The Global Library of School Infrastructure GLOSI

Manual for Using Pre-Disaster Data Collection Form

GLOBAL PROGRAM FOR SAFER SCHOOLS – GPSS

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Global Library of School Infrastructure

The World Bank's Global Program for Safer Schools (GPSS) launched in 2019 the Global Library of School Infrastructure (GLOSI). The GLOSI is a live global repository of evidence-based knowledge and data about school infrastructure and its performance against natural hazard events, as shown in Figure 1-1. A one-stop-shop with open access to global indicators on school infrastructure exposure and risk to natural hazards, taxonomy of school buildings, catalog of building types, fragility and vulnerability information, case studies on vulnerability reduction solutions applied around the world, and data collection tools. In-country data is also available with restricted access. The GLOSI is updated over time through World Bank-funded safer school projects and contributions from development partners with interest in this field.

Why do we need GLOSI?

Safer school projects have taught us that there are three main challenges to global dissemination of knowledge surrounding school building performance: communication to decision makers, the lack of a common language, and facilitation of quantitative risk assessment.

***Global knowledge about school infrastructure performance needs to reach decision** makers*

The engineering community has achieved immense progress in the past few decades towards understanding building performance against natural hazards and devising scalable risk-reduction solutions. However, this knowledge has not reached decision makers, nor has it been used to drive school infrastructure investments. Without this knowledge, the opportunity to maximize benefits from intervention and optimize investments in school safety can be lost.

The first objective is to create a universal "language"

School buildings tend to follow standard designs, yet buildings with similar vulnerability are still difficult to identify in different countries, or even within a country. This is largely due to the lack of a systematic classification system and consistent vulnerability assessment framework. The GLOSI offers a solution by making a taxonomy and vulnerability assessment framework for school buildings globally applicable, and oriented to produce quantitative risk information that will inform large investments in school safety and resilience.

The GLOSI is a tool to mainstream quantitative risk assessment in investment planning

By using a systematic taxonomy, the GLOSI includes a catalog of typical school building types found in different parts of the world with the respective vulnerability data needed to conduct quantitative risk assessments. Countries can map their school facility portfolios with the catalog and use the GLOSI data to perform quantitative risk assessments or vulnerability analyses to identify cost-efficient retrofitting solutions. The availability of this information will ensure that results are scalable across countries and safer school engagements in each country begin with a solid existing technical foundation.

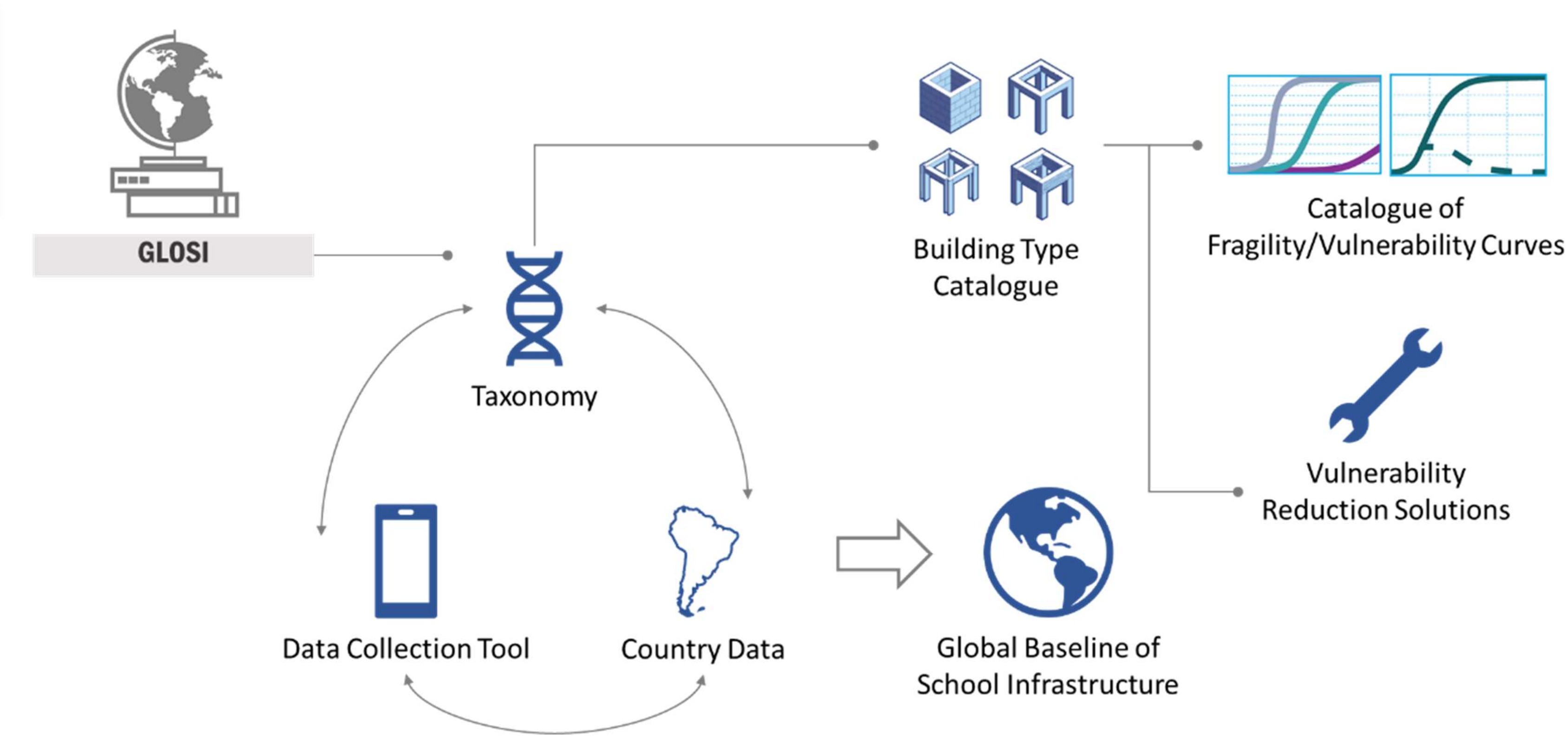


Figure 1-1. Global Library of School Infrastructure

1 Introduction

For the identification of seismic vulnerability parameters and structural classification of school buildings, it is necessary to collect detailed structural and architectural information. This activity is best done by means of field inspections performed by technicians or engineers with some background in construction practices, structural systems and typical construction details that affect the expected seismic behavior of a building. Data collection process is a cumbersome task and is better to carry out in phases, hence three different tiers are proposed for data collection: Tier 1, in which only easy-to-collect (i.e. fast to collect on site and do not require engineering background of the surveyor) data and photographs mainly required to identify first three taxonomy parameters (primary parameters) are collected; Tier 2, in which data and photographs required to identify all the taxonomy parameters are collected and finally Tier 3, where all detailed geometrical, structural and material properties data (intrinsic characteristics) are collected. Tier 1 is the task which can be done using the existing information (databases) available in the countries/regions (for example by the Ministry of Education, school representatives) to identify main taxonomy parameters i.e. Main structural system, Height range and Seismic design level. Tier 2 needs detailed field inspection to collect relevant data and photographs. Tier 3 level information in general should be established from local construction practice, local expert consultation, and existing literature. If such resources are not available, detailed assessment (for example destructive tests to know the internal reinforcement details or non-destructive tests to establish material properties) are required. Figure 1-1 summarizes the data collection framework.

