

03

CONSTRUCTION MATERIALS, STRUCTURES AND DAMAGE TYPES

Lecture-03 periods

LESSON OBJECTIVES

**Upon completion of this lesson,
you will be able to:**

1. Define construction materials and classify them by their composition types and uses.
2. List and describe three forces that can affect construction materials
3. List three properties of each material: concrete, steel and wood.
4. Describe two methods of construction.
5. List four types of structures.
6. List at least three characteristics of a building in each of the following four categories:
 - General
 - Architecture
 - Structural elements
 - Non-structural elements
7. List and describe two types of damage in a structure and their potential resulting failures.
8. Name and describe the four basic collapse patterns.

1

Construction Materials

Notes

Natural materials processed by man and used in the construction of buildings, which consist of structural and non-structural elements.

1.1 Classification by Composition

1.1.1 **Stone:** Marble, granite, slate.

1.1.2 **Organic materials:** Wood, plywood, paper, particleboard

1.1.3 **Metal:** iron, steel, aluminium.

1.1.4 **Conglomerates:** concrete, plaster, adobe, clay

1.1.5 **Ceramics:** tiles

1.1.6 **Glass:** windows, glass block

1.1.7 **Plastics:** polyurethane, polyethylene, thermosetting adhesive

1

Construction Materials (Cont.)

1.2 Classification by Use in the Structure

- Structural/load-bearing elements
- Decorative elements and façades or veneers
- Non-structural walls and partitions
- _____ elements (roofing)

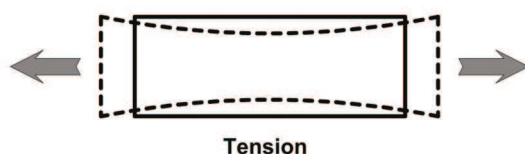
2

Forces Acting on Construction Materials

2.1 Tension

Forces that act to _____ or stretch a material.

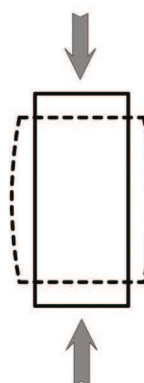
Examples: _____



2.2 Compression

Forces that act to _____ or compress a material.

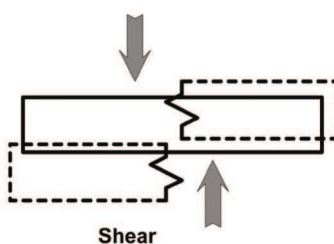
Examples: _____



2.3 Shear

Forces acting in opposite, parallel directions and on different planes so that they cut or break a material.

Examples: _____



The forces of tension, compression and shear, and combinations of these, are those that affect materials and structures, with the potential to cause damage.

Notes

A construction material consisting of a mix of cement, rock, sand and/or other inert materials, water and a small amount of air.

Characteristics

- Resistant to _____ and _____
- Weak under _____ and _____
- Continues to harden with time
- Very heavy: one cubic meter (m³) weighs almost _____



- Concrete cures by hydration, meaning that it needs water to harden. Once dry, concrete always develops cracks, which do not necessarily represent a _____. Concrete is strong in compression but weak in tension, which is why steel rebar is a necessary component of concrete beams, columns and floors.
- To appreciate the significance of concrete in construction and rescue operations, you must know how much it weighs: approximately 2,400–3,000 kg/m³. On a smaller scale, a piece of concrete measuring 15 cm x 30 cm x 30 cm weighs approximately _____ kg.

3

Properties of Construction Materials (Cont.)



4

Methods of Construction

The type of construction will give some indication of the way a building will collapse. Experience has shown that there are patterns in the way structures collapse. Therefore, this knowledge is useful in determining the **probable location** of voids and spaces where victims may be trapped, and in selecting the methods to employ in extricating them. Buildings can be divided into two main categories: _____ and _____.

Notes

3.2 Steel

Characteristics

- Can be bent without breaking (malleable)
- Easily conducts _____, _____ and _____.
- Resistant to _____, _____ and _____. It starts to lose strength above 700 degree Fahrenheit.

