

# IDENTIFYING STRUCTURAL DEFICIENCIES

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## Pillar To Post Continuing Education Program



# Table of Contents

- **Chapter 1:** Overview and Objectives
  - **Chapter 2:** The Leaning House
  - **Chapter 3:** Settlement Cracks
  - **Chapter 4:** Shrinkage Cracks
  - **Chapter 5:** Foundation Failure
  - **Chapter 6:** Interior Elements
  - **Chapter 7:** CEP Quiz
  - **Chapter 8:** Presentation Evaluation
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## CHAPTER 1

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### Overview and Objectives



## Overview and Objectives

A structure's job is to do nothing! More correctly, its job is to NOT shift or deflect excessively under its own weight or applied loads such as pianos, furniture, cocktail parties and stormy weather.

Structural problems occur when the soil under the structure can't adequately support the load of the structure or when one of the structural components of the home can't resist the applied loads.

This course involves recognizing when a residential structure is not performing its intended task. We will also attempt to interpret the significance of structural conditions we might discover in real life situations.

### **This course will teach you:**

- How to identify possible structural problems.
- How to interpret the significance of structural conditions commonly seen in residential homes.

### **By the end of this session you should -**

- Understand what a footing is and where it is located.
- Know the best way to visually identify if a house is standing straight.
- Understand the significance of a leaning house.
- Know possible remedial measures for a leaning house.
- Be able to give a definition of differential settlement.
- Be able to give examples of conditions that could cause minor settlement and conditions that could cause major settlement.
- Be able to describe a settlement crack.

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- Know a common threshold foundation crack size that may indicate a crack is structurally significant.
- Know what causes a shrinkage crack.
- Know what a shrinkage crack looks like.
- Know the significance of a shrinkage crack.
- Know how a shrinkage crack is repaired.
- Know the two functions of a foundation wall for a home with a basement or crawlspace.
- Recognize major failure of a foundation wall.
- Be able to describe a concentrated floor load and give an example.
- Be able to list three “red flags” that may indicate that a sagging or sloping floor may be more than just a cosmetic issue.
- Know the significance of common plaster and drywall cracks.
- Know how to recognize potentially significant plaster and drywall cracks.

**This knowledge will:**

- Help you to recognize a home that may have a structural problem.
- Give you the opportunity to address structural problems up front with your clients and design a fair sales strategy.
- Prevent a deal from failing at the last minute because of a structural problem.
- Prevent you from wasting your time with last minute re-negotiations.
- Show your clients that you are a knowledgeable professional.

## CHAPTER 2

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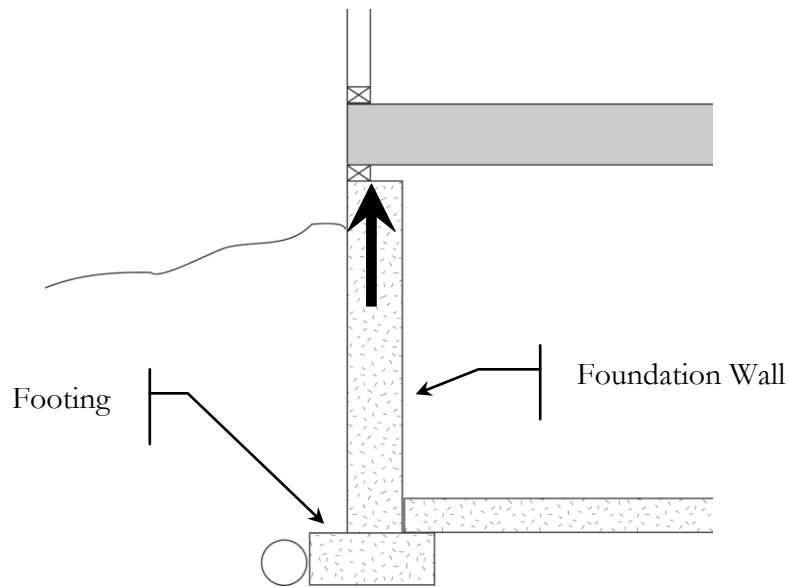
### The Leaning House

Chapter  
**2**

## The Leaning House

### The Footing

To understand why a house might shift, you need to know what a footing is. The footing is a wide pad of concrete under the foundation wall and under columns.