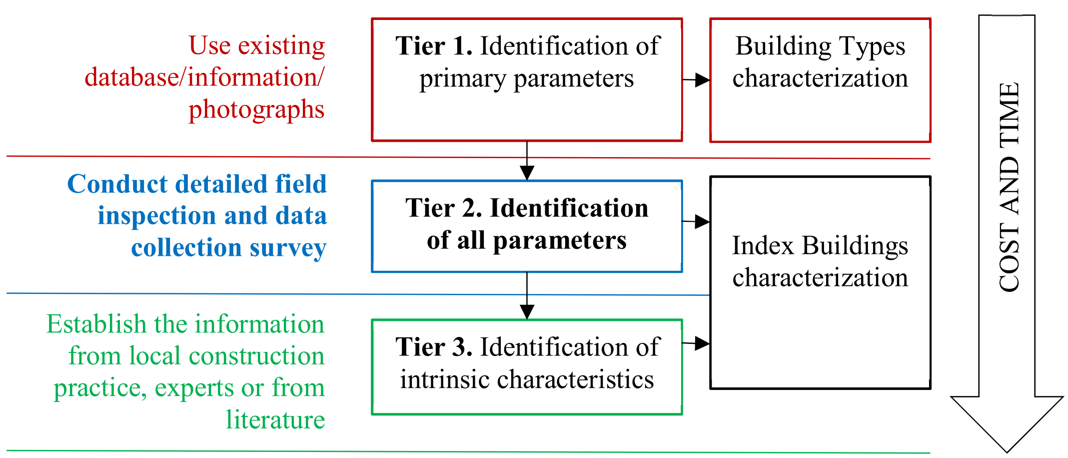


Figure 1-1. Data collection framework.

Thus, Tier 1 evaluates the whole portfolio of school buildings, and it is the basis for the exposure analysis that is part of countrywide risk assessment process. Based on the results of Tier 1, a statistically representative sample of school facilities can be selected for Tier 2 level survey. Tier 3 level is conducted over the set of index buildings (i.e. representative buildings to represent the seismic performance of a group of buildings share the same taxonomy string) identified in Tier 2, and hence Tier 3 is not conducted over a "real" portfolio of school buildings, but over a "virtual" portfolio of index buildings.

This deliverable deal with the Tier 2 level data collection. In the case of Tier 2, the data collection process can be carried out by civil engineers with adequate trainings as it is mainly based on field observation and measurements. The process can be simplified using the following strategy:

- Employ technicians or unexperienced but trained civil engineers in the field for the data collection.
- Then employ experienced seismic/structural engineers to perform the evaluation of taxonomy parameters and classification of buildings. This last activity to be carried out in the office based on the collected data from the previous step.

In order to facilitate the data collection process using the proposed approach for Tier 2, a standardized, simple to use, self-explanatory and globally applicable data collection form (Advanced Form) has been developed and tailored specifically for school buildings (Refer to the Advanced Form both in paper version and mobile App version). The advanced form consists of a standardized and flexible format that is applicable to a large number of building types, concise enough to require limited time on site, and recording observable quantities rather than requiring judgement and interpretation so as to avoid implicit biases by the surveyor. The main sections contained in the advanced form (Building Structure section):

- Parameter 0 – Building category
- Parameter 1 – Main structural system
- Parameter 2 – Height range
- Parameter 3 – Seismic design level
- Parameter 4 – Diaphragm type
- Parameter 5 – Structural irregularity
- Parameter 6 – Wall panel length or span length
- Parameter 7 – Wall openings or pier type
- Parameter 8 – Foundation type
- Parameter 9 – Seismic pounding risk
- Parameter 10 – Seismic retrofitting
- Parameter 11 – Structural health condition
- Parameter 12 – Vulnerable nonstructural components

This manual deal with the guidelines for using the advanced form developed for the Tier 2 level data collection.

Chapter 2 presents the detailed description of each one of the fields contained in the Tier 2 advanced form. In each case and for each parameter, the different options of answers are explained in detail. This information serves as the User Manual of the Tier 2 advanced form.

2 Guidelines for Filling the Tier 2 Advanced Form

2.1 BUILDING ID

This is the identification given in the field for each one of the independent building structures found in the school.

You must write down the 'BUILDING ID'. The building ID comprises of the school code plus the building number: school code-1, school code-2, etc. For example, if the school code is 12345, and the building number is 1, then the 'BUILDING ID' is 12345-1.

Are architectural/structural drawings available?

These drawings are of great importance during analytical modelling for the seismic vulnerability assessment. Ask the school representative present during the field inspection about the availability of the architectural/structural drawings.

You must answer yes or no. If you answer yes, you need to collect the drawings either in the form of a hard copy or you need to take photographs.

Who has the architectural/structural drawings?

You must write down who has the structural drawings. For example, the school, the District Education Office etc.

2.2 P0. BUILDING CATEGORY

Load bearing masonry (LBM)	Example
Description: This structural system has load bearing walls made up of masonry materials such as stone or brick or concrete block in mud or lime or cement mortar. Usually this category of buildings is easy to identify in the field looking at the walls on the two major sides of the building. These buildings generally are single storied, the roof structures are light and are double pitched with gable ends. Sometimes, light steel or RC or timber columns are also provided in LBM structures, for example to support the gravity loads from the roof. In the cases were the walls are covered, the inspector shall verify that this is a LBM structure by talking to the school representative present during the field inspection.	 **Illustration 2.1. An LBM school building (Photo from Nepal, Copyright: The World Bank).**

Reinforced concrete (RC) Frames	Example
Description: This structural system corresponds to a 3D composition (frames) of beams and columns made of reinforced concrete materials. The inspector needs to verify the presence of concrete columns and beams. Other structural components can be combined such as RC walls, or steel braces. Usually the system is complemented with masonry infill walls or other type of partitions and facades. Floor systems are usually one or two-way joist or solid slabs.	 **Illustration 2.2. An RC school building in Colombia (Source: UNIANDES)**

Steel frame (SF)	Example

<u>Description:</u> This structural system corresponds to a 3D composition (frames) of beams and columns made of steel sections. Other structural components can be combined such as RC walls, or steel braces. Usually the system is complemented with masonry walls, drywalls or other type of partitions and facades. Floor systems are usually steel deck and concrete slabs.	 **Illustration 2.3. An SF school building in Colombia (Source: UNIANDES)**

Timber frame (TF)	Example
<u>Description:</u> This structural system corresponds to a composition (frames) of columns, beams and walls made of timber material. Floors and roof structures are also usually made of wooden elements.	 **Illustration 2.4. A TF school building (Photo from Nepal, Copyright: The World Bank).**

Others	
<u>Description:</u> Structural systems and materials that do not correspond to any of the descriptions indicated above. For example: mixed systems (LBM in one direction and RC frames in other; LBM in first story and timber framed in second story etc.), informal and vernacular constructions (for example schools made up of bamboo structure), under construction etc.	

2.3 P1. MAIN STRUCTURAL SYSTEM

This is the most important parameter affecting the seismic performance of a building structure. The inspector needs to identify the type of main structural system and select one of the followings.