3.3 Wood

Characteristics

- Easy to cut
- Light
- Not fire-resistant
- Good _____ (will not transmit electricity)
- Provides warning — _____ before breaking

4.1 Unframed Structures

Unframed structures are those in which the weight of the floors and roof are supported by the _____.

Examples of this type of structures are brick and joist (support pillar for ceiling or floor) buildings and wood apartment buildings. As a general rule, these do not exceed seven stories in height. Rescue operations in unframed structure collapses are usually difficult, lengthy and dangerous. To the uninitiated, an extensive collapse gives the impression that the occupants have little chance of survival. Fortunately, rescues can be made because of the formation of voids created by structural members, strong objects such as machinery and heavy furniture, or a combination of these.



NON FRAMED STRUCTURE

4.2 Framed Structures

Framed structures are erected by constructing a structural steel or reinforced concrete skeleton made of _____ and _____.

The floors and/or roof are **not** dependent on the walls for support. Collapse can be more localized, but older concrete structures can suffer a pancake failure, and some steel structures with poor joints have overturned. The rescue teams face the same problem and seek out voids created by the collapse, as in unframed structures. Many buildings have elements of both unframed and framed structures. Most buildings have non-bearing walls. A common structure is one with exterior bearing walls with an interior framed system. A few examples would be tilt-up concrete walls with a wood roof and floors, and older brick or concrete wall warehouses with wood or concrete floors.



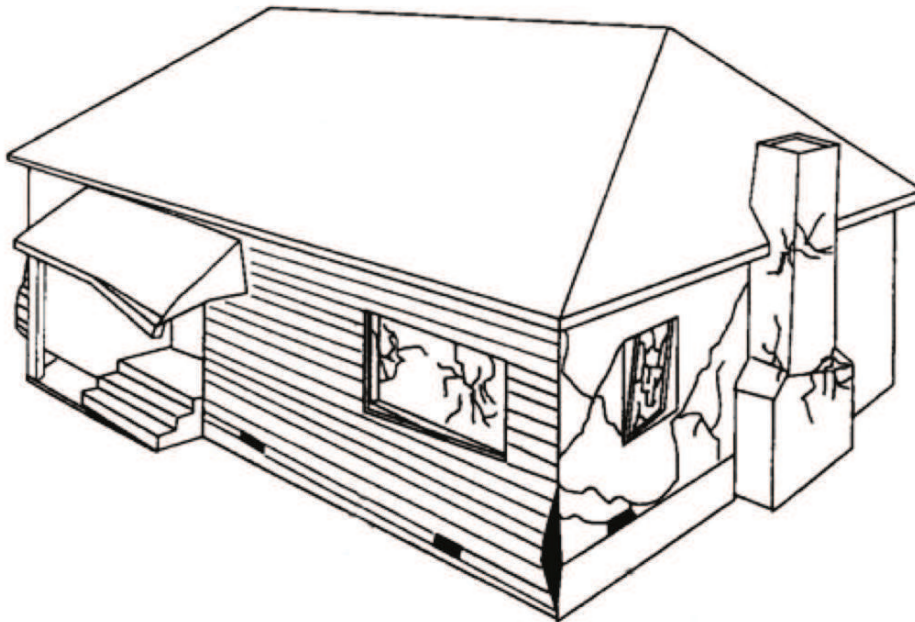
**Frame
structure**

Structural Types

Based on experience with earthquakes and collapses, building types can be also divided into four separate groups, with each exhibiting a distinctive collapse pattern. These groups are:

5.1 Light Frame

- Residential homes and apartments of up to _____ stories, and constructed mainly of _____. The principal weakness is the _____ strength of the walls and the connections.



- Rescuers operating in a light-frame building collapse should check for stability problems by looking for badly cracked or leaning walls and offset of the structure from the foundation, or a leaning first story in multi-floor dwellings.