The footing spreads the weight of the structure out over a large area so the structure doesn't sink into the ground. The footing reduces the pressure on the soil.



This photograph shows a basement floor smashed away. You can see the inside edge of the footing under the concrete block foundation. Whether the home has a basement, crawlspace or slab on grade, footings are needed to support the weight of the load bearing walls and columns.

A heavier house will need a larger footing than a lighter house. A house built on strong soil can have a smaller footing than one built on weak soil.

As you can see, the footing is a critical element. If the footing shifts, the house shifts.

Often clients will ask, "is the foundation strong enough to add another level to this house"? Now you know that it has little to do with the foundation and everything to do with the footing.

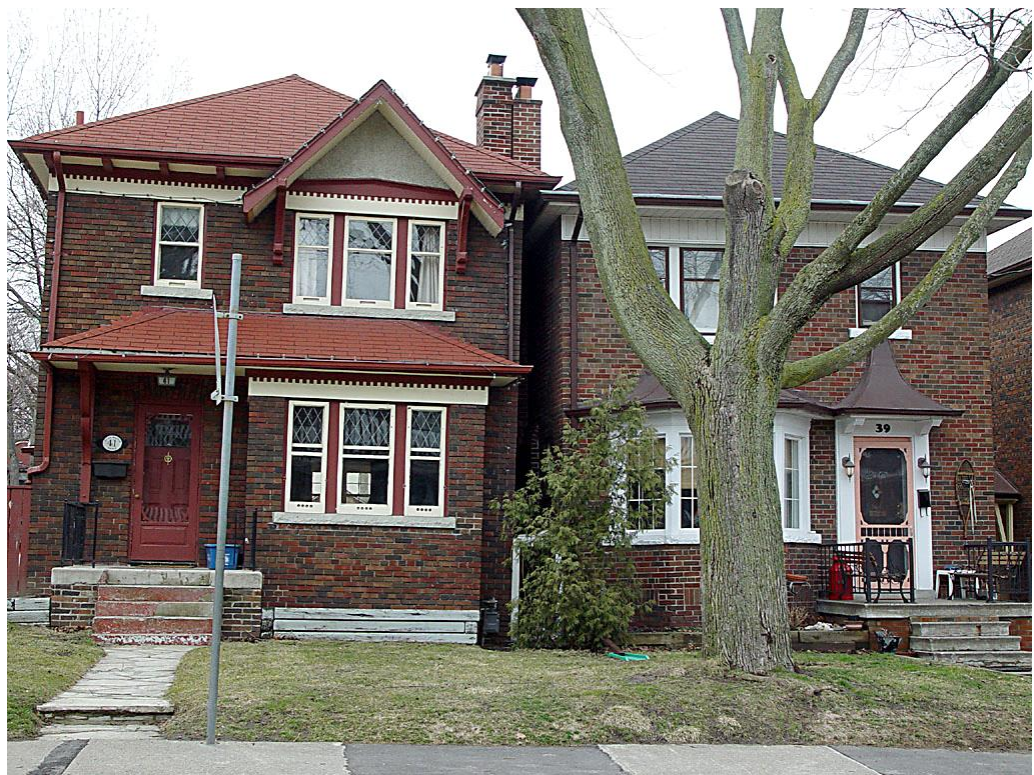
Columns have footings too. Occasionally a home owner will want to move a column to make space for a piece of furniture or to open up a room. Now you



know it's not as simple as placing a new post and removing the old one. There is a footing under that post that you can't see. There are other problems with moving a post as well but we won't go into that right now.

## **How to Identify a Leaning House**

The best way to identify major structural deficiencies is to step back from the house. If you stand too close to the house, you may miss it entirely. The best vantage point is across the street.



From this vantage point, it is quite obvious that the house on the left is leaning. Most likely, both houses are leaning into each other.



Here is a close-up showing the tops of the chimneys touching and the roof lines intersecting.