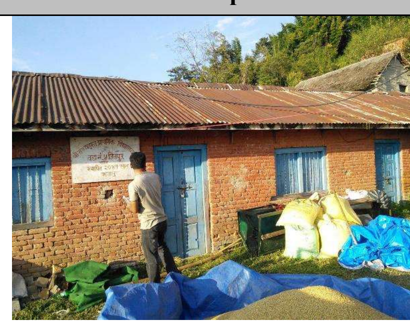
Adobe buildings (A)	Example
Description: These are LBM structures made of sun dried adobe bricks (mud bricks) or compressed stabilized soil blocks in mud mortar. As these buildings are locally constructed by communities (non-engineered constructions), the dimensions, materials and construction technology largely vary across the regions. If the walls are not covered, it looks grey in color compared to burnt clay bricks.	 **Illustration 2.5. Typical A school building (Photo from Nepal, Copyright: The World Bank).**

Dry Stone Masonry (UCM/URM1)	Example
Description: These are LBM structures made of dry stone (dressed or semi-dressed) masonry without any mortar.	 **Illustration 2.6. Typical UCM-URM1 school building (Photo from Nepal, Copyright: The World Bank).**

Rubble Stone in Mud Mortar (UCM/URM2)	Example

Description: These are LBM structures made up of random rubble stone in mud mortar masonry walls. The stones are shaped irregularly (usually rounded) and have varying size.	 **Illustration 2.7. Typical UCM-URM2 school building (Photo from Nepal, Copyright: The World Bank).**

Dressed Stone in Mud Mortar (UCM-URM3)	Example
Description: These are LBM structures made up of dressed (or semi-dressed) stone in mud mortar. Dressed stones are the cut stones having proper rectangular shape and have almost uniform size while the semi-dressed stones are cut on some sides only and have less uniformity in shape and size. Stone units are usually larger than normal bricks.	 **Illustration 2.8. Typical UCM-URM3 school building (Photo from Nepal, Copyright: The World Bank).**

Rectangular Blocks in Mud Mortar (UCM/URM4)	Example
Description: These are LBM structures made up of rectangular blocks (burnt clay bricks) in mud mortar.	 **Illustration 2.9. Typical UCM-URM4 school building (Photo from Nepal, Copyright: The World Bank).**

Rubble Stone in Cement Mortar (UCM/URM5)	Example

Description: These are LBM structures made up of random rubble stone in cement mortar. The stones of this masonry are shaped irregularly and vary greatly in sizes.	 **Illustration 2.10. Typical UCM-URM5 school building (Photo from Nepal, Copyright: The World Bank).**

Dressed Stone in Cement Mortar (UCM/URM6)	Example
Description: These are LBM structures made of dressed stone in cement mortar. The stones are shaped regularly because they are cut before forming the wall.	 **Illustration 2.11. Typical UCM-URM6 school building (Photo from Nepal, Copyright: The World Bank).**

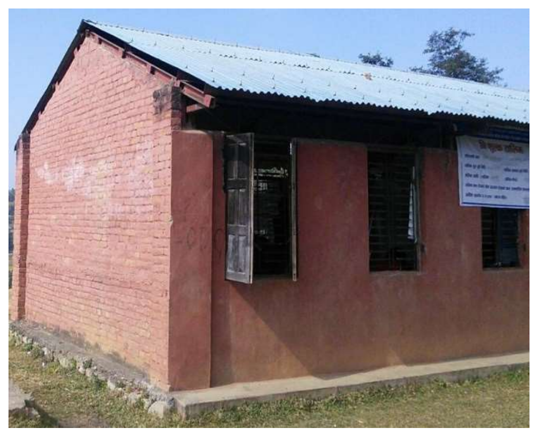
Rectangular Block in Cement Mortar (UCM/URM7)	Example

Description: These are LBM structures made of rectangular block (burnt clay bricks or concrete block) in cement mortar.	 **Illustration 2.12. Typical UCM-URM7 school building (Photo from Nepal, Copyright: The World Bank).**

Confined Masonry (CM)	Example
Description: Confined masonry buildings mainly consist of masonry walls (burnt clay bricks or concrete block in cement mortar) confined by small RC columns and beams (known as tie-columns and tie-beams). The size of confining RC elements is usually same as the wall thickness.	 **Illustration 2.13. Typical CM school building (Photo from El Salvador, Copyright: The World Bank).**

Reinforced Masonry (RM)	Example

Description: Reinforced masonry buildings mainly consist of hollow concrete blocks in cement mortar with internal vertical and horizontal steel reinforcement.	 **Illustration 2.14. Typical RM school building (Photo from El Salvador, Copyright: The World Bank).**

Light Steel Frame with LBM Walls (SFM1 to SFM6)	**Example**
Description: These are light steel frames (mainly consists of gravity columns to support the roof truss structures) with LBM walls. - SFM1 if the LBM walls are made of stone in mud mortar masonry. - SFM2 if the LBM walls are made of rectangular block in mud mortar masonry. - SFM3 if the LBM walls are made of stone in cement mortar masonry. - SFM4 if the LBM walls are made of rectangular block in cement mortar masonry. - SFM5 if the LBM walls are made of CM masonry. - SFM6 if the LBM walls are made of RM masonry.	 **Illustration 2.15. Typical SFM4 school building (Photo from Nepal, Copyright: The World Bank).**

Reinforced concrete (RC1)	**Example**

<u>Description:</u> Reinforced concrete moment resisting frames with/without in-fill walls that do not contribute to lateral stiffness. This can be found in recent structures in which masonry walls are well separated from the structure or those in which partitions and facades do not consist in masonry walls.	 **Illustration 2.16. Reinforced concrete 1. (Photo from Peru, Copyright: The World Bank).**

Reinforced concrete (RC2)	Example
<u>Description:</u> Reinforced concrete moment resisting frames with in-fill walls as stiffening element, not isolated from the concrete structure. In this kind of structures, usually the masonry walls go from column to column and from floor to roof but there might be specific cases in which this doesn´t happened, in any case, no captive columns are generated. The walls may have window openings. The masonry walls may present an out-of-plane type of failure.	 **Illustration 2.17. Reinforced concrete 2. (Photo from Nepal, Copyright: The World Bank).**

Reinforced concrete (RC3)	Example
<u>Description:</u> Reinforced concrete moment resisting frames with masonry infill walls in contact with the structure. Masonry walls include uniform openings along the longitudinal direction of the building generating the possibility of the captive column type of failure. When the masonry walls is not well reinforced may present an out-of-plane type of failure.	 **Illustration 2.18. Reinforced concrete 3. (Photo from Peru, Copyright: The World Bank).**

Reinforced concrete (RC4)	Example
Description: Reinforced concrete combined or dual system. They consists of a moment resisting frame complemented by a reinforced concrete shear wall or steel brace. It is usually used for medium or high rise buildings. It can also be a result of a retrofitting work of a moment resisting frame.	 **Illustration 2.19. Reinforced concrete 4. (Photo from Colombia, Source: UNIANDES).**