Notes

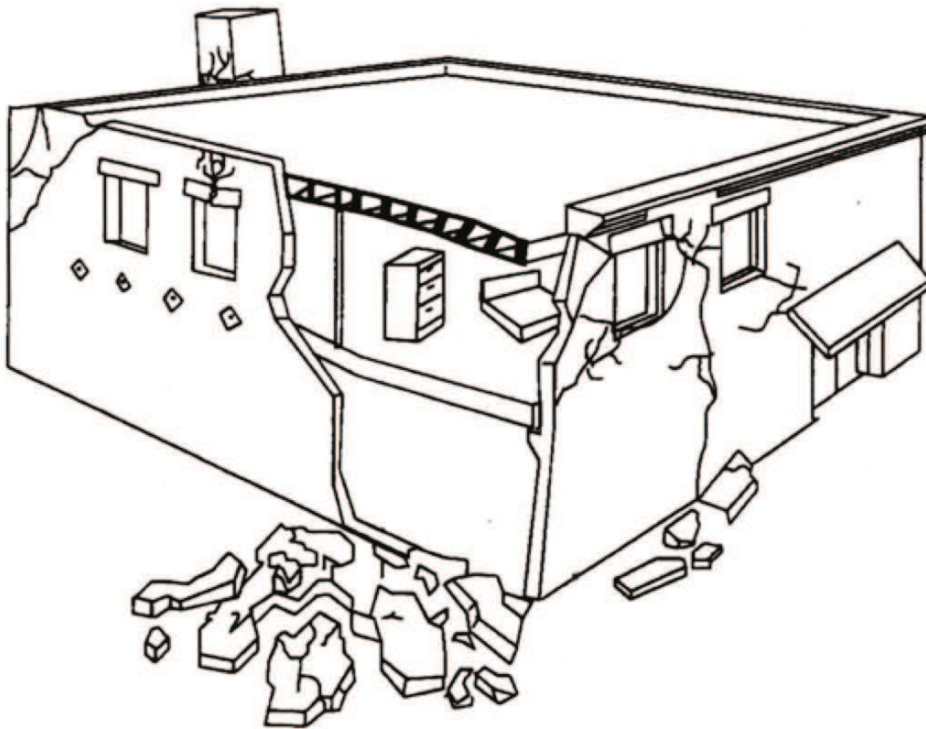
Structural Types

5.2 Heavy Wall (URM) Unreinforced Masonry

(Cont.)