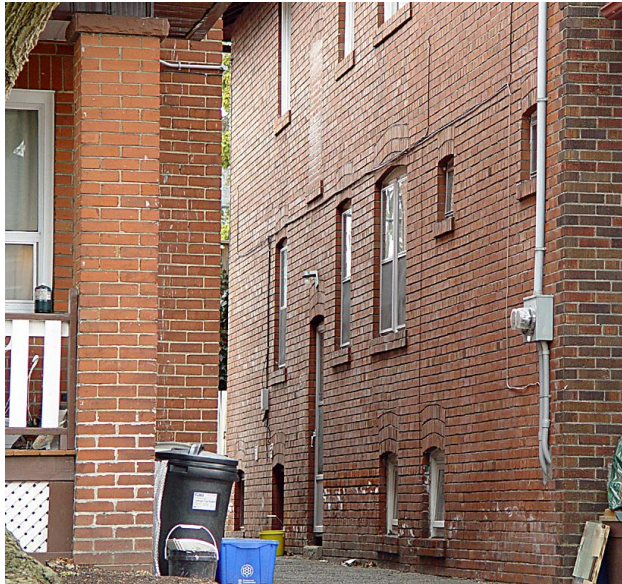
A really neat way to identify if a house is leaning or to confirm that it is standing straight is to step across the street, position yourself so you are sighting angle where you can line up the front corner of one house with the back corner of the adjacent house. The gap between the two houses should have parallel sides.

Have a look at the next two photographs. They show this trick in action. The first photo shows a house that is obviously not standing straight and the next photo shows a house that looks good.

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This house above is obviously leaning while the house below is standing straight (there is a bit of a curve in the column though).





To identify a leaning house or to verify that a house is standing straight, step across the street, find a vantage point where you can line up the front corner of one house with the back corner of the adjacent house. The gap between the houses should have parallel sides. If they don't, then one of the two houses is not standing straight!

Which house has the structural problem here? In this case we don't need to line up anything to see that the house has a serious structural problem.



## The Significance of a Leaning House

If the entire house is leaning, it means the house is sitting on unstable soil or there is soil erosion. There is nothing that can be said definitively from a visual inspection. Unless the structure has been stabilized with some sort of underpinning, it is possible, if not probable, that the condition will get worse.

Even if the condition does not get worse, the lean itself is a concern. For example a tall chimney on a leaning house could topple over, a gas line or water main could sever, the drain line may not slope properly.

What can be done about a leaning house? All of the options are very expensive. The home can be stabilized by underpinning. In less serious cases, the footing may be widened to reduce the pressure on the soil beneath. For a leaning house, the more likely scenario involves re-supporting the home on stable soil or rock. This usually involves hammering steel columns, called piles, deep into the ground and supporting the house on the piles. The piles essentially bypass the unstable soil and support the house on something solid.

Once the house is re-supported on piles, the house can be either stabilized in its leaning position or it can be jacked straight. The decision depends on how much the house is leaning and the cost of repairs when the house is jacked. Often the entire house will have to be gutted and re-worked.

## It's Not a Common Problem

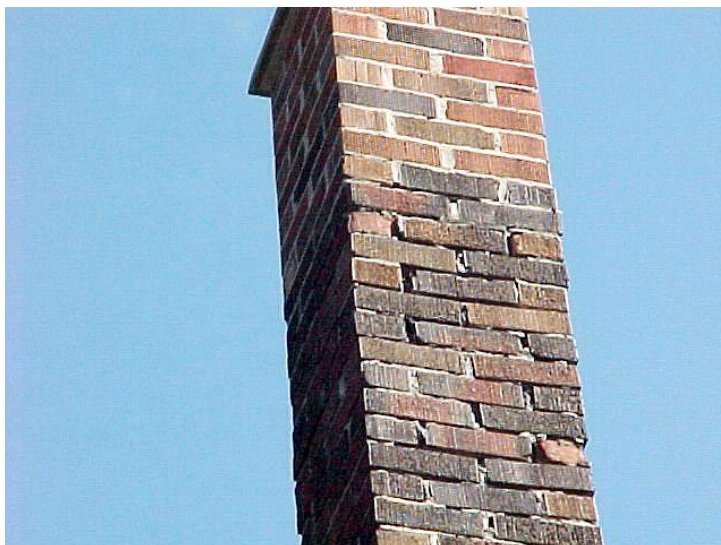
A leaning house is not a common problem in most areas of the country but it is a serious problem if it does happen.