Reinforced concrete (RC5)	Example
Description: Non-engineered reinforced concrete structure. It usually includes a certain distribution of columns that may not correspond in all floors. Slabs usually consist of a solid or one direction joists slab without beams or girders. The structural elements may not conform standard moment resistant frames. Partition walls and facades are usually built with unreinforced masonry in contact with the structural elements, providing some initial apparent stiffness.	 **Illustration 2.20. Reinforced concrete 5. (Photo from Nepal, Copyright: The World Bank).**  **Illustration 2.21. Reinforced concrete 5. (Photo from Cali, Copyright: The World Bank).**

Reinforced concrete (RC6)	Example

Description: Prefabricated reinforced concrete systems conforming load bearing walls or moment resisting frames.	 Retrieved from: http://www.capresa.co.cr/ **Illustration 2.22. Reinforced concrete 6.**

Steel Framed 1 (SF1)	Example
Description: Moment steel frame (standard elements) with RM, CM or precast as infills.	 **Illustration 2.23. Steel Framed 1. (Photo from Cali, Copyright: The World Bank).**

Steel Framed 2 (SF2)	Example
Description: Braced steel frame (standard elements) with RM, CM or precast as infills.	 **Illustration 2.24. Steel Framed 2. (Photo from Colombia, Source: UNIANDES).**

Timber frame (TF)	Example
Description: Structural system that corresponds to a composition of columns, beams and walls made of wood. Floors and roof structures is also made of wood elements. Usually a non-engineered construction.	 **Illustration 2.25. Timber frame. (Photo from Nepal, Copyright: The World Bank).**

Other	Example
Description: Structural systems and materials that do not correspond to any of the descriptions indicated above. For example: mixed constructions (LBM in one direction and RC frames in other; LBM in first story and timber framed in second story etc.), informal and vernacular constructions (for example schools made up of bamboo structure), under construction etc.	 Retrieved from: http://radiorsd.pe/noticias/nuevo-chimbote-alumnos-de-colegio-ndeg88417-estudian-en-precarias-condiciones **Illustration 2.26. Other structural system.**

Note: any building previously subjected to a retrofitting work, shall be classified into the present structural system and not the original one

2.4 P2. HEIGHT RANGE

Number of stories	Example

<u>Description:</u> A story is a vertical space between two floors and the total number of these in a building gives the total number of stories. For the highest story to be counted, the area of the roof level occupied must be at least 35% of the area of the previous level.	 **Illustration 2.27. Figure showing the floor levels and stories. In this building, there are 3 stories (Photo from Nepal, Copyright: The World Bank).**

Total height	Example
<u>Description:</u> This is the total height measured from the ground surface level to the highest point of the structure. If the roof is sloped, then mention it in the sketch.	 **Illustration 2.28. Height. (Source: UNIANDES)**

2.5 P3. SEISMIC DESIGN LEVEL

Building construction year

It refers to the year when the building was built. It gives an indication of the seismic design codes and practice used in the building construction. If the exact year of construction is not known, the inspector needs to ask the school representative present in the field about the approximate construction year.

Construction responsible

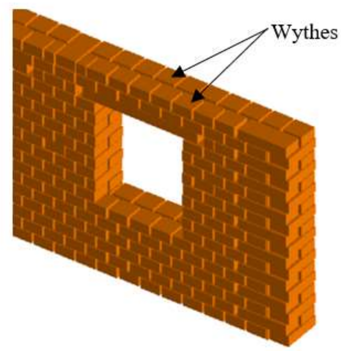
It refers to the organization involved in the design and construction of the school building and one of the followings should be selected: CR1 (National government) / CR2 (subnational government) / CR3 (NGO or donors) / CR4 (community) / CR0 (no information).

For LBM

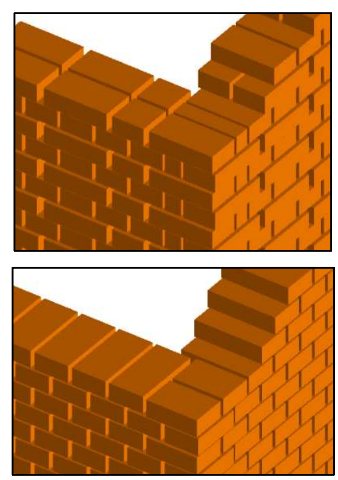
Wall thickness, m

It is the thickness of the main lateral load bearing walls, in meters. This might vary in a building; the inspector should report here the thickness in the first story walls and mention the varying wall thickness in comments section.

No of wythes

No of wythes	Examples
Description: This is the number of leaves in the load bearing masonry walls which are connected to each other by interlocking or using external materials such as steel ties. In stone masonry, there are usually more than one wythes which are connected to each other using corner/through stones at regular intervals. If not visible, the inspector needs to get this information from school representatives or from local experts.	 **Illustration 2.29. A two-wythes masonry wall.**

Masonry bond pattern

Masonry bond pattern	Examples
Description: This is the masonry wall laying pattern which can be English bond, Running bond, Flemish bond etc. This affects the seismic performance at wall level as well as determines the interlocking between the cross walls at the corners (thus affecting the OOP behavior). If not visible, the inspector needs to get this information from school representatives or from local experts.	 **Illustration 2.30. Top: English bond pattern and Bottom: Running bond pattern.**

Seismic enhancement measures

<table>
<tr><th>Seismic enhancement measures</th><th>Examples</th></tr>
<tr><td>
<u>Description:</u>
Seismic enhancement measures are the construction features included in the original construction which improve the seismic performance of the structures.

Presence of horizontal ring beam (RC, timber or steel) at the floor/roof level
Presence of lintel band beam (RC, timber or steel)
Presence of window sill level band beam (RC, timber or steel)
Presence of intermediate ties/stitches (RC, timber or steel) at corners
Presence of light material gables or gable band beams
Presence of vertical columns (RC, timber or steel) at the corners
Presence of vertical steel reinforcement bars at the corners
Presence of regularly spaced corner and through stone in stone masonry walls
Buttress in masonry walls with long panel lengths
Presence of anchored ties (RC, timber or steel) connecting parallel walls

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Lintel level band beam.

An unreinforced masonry building with gables, gable band beams, lintel band beam, sill level band beam and intermediate bands.

Corner stone in stone masonry
Illustration 2.31. Examples of seismic enhancement measures in LBM structures (Photo from Nepal, Copyright: The World Bank).
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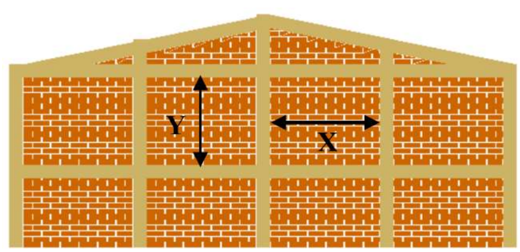
<u>For CM</u>