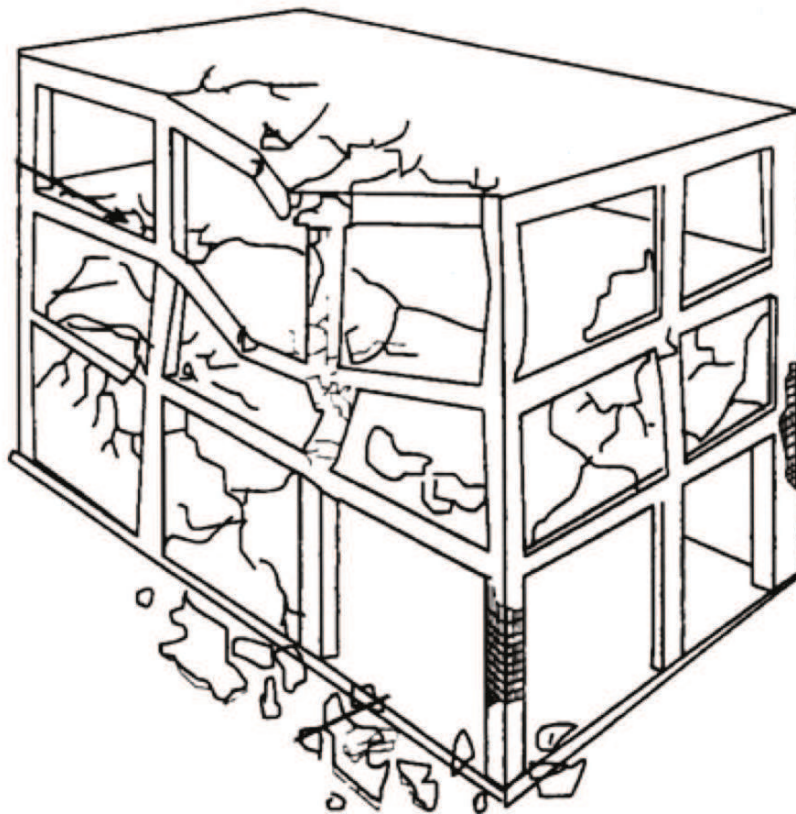
Notes

These buildings are one to _____ stories in height, and may be residential, commercial, industrial, or institutional. They have _____ masonry walls and _____ floors. When operating in an unreinforced masonry building make sure to check for loose and broken parapet walls and ornamental masonry, broken connections between walls and floors, cracked wall corners, and unsupported and partially collapsed floors.



5.3 Heavy Floor

Structures in this category can be residential, commercial, or industrial (concrete highway bridges). They have concrete frames and may be up to _____ stories tall.



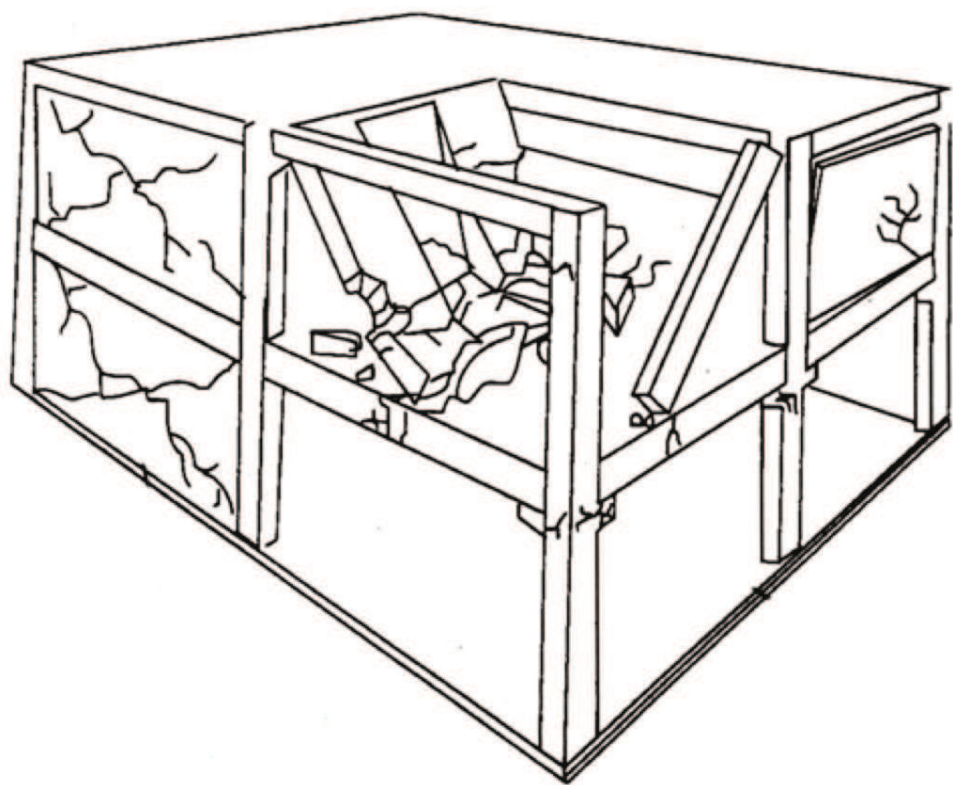
Rescuers should evaluate the stability of the structure by checking:

- The confinement of the concrete within the reinforcement of the columns
- Cracking of columns at each floor line
- Diagonal shear cracking in major beams adjacent to supporting columns
- Cracks in shear walls

Notes

5.4 Pre-Cast Concrete

Buildings with fairly _____ floors and some _____ walls. Precast structures may be commercial or residential and also include pre-cast parking facilities. These structures generally are one to _____ stories in height. Principal weakness is in interconnection of parts: slabs to walls/beams; beams to columns; walls to slabs, etc. Rescuers operating at a pre-cast building collapse should check for badly cracked walls, _____ connections for broken welds and cracked corbels, column cracking at the top and the bottom of joints, and wall panel connections and shear wall connections at floor areas.