The trick we covered to identify a leaning house can be used just as well to demonstrate that a house is standing straight.

## Great Vantage Point

While you are across the street looking at the structure, look at the roof line, columns and walls. Across the street is the best place to stand to look for other structural problems as well. For example, the next photograph shows a chimney that needs work.

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## Check Your Knowledge

Answer the questions below in the spaces provided

1. What is the purpose of a footing?

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2. Describe a great trick for identifying a leaning house.

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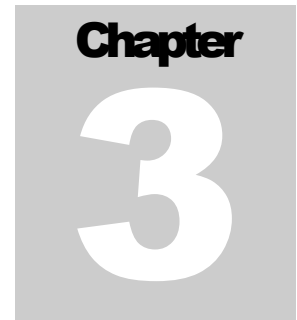
3. What is the structural solution for a leaning house?

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## CHAPTER 3

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### Settlement Cracks



Chapter

3

## Settlement Cracks

**W**e have already looked at houses that are tipping. One of the interesting things about tipping settlement is that there are often no cracks in the structure, the entire house tips as a unit.

The soil conditions that cause tipping settlement are quite rare so a tipping house is not something you will see every day. On the other hand, minor settlement, where the house is basically standing straight while a corner settles, is fairly common. This is called differential settlement and differential settlement causes cracking.

### Differential Settlement

Settlement means that the soil under the footing has moved or has been displaced and thus the footing shifts. Minor settlement is quite common and not usually cause for alarm.



Differential settlement is when the house is standing straight but one area has settled. This will cause cracking.

Minor differential settlement is very common and not usually cause for alarm.

**Minor Settlement:** Here is one example of how it might happen –

- During construction, an excavation is made for the footings and foundation or slab on grade.
- Footings are supposed to be placed on undisturbed soil.
- Sometimes a corner may have been excavated a little too much and the soil replaced. While this is not supposed to happen, sometimes real life gets in the way of perfection.
- After construction, the soil may compact a little bit, resulting in settlement at the corner and perhaps a settlement crack

In this situation, the settlement is minor and will be a one time event. The settlement crack that results has no structural significance.

**Major Settlement:** It is possible to have much more serious differential settlement such as when –

- a home is built on weak soil.
- a home is built on a land-fill site or re-claimed land.
- a home is built on disturbed soil such as a cut and fill lot on a hill.
- the house is built over variable soil types such as a pocked of weak soil.
- new loads are added to the house such as a second story.

These serious cases will result in settlement cracks that are more substantial along with visible evidence of shifting of the structure.

## **What Do Settlement Cracks Look Like?**

A settlement crack is usually a vertical crack (could also be diagonal or step crack if the foundation is brick or block). The crack will be slightly wider at the top.

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The picture above shows a settlement crack in a concrete foundation. The crack is slightly wider at the top. There is no evidence of shifting of the structure beyond the local cracking. The picture below shows a crack pattern that includes substantial shifting of the structure as well.



## The Significance of Settlement Cracks

We won't go into great detail here on "reading cracks" but here are few quick rules for assessing settlement cracks.

- Small cracks tend to be less serious than large cracks.
- 1/4 inch width is a reasonable threshold size. A SINGLE vertical crack that is less than 1/4 inch is likely a minor settlement event and is unlikely to continue to settle and get worse (this assumes the house has been there for a few years – not a newly built home). This is not based on any science or engineering principles.
- A crack larger than 1/4 wide is more worrisome.
- Multiple cracks are likely due to a more serious settlement condition.
- You cannot predict if there will be ongoing movement from a single visit to the house. You can only make an educated guess based on the crack size and pattern. The longer the house has been there, the more confident you can be of your assessment.