Level of confinement

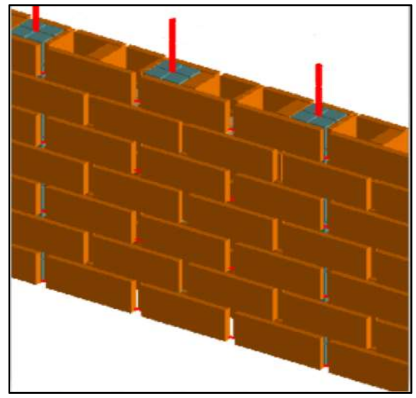
Level of confinement	Example
<u>Description:</u> The level of confinement might be different, and it affects the seismic performance of a CM building. The inspector should select one from the following options: 'Well confined' or 'Partially confined'. Some building might be 'Well confined' with confinements provided at regular spacing and over all the openings as well. While in 'Partially confined' CM buildings, the level of confinement is not sufficient i.e. at large spacings and/or leaving the openings unconfined.	 A 'Well confined' CM school building.  A 'Partially confined' CM school building. **Illustration 2.32. CM buildings with different levels of confinements (Photo from El Salvador, Copyright: The World Bank).**

Details of confinement

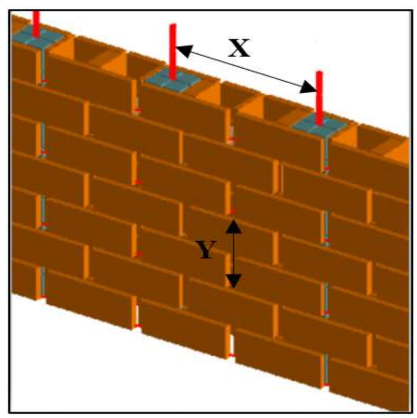
Details of confinement	Example
<u>Description:</u> **<u>Cross-section of RC tie-beams/columns, m x m</u>** This is the cross-sectional area of the RC tie-beams/columns, given as width x depth, in meters. **<u>Horizontal spacing (max.) of confinement, m</u>** This is the maximum distance between two consecutive tie-columns, in meters. **<u>Vertical spacing (max.) of confinement, m</u>** This is the maximum distance between two consecutive tie-beams, in meters.	 **Illustration 2.33. Spacing of confinement: X = maximum horizontal spacing and Y = maximum vertical spacing.**

For RM

Type of reinforced masonry

Type of reinforced masonry	Example
Description: This information is critical to determine the seismic performance of RM buildings, thus needs to be collected. The inspector needs to ask the school representatives and/or the local experts or should consult the seismic design codes in the region to collect this information. The inspector must choose one of the followings: 'Fully grouted', 'Partially grouted' or 'No information' if the information cannot be collected. A fully grouted RM construction is that in which every vertical hole in the hollow concrete block masonry is filled with grouted reinforcement. Whereas, in partially grouted RM construction, the grouted reinforcement is provided at regular spacing skipping few holes (usually one or two).	 **Illustration 2.34. A partially RM construction.**

Details of reinforcement

Details of reinforcement	Example
Description: This information is critical to determine the seismic performance of RM buildings, thus needs to be collected. Again, the inspector needs to ask the school representatives and/or the local experts or should consult the seismic design codes in the region to collect this information. **Spacing of vertical reinforcement, m** This is the distance between two consecutive vertical reinforcements, in meters. **Spacing of horizontal reinforcement, m** This is the distance between two consecutive horizontal reinforcements, in meters.	 **Illustration 2.35. Spacing of vertical reinforcement (X) and horizontal reinforcement (Y).**

For RC

Seismic enhancement measures

Seismic enhancement measures	Example

<u>Description:</u> For RC: • Infill walls or parapets or facade components isolated from the structure • Infill walls or parapets or facade components with evidence of internal reinforcement or confinement or effective connection to the structure • Stronger columns with respect to beams • Columns with minimum dimension greater or equal to 30 cm. •	 **Illustration 2.36. Wall isolation from the column. (Photo from El Salvador, Copyright: The World Bank).**

2.6 P4. DIAPHRAGM TYPE

<u>Type of structure (roof or floor)</u>

RC solid slab	Example
<u>Description:</u> Reinforced concrete solid slab with uniform thickness. It is a rigid type diaphragm. <u>Additional information</u> • Specify depth of the solid slab	 **Illustration 2.37. RC solid slab. (Source: UNIANDES)**

RC two way joists slab	Example

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<u>Description:</u>

Two-way joist slab distributing loads in both directions. It is a rigid diaphragm.

<u>Additional information</u>

- Specify total depth of the joists
- Specify joists separations
- Specify joist typical width

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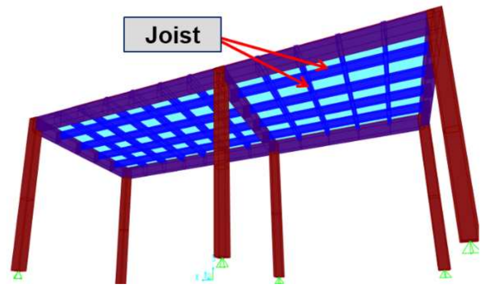

Illustration 2.38. RC two way joists slab.

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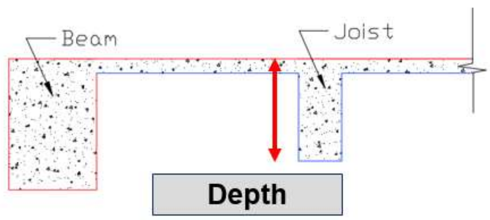

Illustration 2.39. Additional information 1, joists slab.

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Illustration 2.40. Additional information 2, joists slab. (Source: UNIANDES)

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<th>RC one-way joist in longitudinal direction</th>
<th>Example</th>
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<u>Description:</u>

One-way joist slab distributing loads in only one direction with a superior slab built monolithically. It is considered as a rigid diaphragm.

<u>Additional information</u>

- Specify total depth of the joists
- Specify joists separations
- Specify joist typical width

</td>
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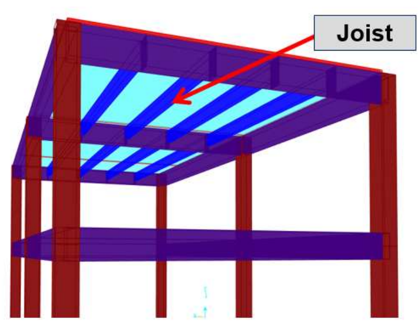


Illustration 2.41. RC one-way joist 1.

</td>
</tr>
</table>

Timber structure	Example

Description: Roof or floor structure made of timber elements with light coverings. It is usually a flexible type diaphragm. However, if there are diagonal in-plane bracings thereby providing sufficient in-plane stiffness and the timber joists are well connected (e.g. anchored) to the walls, the roof can act as a rigid diaphragm.	 **Illustration 2.42. Timber roof structure (Photo from Nepal, Copyright: The World Bank).**

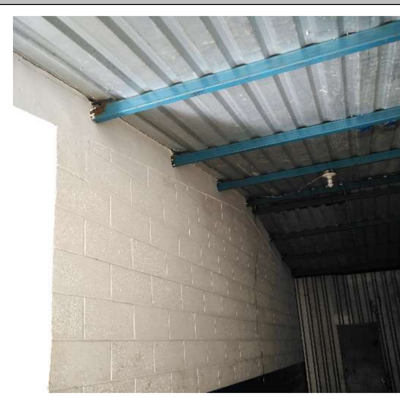
Steel deck with concrete slab	Example
Description: Steel deck and concrete slab distributing loads in one direction. It is a rigid diaphragm.	 **Illustration 2.43. Steel elements 1. (Source: UNIANDES)**

Steel structure	Example
Description: Steel elements roof with light coverings. It is usually a flexible diaphragm. However, if there are diagonal in-plane bracings thereby providing sufficient in-plane stiffness and the steel elements are well connected (e.g. anchored) to the walls, the roof can act as a rigid diaphragm.	