Characteristics of a Structure

After seismic activity or other force causes structural and non-structural damage, it is important to relate the characteristics of the structure to the damage it has suffered.

6.1 General

General characteristics of a structure include the following elements:

- _____ type
 - Modifications to the original structure/plans (if applicable)
 - Location of _____
 - Contents
 - Number of occupants
-
-

6.2 Architecture

Architectural characteristics of a structure include the following elements:

- Shape of building and foundation
 - Height and number of _____
 - Number of _____
 - Major cantilevers
 - Location of _____
(stairwells, elevator shafts and service chutes)
 - Primary materials used
-
-

Notes

Characteristics of a Structure (Cont.)

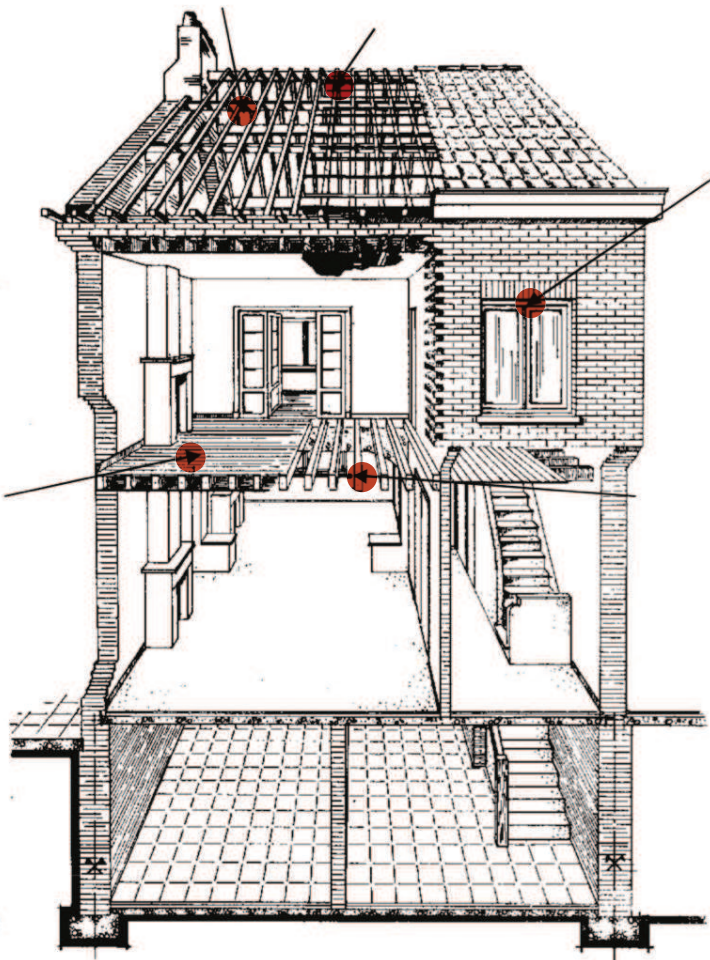
6.3 Structural Elements

The structural or load-bearing elements of a structure include the following:

- Columns
- Beams, girders, trusses, joists, rafters, purlins, studs
- Floor slabs, roof
- Load-bearing walls
- Foundations

6.4 Non-structural Elements

- Non-load-bearing walls, partitions, in-fill
- Windows, doors and other openings (fenestrations)
- Façades, veneers, parapets, and other



Notes

Damage Types and Potential Hazards

Damage to buildings can be categorized as structural and non-structural. _____ affects the _____ elements of a building, and likewise, non-structural damage affects the _____ elements of a building. However, both types of damage are capable of causing injury, death, contamination and other hazards.