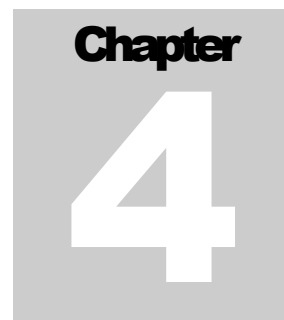
There is more that goes into deciding if a settlement crack is structurally significant. The rules we have discussed are not universal. While these rules are helpful, be sure to take them with a grain of salt.



## Check Your Knowledge

Answer the questions below in the spaces provided

1. Which type of settlement is more common, tipping settlement or differential settlement?  
\_\_\_\_\_  
\_\_\_\_\_
2. Which type of settlement is more likely to have cracks associated, tipping settlement or differential settlement?  
\_\_\_\_\_  
\_\_\_\_\_
3. Give one condition that can lead to major settlement (there are more than one listed in this text)  
\_\_\_\_\_  
\_\_\_\_\_
4. What is the common threshold size (width) used to determine if a settlement crack might be a significant structural problem?  
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## CHAPTER 4

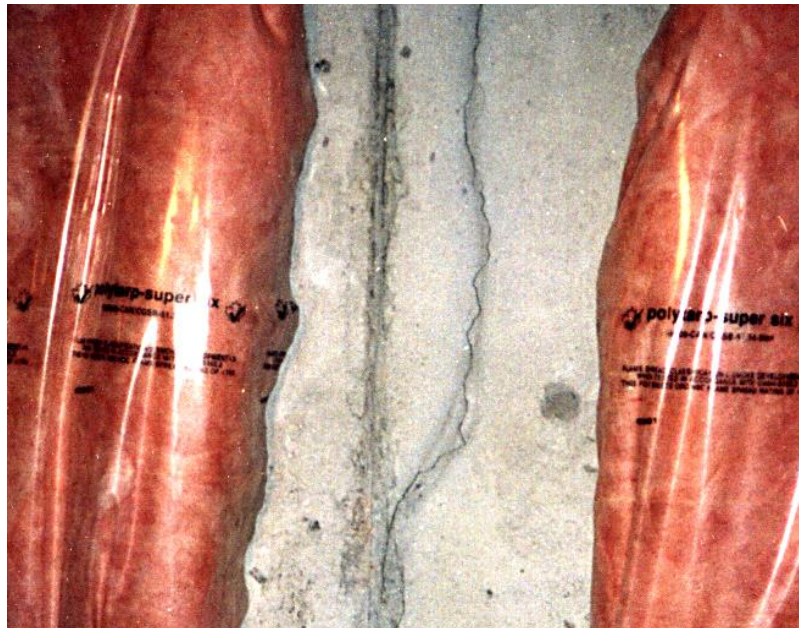
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### Shrinkage Cracks

## Shrinkage Cracks

Shrinkage cracks are caused by the natural curing of concrete. When a new house is constructed, foundation forms are erected and concrete is poured in. As the concrete cures, it shrinks. It shrinks about  $1/8^{\text{th}}$  of an inch over about 20 feet.

Here is a photograph of a shrinkage crack in a poured concrete foundation in a house with a full basement. The orange stuff on either side is fiberglass insulation.



