm dia	Size 8 mm dia	4 mm x 60 mm
50-100 kg	Size 8 mm dia	Size 8 mm dia	Size 8 mm dia	Not Recommended
100+ kg	**Consult an engineer to select steel anchors.**			Not Recommended

Annexure D: Hazard Assessment Checklist for Schools:

School's Name:						Date of Hazard Assessment			
Location in School:						Hazard Assessment conducted by:			
		Comment		Risk Types (Check all that apply)				Priority High Medium Normal	
Potential Hazards	Check if item is present	M=Move A= Anchor	Total items	Life loss, injuries	Exit loss	Financial loss	Operational loss		Remarks
Furniture and Equipment									
Cupboards									
Rack shelves									
Magazine Stands									
Trophies									
Tube lights									
Glass windows									
Gas cylinder									
UPS, Monitor and CPU									
Others									
Overhead items									
Trophies									
Portraits									
Wall clocks									
Altars									
Statues									
Flowerpots									
Ceiling fans									
Others									
Wall-Mounted items									
Classroom boards									
AC									
Electric boards									
Wall fans									
Others									

Towards Safer Schools

DEPARTMENT OF DISASTER MANAGEMENT

MINISTRY OF HOME AND CULTURAL AFFAIRS

ROYAL GOVERNMENT OF BHUTAN

2017