7.1 Structural Damage

- Total structural collapse

- Leaning floors, roofs and walls

- _____ and _____

- Collapsed columns in one or more floors

- Substantial, permanent _____ shift in the structure

- _____

- Cracked foundation

- Cracked elevator shaft

Notes

7.2 Non-Structural Damage

- Generalized cracking

- Cracked or fallen _____ and _____

- Fallen staircases

- Shift in the elevator shaft

- _____

- Building signs and balconies

7.3 Types of Hazards

In damaged, partially and fully collapsed structures, we can identify three types of hazards:

- **Falling:** Part of the structure or its contents are in danger of falling.

- **Collapse:** The volume of enclosed space made by the structure will be reduced, as stability is lost.

- **Other:** Electricity, water, fuels, toxic gases (carbon monoxide), hazardous materials (asbestos), biohazards (industrial, medical), etc.

8.1 Cantilever

Results from a wall collapse which allows a floor or roof assembly to drop _____, but to remain _____ above the floor or base below on the side where the wall failed. The opposite end of the floor assembly remains _____ to the wall and at its original connection point. This type of collapse is extremely unstable and dangerous.

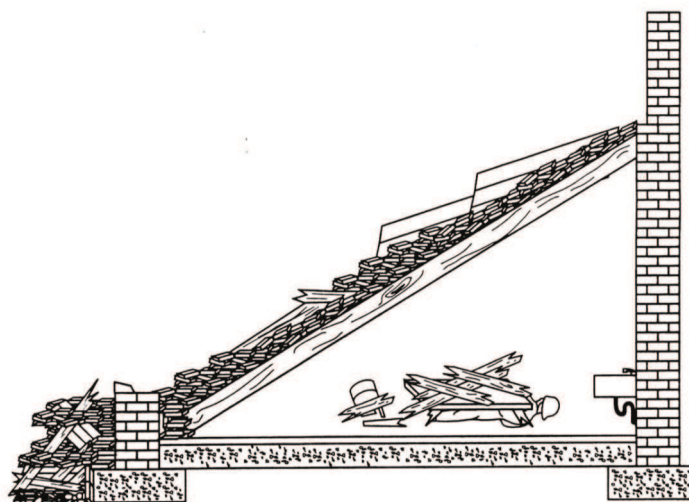
Cantilever ►



8.2 Lean-to

Found where a wall failure causes a floor or roof section to fall completely on _____, while the other end remains _____. This collapse usually results in a _____ void. Remember that the remaining supported end of the fallen section may be precariously supported.

Lean-to ►



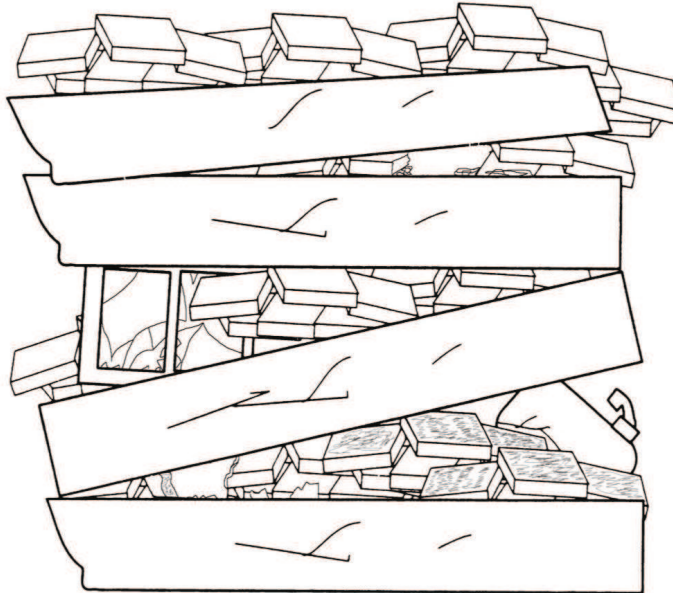
Notes

Basic Collapse Patterns (Cont.)