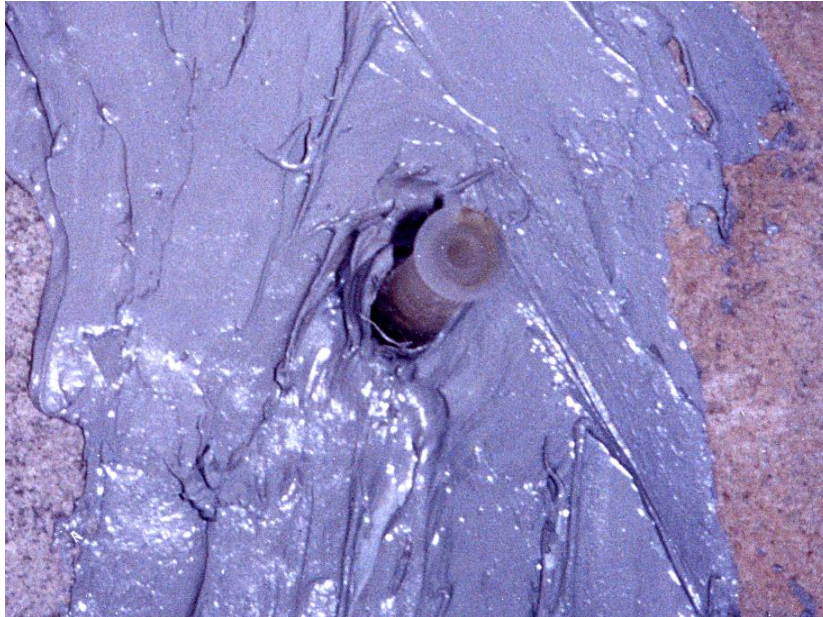
Shrinkage cracks are usually small (less than  $1/8^{\text{th}}$  of an inch) and are vertical, like the one shown in the photo above.

## The Significance of Shrinkage Cracks

Shrinkage cracks in a poured concrete foundation are common and have no structural significance. The only practical significance is that a shrinkage crack may leak water. For this reason, home owners often choose to have shrinkage cracks injected.

If there are many shrinkage cracks, there is still no structural significance but it may indicate that the concrete pour was of poor quality, possibly too wet a mix.

**Crack Injection:** Injection is with epoxy or polyurethane. Holes are drilled in the foundation to insert the injection ports. The picture below is of an injection port cemented in place with epoxy.

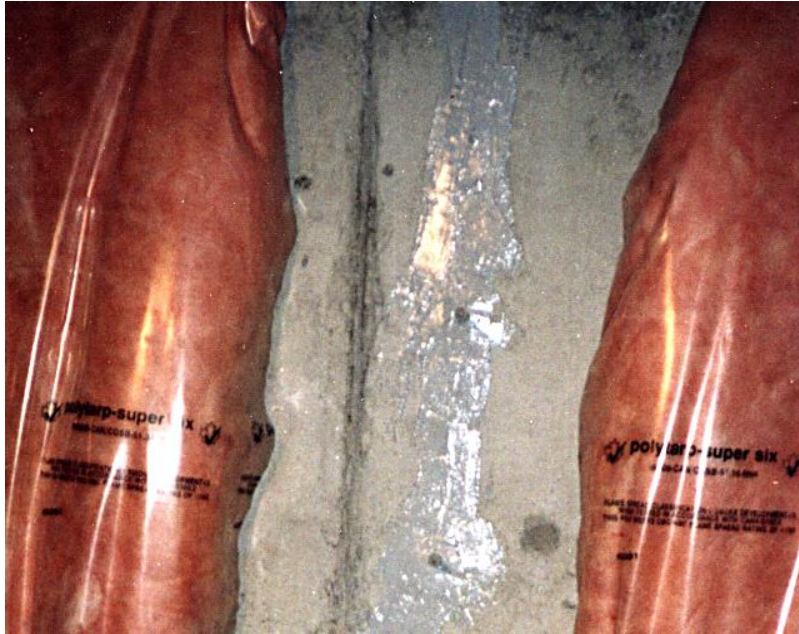




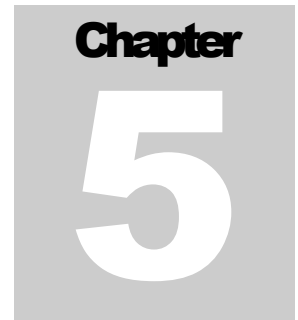
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Next, an injection device is connected to the injection port and epoxy or polyurethane is squeezed into the crack under high pressure.





Buyers are often worried when they see an injected crack. It looks like there must be a huge problem with the foundation to have epoxy smeared around on the surface. In fact what they are seeing is the residual epoxy that was used to hold the injection ports in place. Don't forget, the whole purpose of the repair was to keep water from leaking through. This is not a structural repair.