	Illustration 2.44. Steel (Photo from Nepal, Copyright: The World Bank).

Other	Example
Description: Systems that do not correspond to any of the descriptions indicated above (e.g. mixed roof structure or informal roof construction such as thatched roof with bamboo).	 **Illustration 2.45. Combined systems. (Source: UNIANDES)**

Connection to the lateral load resisting system

Monolithic or embedded or anchored	Example
Description: The roof or floor structure elements have monolithic connections or are embedded into the structural elements, usually RC beams.	 **Illustration 2.46. Roof structure embedded into the RC ring beam. (Photo from El Salvador, Copyright: The World Bank).**

<table>
<tr><th>Resting over lateral resisting system</th><th>Example</th></tr>
<tr><td><u>Description:</u>
The roof or floor structural elements are simply supported over structural elements. No or poor connection exists between them.</td><td>
Illustration 2.47. Resting over lateral resisting system (Photo from Nepal, Copyright: The World Bank).</td></tr>
</table>

Other	
Description: Connections that do not correspond to any of the descriptions indicated above.	

Roof cladding

<table>
<tr><th>Heavy</th><th>Example</th></tr>
<tr><td><u>Description:</u>
Refers to heavy roof covers such as stone slates or clay tiles.</td><td>
Illustration 2.48. Heavy roof cladding (Photo from Nepal, Credit: UCL).</td></tr>
</table>

Light	Example

Description: It refers to light roofs covers, such as CGI sheets, fiber cement tiles and zinc.	 **Illustration 2.49. Light roof cladding (CGI sheets) (Photo from Nepal, Copyright: The World Bank).**

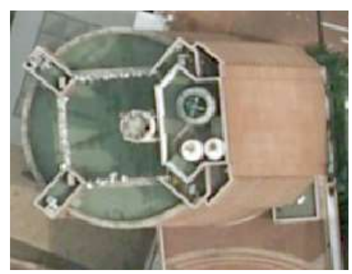
2.7 P5. STRUCTURAL IRREGULARITY

Structural irregularities are the architectural/construction features that causes sudden change in the geometry/mass/stiffness of a building structure. There are two types of structural irregularities: horizontal (dealing with the irregularities in plan) and vertical (dealing with the irregularities in elevation).

Horizontal Irregularity

It refers to the irregularities in the plan shape (see following illlustrations).

Square	Rectangular
 **Illustration 2.50. Square structure. (Source: Google Earth)**	 **Illustration 2.51. Rectangular structure. (Source: Google Earth)**
H-shaped	**L-shaped**

 **Illustration 2.52. H-shaped. (Source: Google Earth)**	 **Illustration 2.53. L-shaped. (Source: Google Earth)**
U-shaped	**T-shaped**
 **Illustration 2.54. U-shaped. (Source: Google Earth)**	 **Illustration 2.55. T-shaped. (Source: Google Earth)**
Arc-shaped	**Circular**
 **Illustration 2.56. Arc-shaped. (Source: Google Earth)**	 **Illustration 2.57. Circular structure. (Source: Google Earth)**
Asymmetrical	**Other**
 **Illustration 2.58. Asymmetrical structure. (Source: Google Earth)**	 **Illustration 2.59. Other shapes. (Source: Google Earth)**

Vertical Irregularity

This deals with the irregularities in elevation with respect to the sudden change in mass or stiffness.

Soft story	Example
Description: It refers to the sudden change of stiffness from one story to another. It is frequently found in lower stories, when some structural elements (columns or walls) are interrupted and do not reach the foundation level.	 **Illustration 2.60. Soft story. (Source: UNIANDES)**

Variation in story height	Example
Description: It can be found in structures of more than one story, in which the story height of one or several of them can be different.	 **Illustration 2.61. Variation in story height. (Source: UNIANDES)**

Variation in story mass and/or stiffness	Example
Description: It refers to the structures in which one or more stories presents a load or a heavier weight than the other stories. For example: elevated water tanks or pools; High density of walls in upper stories.	

	Illustration 2.62. Variation in story mass and/or stiffness. (Source: UNIANDES)

Setback irregularity	Example
Description: It is found when a setback is found from one story to another. This setback generates a lack of continuity in vertical elements.	 **Illustration 2.63. Setback irregularity. Photo from Cali School Building (Copyright: The World Bank).**

1st Story : Foot print

The dimension of the area enclosed by the structure must be specified in the first story.

Dimensions	Example
Description: X is considered as the longest length of the structure. It is considered Y as the shortest length of the structure. A bay is determined as the spacing between consecutive columns in RC, SF and TF; and between consecutive walls in LBM structures.	 **Illustration 2.64. Dimensions and number of bays in two principal directions. (Source: UNIANDES)**

2.8 P6. WALL PANEL LENGTH OR SPAN LENGTH

LBM: WALL PANEL LENGTH, RC: SPAN LENGTH	Example

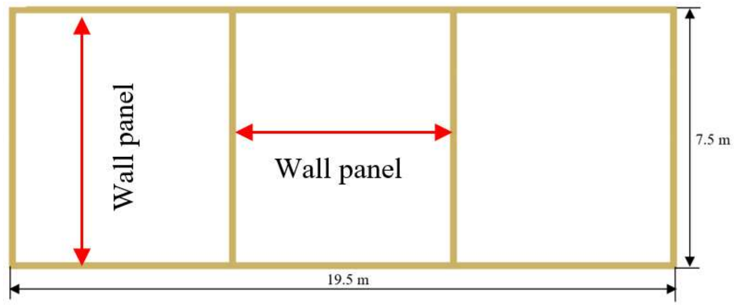
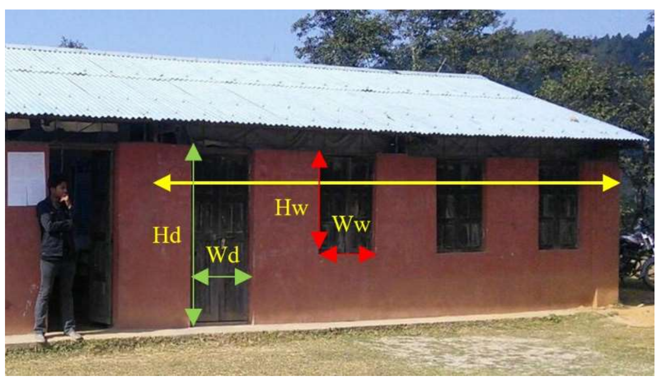
<table>
<tr>
<td>
<u>Description:</u>
For LBM, it is the span of the longest unrestrained panel (between two cross walls) or between two consecutive buttresses if provided. If SFM, maximum bay length between steel columns must also be given (although these usually are too small to provide proper restraint to the thicker walls).
For RC, SF and Timber frame, indicate the maximum length of bay in X and Y.
</td>
<td>


Illustration 2.65. Dimensions of structure LBM
</td>
</tr>
</table>

2.9 P7. WALL OPENINGS OR PIER TYPE

For LBM structures, the typical size of window opening (width x height), typical size of door opening (width x height) as well as the total width of the openings in the wall panel with maximum openings must be noted.