8.3 Pancake

Refer to multi-floor collapses where several floor slabs completely fail and _____ on top of each other. The resulting voids are _____ in space and are difficult to access, especially in concrete structures.

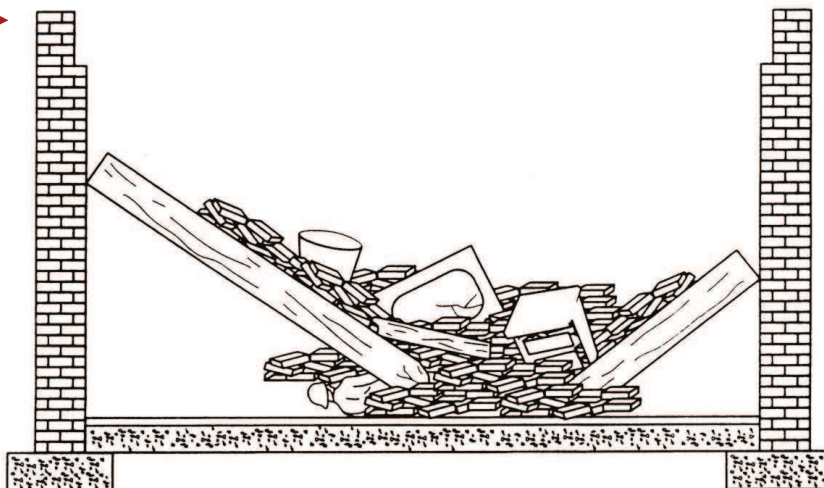
Pancake ►



8.4 V-Shape

This collapse will be created when a floor assembly collapses in the _____ due to failure of centre supports or overload of the floor. The result is two identifiable voids which are created on _____ of the broken floor assembly.