## CHAPTER 5

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### Foundation Failure

## Foundation Failure

**T**his discussion concerns foundations for homes with basements or crawl-spaces. Slabs on grade structures will not have the same soil loads applied to cause foundation failure in the manner discussed here.

Foundation walls have two functions -

1. To hold up the house.
2. To hold back the surrounding soil. The foundation wall acts like a retaining wall. When the soil pressure gets too much for the foundation, the foundation will fail by bowing inward or cracking. The crack that results is a characteristic horizontal crack.



Generally speaking, a horizontal crack in a foundation is a much more serious crack than a vertical crack (there are some exceptions that we won't go into here). The reason is that a horizontal crack indicates that the foundation can't resist the soil pressure while a vertical crack is indicating settlement that may only be an isolated one time event.

The previous photo shows a foundation that is failing because the soil pressure has overcome the strength of the foundation. The foundation will have to be repaired. There are several ways it can be repaired including –

- Rebuilding the affected foundation section.
- Steel columns against the wall to hold the wall in place and resist the soil pressure.
- Kevlar and carbon fiber straps.
- Soil anchors.



## Check Your Knowledge

Answer the questions below in the spaces provided

1. Give two functions of a foundation wall for a home with a basement or a crawlspace -

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2. If the soil pressure on the foundation wall is greater than the foundations ability to resist the load, what type of crack is likely to result?

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3. Generally speaking, what type of crack in a foundation wall is more serious, a vertical crack or a horizontal crack?

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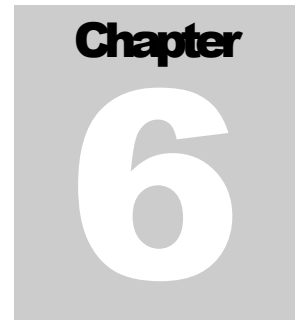
4. Give two methods of repairing a failing foundation wall:

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CHAPTER 6

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Interior Elements

Chapter  
**6**

## Interior Elements

**S**o far we have looked at key structural components, footings and foundations. We have looked at typical failures such as settlement and foundation cracks. This section looks at the key interior elements that are readily visible to the buyer – floors, walls and ceilings. It's these areas that generate the most questions from clients even though they tend to be the least significant structurally.

### Sagging Floors

Most houses have imperfections in the floors. New houses may have irregularities such as cracks or bumps. Older houses may have sags. In most cases these are cosmetic issues, not structural. Let's have a look at floor sags in older homes.

Many older homes have sags in the floor. The floor probably started out straight enough but over time the floors creep and sag under load. People that live in and love older homes see this as part of the charm.

In some situations floors can be jacked back into place slowly with minimal damage to the cosmetics. More commonly, floor sagging problems are difficult to fix unless you are planning a major renovation. Most homeowners elect to live with the irregularities.

You will see more sagging where there is a concentrated load such as at a staircase. A staircase is a concentrated load for two reasons –

1. The opening in the floor means floor loads have to be carried around the opening. All floor loads that would have been carried by joists passing through the floor opening are now carried by joists at either end of the opening. Hence a concentrated load.



2. The weight of the staircase itself is a concentrated load.

In an old home it is very common so see the floor sagging toward the stairs.

While most floor sagging is a cosmetic issue, there are some situations where uneven floors may indicate a structural problem -

Red Flag #1: While sagging inside the house is usually just a cosmetic issue, a slope towards an outside wall could be indicating a structural problem. For example, a sill plate that has rotted or a footing that is settling could cause such a slope.

Red Flag #2: Floors that sag immediately next to an interior wall could indicate a wall that is not properly supported or loads that are misaligned such as a load bearing wall that is not bearing down directly over the main beam. This is definitely worth a closer look.

Red Flag #3: A sagging floor that is also excessively bouncy or associated with splits in the plaster or drywall. This is worth a second look because a column may be damaged or rotted or a main beam may have been removed. This is an extreme case and not very common. Anybody that is familiar with old homes will recognized this as distinctly different from cosmetic floor sag.

## **Floor Tile Cracks**

Floor tiles are not really part of this presentation but it is so common and such a common complaint that it is worth a comment here.