For RC, SF and TF structures, typical column (width x depth) and typical beam (width x depth) should be recorded.

Example
 Opening details in LBM structures: Yellow arrow indicates the panel with maximum openings; Wd, Hd are the dimensions of door; Ww, Hw are the dimensions of a typical window. Here, the total width of opening in the indicated panel is Wd + 3*Ww. (Photo from Nepal, Copyright: The World Bank).

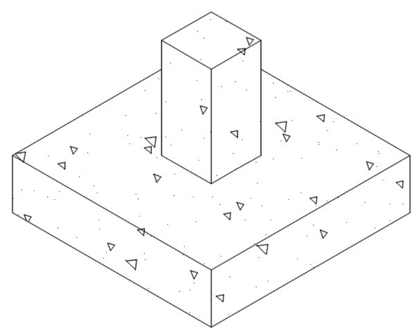
Pier type in RC structures

Illustration 2.66. Opening and geometrical details of structures.

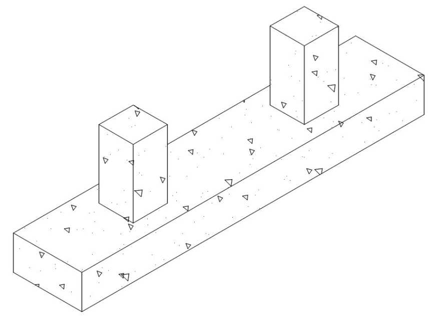
2.10 P8. FOUNDATION TYPE

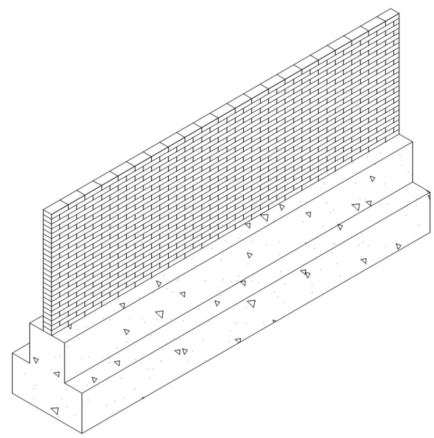
Previous work is needed to inform this parameter (collect technical drawings or MoE/local expert experiences on typical construction practice and soil type)

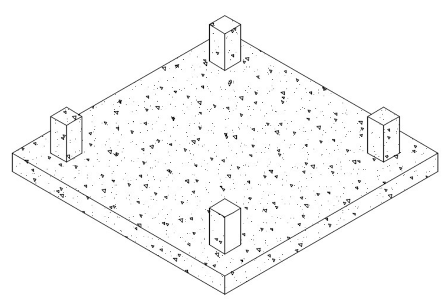
<u>Foundation structure</u>

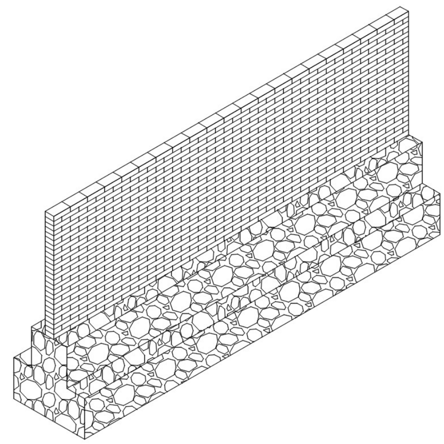
Reinforced concrete isolated spread footing	Example
<u>Description:</u> Reinforced concrete isolated spread footing provides support to each column. Usually connected at surface level by RC beams.	 **Illustration 2.67. Reinforced concrete isolated spread footing.**

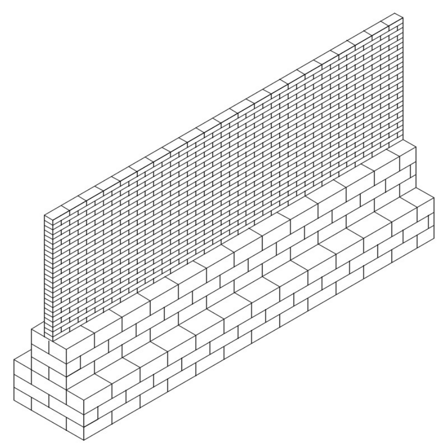
Reinforced concrete combined footing	Example
<u>Description:</u> Reinforced concrete combined footings are constructed for two or more columns when they are close to each other.	

	 **Illustration 2.68. Reinforced concrete combined footing.**

Reinforced concrete strip footing	Example
<u>Description:</u> Reinforced concrete strip footings consist of a continuous concrete strip, formed centrally under load bearing walls.	 **Illustration 2.69. RC strip footing.**

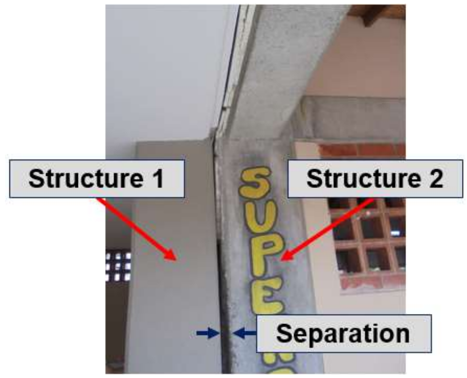
Reinforced concrete mat footing	Example
<u>Description:</u> A reinforced concrete mat footing is a large slab supporting a number of columns and walls under the entire structure or a large part of the structure.	 **Illustration 2.70. Reinforced concrete mat footing.**

Stonework strip footing	Example
Description: Stonework strip footing consists of a unified arrangement of stone masonry formed centrally under load bearing walls.	 **Illustration 2.71. Stonework strip footing.**

Brickwork strip footing	Example
Description: Brickwork strip footings are a type of shallow foundation that are used to provide a continuous level strip of support to a linear structure such as a wall or closely-spaced rows of columns.	 **Illustration 2.72. Brickwork strip footing.**

2.11 P9. SEISMIC POUNDING RISK

Minimum building separation	Example

Description: Measure the minimum separation between adjacent buildings, indicating the possibility of pounding.	 **Illustration 2.73. Building separation. (Source: UNIANDES)**
Height of the shortest building	**Example**
Description: The critical height is defined to be the height of the shortest building.	 **Illustration 2.74. Height of the shortest building. (Source: UNIANDES)**

2.12 P10. SEISMIC RETROFITTING

Previous work is needed to inform this parameter (collect technical drawings or MoE/local expert's experience).

Original Structure?

Answer if the structure has been effectively retrofitted (for example, strengthening of columns or walls; strengthening of roof structure etc.) or not, compared to the original building.

Year of retrofitting (if retrofitted)?

Year of retrofitting intervention implemented in the structure.

What was the retrofitting intervention?

Write the structural and non-structural modifications that the structure has had.

Who designed the retrofitting intervention?

Refers to the organization who designed/implemented the retrofitting intervention. For example: National government, subnational government, NGO or donors, or community

Note: This parameter permits to differentiate between an original and a retrofitted structure classified with an identical structural system, for instance, a combined system. In the case of a retrofitted structure the expected behavior would not be as good as the equivalent one, constructed originally with a combined system.