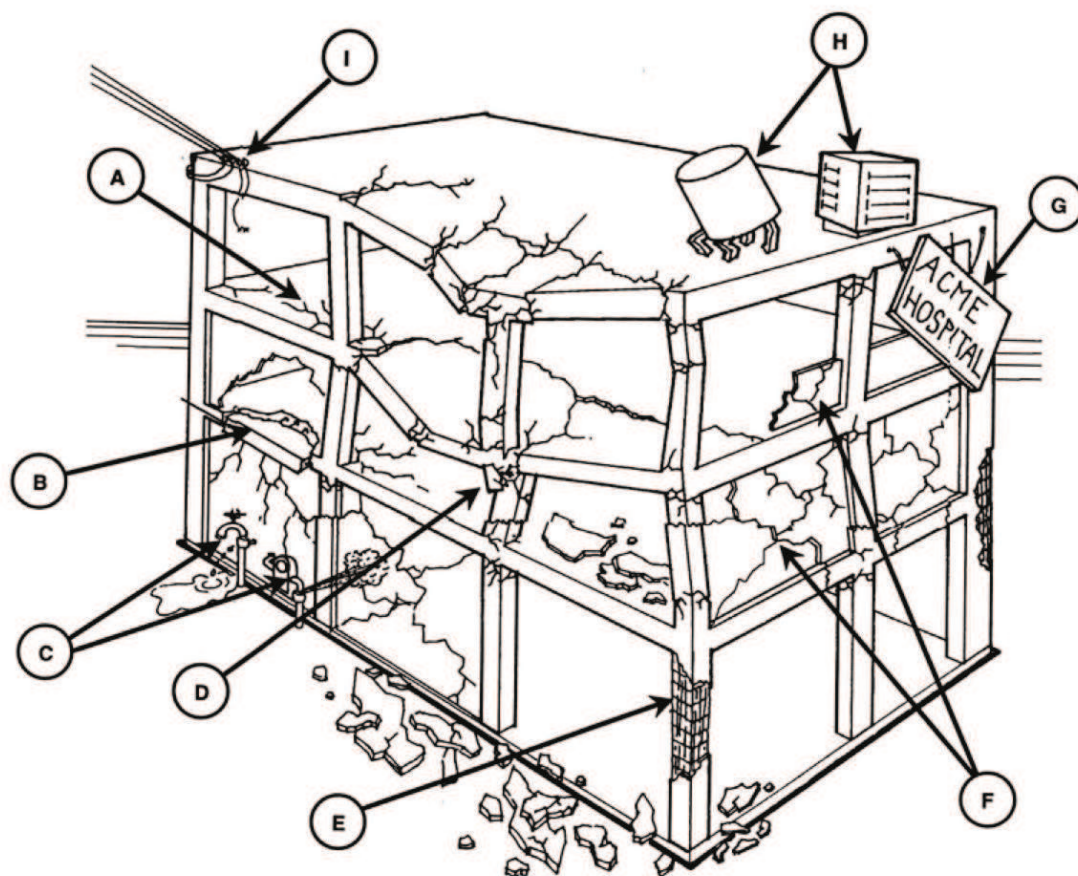
V-Shape ►



Notes

Identify the Failure Types

Notes



Identify the failure types above and whether they are structural or nonstructural:

- A. _____
- B. _____
- C. _____
- D. _____
- E. _____
- F. _____
- G. _____
- H. _____
- I. _____

[illegible]

POST-TEST | LESSON 3

Construction Materials, Structures and Damage Types

ID #

1. Match the following construction materials (Column A) with their classification by composition (Column B). Write the corresponding numbers in the spaces.

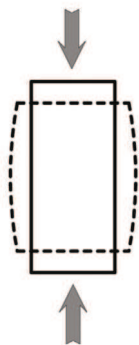
Column A

1. Aluminium
2. Tiles
3. Wood
4. Marble
5. Cement

Column B

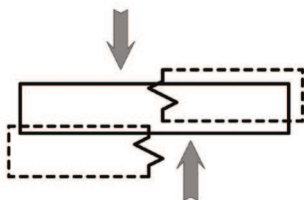
- | | |
|--------------------------|---------------|
| ☐ | Ceramics |
| ☐ | Organic |
| ☐ | Conglomerates |
| ☐ | Metals |
| ☐ | Stone |

2. Identify the each type of force in the three diagrams below and describe its effect on construction materials.



Force: _____

Effect: _____



Force: _____

Effect: _____



Force: _____

Effect: _____

3. List three characteristics for each of the following three materials:

Concrete	1.
	2.
	3.
Steel	1.
	2.
	3.
Wood	1.
	2.
	3.

4. Identify the structure type of the damaged building pictured below:



_____ Framed

_____ Unframed

5. List the four basic types of structures.

- _____
- _____
- _____
- _____

6. List two structural elements and two non-structural elements of a building:

Structural: _____

Non-Structural: _____

7. Draw arrows and label the types of damage you note in the following two paragraphs. Classify them as structural (S) and non-structural (NS).



8. Name and briefly describe the four basic collapse patterns.

- _____

- _____

- _____

- _____

CSSR LESSON 3 EVALUATION

Course Location: _____ Dates: _____

Do not write your name on this form. Please complete a copy of this form at the end of every lesson. Your evaluations are very valuable towards improving the course. Please use the ratings below.

	1 VERY POOR	2 POOR	3 AVERAGE	4 GOOD	5 EXCELLENT
Please fill in the required information.	Lesson Number :		Lesson Name :		
	Instructor's Name				
Use a scale from 1 to 5 as described above to rate the various lesson components.	Lesson Rating (rate 1 to 5)				
	Content		Instructor		Method
	Workbook		Interaction		
Mark your selection with an "X"	Instruction Level ☐ Too basic		☐ Appropriate		☐ Too advanced
	Duration ☐ Too short		☐ Appropriate		☐ Too long
	Usefulness Was this lesson useful to you?				
	☐ Yes ☐ No				
Rate from 1 to 5	Overall Lesson Rating Taking all the above into consideration, I rate this lesson: _____				
If you need additional space, please use the back of the sheet.	Comments and Observations				

Thank you for your help. Your input is valuable.
Please turn in this completed form to the instructor.