A proper floor tile job involves several elements –

- The right tile for the job.
- The right grout / grout thickness for the application and tile type.
- A proper sub-floor.
- Correct floor stiffness for a tile application (size of joists and bridging etc.).

If any one of these elements is not done properly, cracks could result. What's more, the person applying the sub-floor may not know what kind of tiles have been selected and the person who applies the tiles may assume that the floor structure has been stiffened to accommodate tiles. The bottom line is that floor tile cracks usually involve the "blame game".

In the end, it's a cosmetic issue that may require substantial work to remedy. Each situation has to be evaluated on a case by case basis. For example, should you remove the tiles and replace them with more flexible tiles or should you stiffen the floor and use a thicker bed of grout and the same tiles. The concepts are not difficult and the problem is easy to fix but it is usually fairly expensive.

## **Plaster & Drywall Cracks**

Home buyers seem to zoom in on plaster cracks. The thought is that the cracks are pointing to an underlying structural deficiency or shifting. This is almost never the case.

Most plaster cracks are the result of –

- Expansion and contraction of the surface with temperature and humidity
- Poor drywall tape joint
- Warping or drying out of wall studs

The cracks usually occur at corners of doors or windows because this is a stress concentration or at a drywall seam. The cracks are not related to shifting of the structure. Once the crack is there you can't make it go away by filling it in with plaster. It will simply re-crack. The crack has to be taped and plastered.

It is possible to have plaster or drywall cracks that are structurally significant. Here are a few tips that the drywall crack may be related to structural shifting –

1. The crack is very large – 1/4 wide or larger
2. The crack runs diagonally across a wall
3. The crack you see in the drywall can be seen on the exterior of the house as well.



## Check Your Knowledge

Answer the questions below in the spaces provided

1. Why do most home owners elect to live with floor sags rather than jacking them back into place?

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2. Give one red flag that the floor slope may be more than a cosmetic issue:

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3. Give one red flag that a crack in the drywall or plaster may be more than just a cosmetic issue:

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## CHAPTER 7

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### CEP Quiz

**CEP Quiz – Structural Deficiencies -**

Name \_\_\_\_\_

1. What are the two functions of a foundation wall for a house that has a full basement?

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\_\_\_\_\_  
\_\_\_\_\_

2. What is the significance of a leaning house?

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\_\_\_\_\_  
\_\_\_\_\_

3. What is the best vantage point for looking for major structural movement?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

4. What is differential settlement?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

5. What is a shrinkage crack?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

6. How is a shrinkage crack repaired?

\_\_\_\_\_  
\_\_\_\_\_

7. For a foundation that has failed under the surrounding soil pressure, give three techniques to repair the foundation:

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8. Give an example of a concentrated load that may cause floor sagging:

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9. A floor tile problem may involve cracking tiles and is usually an installation issue. Why is it hard to figure out whose fault it is?

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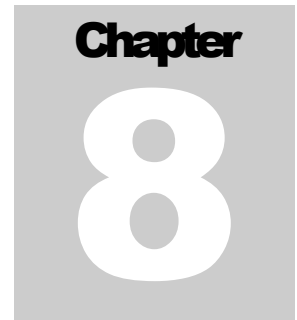
10. List three things that cause common plaster cracks:

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## CHAPTER 8

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### Presentation Evaluation

## Presentation Evaluation – Structural Deficiencies

### TECHNICAL CONTENT

	Excellent	Average	Poor	No Opinion
Presenter's knowledge of subject matter	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ability to keep you interested	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Discussion / overview / recap	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
How well did this course meet your expectations?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Comments:

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### ORAL PRESENTATION

	Excellent	Average	Poor	No Opinion
Explanation of objectives	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Voice (volume, clarity, speed)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Answers question clearly	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Comments:

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### VISUAL PRESENTATION

	Excellent	Average	Poor	No Opinion
Voice (volume, clarity, speed)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Answers question clearly	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Effectiveness of visual aids	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Presenter's eye contact	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Comments:

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### MATERIAL HANDOUTS

	Excellent	Average	Poor	No Opinion
Effectiveness of handouts	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Comments:

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