2.13 P11. STRUCTURAL HEALTH CONDITION

The structural health condition is assessed on the basis of a number of defects that affect the seismic performance. The inspector must observe and select all of the following defects which are applicable.

Structural cracking	Example
Description: Cracking in main structural components (wall, beam, column etc.)	 **Illustration 2.75. Structural cracking. (Photo from Nepal, Copyright: The World Bank).**

Corner separation	Example
Description: Separation of cross wall corners at the joints.	 **Illustration 2.76. Corner separation. (Photo from Nepal, Copyright: The World Bank).**

Foundation settlement	Example
Description: Differential settlement in the building. This can produce cracking in walls.	 **Illustration 2.77. Foundation settlement. (Source: UNIANDES)**

Corrosion of steel rebar/members	Example
Description: Corrosion of steel rebar due to exposure or bad quality of concrete.	 **Illustration 2.78. Corrosion of steel rebar. (Source: UNIANDES)**

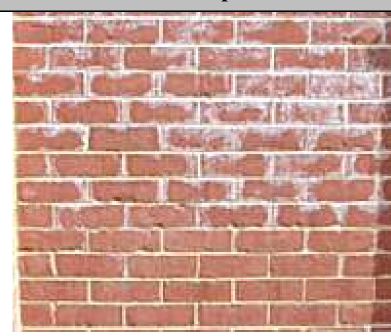
Poor quality of materials in lateral load resisting elements	Example
Description: Poor quality in materials in lateral load resisting elements such as walls, columns, beams, etc.	 **Illustration 2.79. Poor quality of materials in lateral load resisting elements. (Source: UNIANDES)**

Poor quality of materials in floor or roof elements	Example
Description: Poor quality in floor or roof elements (beams, coverings, tiles, girders, joists, etc.)	 **Illustration 2.80. Poor quality of materials in floor or roof elements. (Source: UNIANDES)**

Poor quality of construction process in in lateral load resisting elements	Example
Description: Poor quality of construction can be seen in discontinuous beams or columns, bad concrete pouring, misaligned elements, rebar exposure, etc.	 **Illustration 2.81. Poor quality of construction process in in lateral load resisting elements. (Source: UNIANDES)**

Poor quality of construction process in floor or roof elements	Example
Description: Poor quality of construction in floor or roof can be seen in discontinuous beams or columns, bad concrete pouring, misaligned elements, rebar exposure, etc.	 **Illustration 2.82. Poor quality of construction process in floor or roof elements. (Source: UNIANDES)**

Structural deflection	Example
Description: Noticeable deflections in beam, girders or joists.	 **Illustration 2.83. Structural deflection. (Source: UNIANDES)**

Masonry efflorescence	Example
Description: Masonry efflorescence can be identified when white, brown, green or yellow powdery substance is observed in bricks.	 Retrieved from: https://kingwoodpressurewashing.com/efflorescence-removal/ **Illustration 2.84. Masonry efflorescence.**

Covering or plaster cracking/detachment	Example
Description: Cracking/detachment of plaster in masonry walls.	 **Illustration 2.85. Plaster cracking (Photo from Nepal, Copyright: The World Bank).**

2.14 P12. NON-STRUCTURAL COMPONENTS

In this section, the inspector must select the condition of non-structural elements (such as parapet, gables etc.): **Poor** (very poorly connected or disconnected / heavy element / life threatening), **Fair** (poorly connected / light element / expected economic losses) or **Good** (good connection / light element).

Parapets	Example
Description: A parapet is a low wall or barrier at edge of a balcony, platform, roof or bridge. Its connection details and weight should be observed.	 This is **good** condition of the parapet wall since there are no visible cracks or tilt in it. **Illustration 2.86. Parapet. (Source: UNIANDES)**

Gables	Example
Description: It is normally a triangular portion of wall formed by a sloping roof. The reinforcement, confinement or connection to the structure should be observed.	 This is **poor** condition of gables because these have heavy weight, larger height, are poorly connected / free standing without any confinement. **Illustration 2.87. Gables (Photo from Nepal, Copyright: The World Bank).**

Overhangs	Example

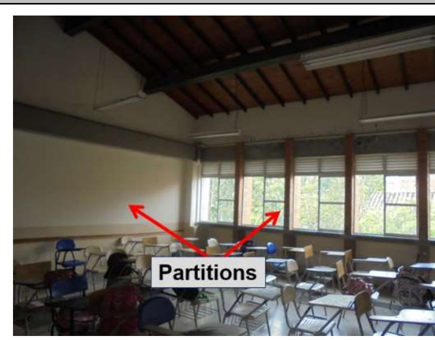
Description: Overhangs are protruding structures that do not have any support from below and do not have an engineered type of connection to the supporting structure.	 The condition of these overhangs in this building is **good** because these are light and are well supported by the trussed steel beams. **Illustration 2.88. Overhangs. (Source: UNIANDES)**

Roof cladding	Example
Description: Roof coverings serve as exterior enclosure, with main function as protection against climatic agents and other factors, giving privacy, acoustic and thermal insulation. Roof coverings can be made of different materials such as slate, tile, metal sheet etc.	 The figure shows a **poor** condition of roof cladding because these are mud tiles (heavy) and poorly connected to the roof frame. These can fall due to small shaking and are life threatening. **Illustration 2.89. Roof coverings. (Source: UNIANDES)**

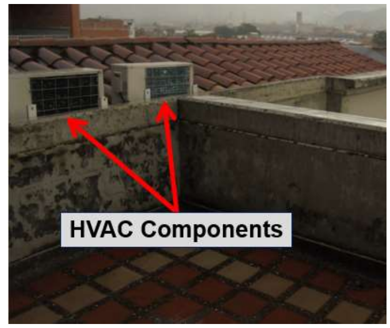
Ceilings	Example
Description: It is the flat and smooth surface that is located at a certain distance from de roof. The ceiling creates a closed space for the passage of the HVAC/electrical facilities. If these are not well connected to the roof or upper slab, these can collapse under lateral loads.	

	This photo shows a **good** condition ceiling because these are light weight and well connected to the structure. **Illustration 2.90. Ceilings. (Source: UNIANDES)**

Bookshelves	Example
Description: A bookshelf is a piece of furniture used to store and hold books. If not secured to the walls and floors, these can slide and topple during earthquakes.	 The condition of bookshelf in the photo is **fair** because this is secured to the wall, but it would have been better if it was resting its base on the floor. **Illustration 2.91. Bookshelves. (Source: UNIANDES)**

Partitions	Example
Description: Partitions are non-load bearing walls made of brick, drywall or any other material, separating spaces and providing privacy, acoustic isolation or fire separation. They usually are linked to the structures but do not have any kind of reinforcement or confinement and the connections are not engineered.	 This is **good** condition of the walls since there are no visible cracks, tilt or spalling. **Illustration 2.92. Partitions. (Source: UNIANDES)**

HVAC Components	Example

Description: A HVAC (heating, ventilation and air conditioning) components are the equipment used to provide and control the interior thermal conditions and air conditioning. They usually don.t have good supporting elements or connector.	 This is **fair** condition of the HVAC components since they are poorly connected to the structural system. **Illustration 2.93. HVAC Components. (Source: UNIANDES)**

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