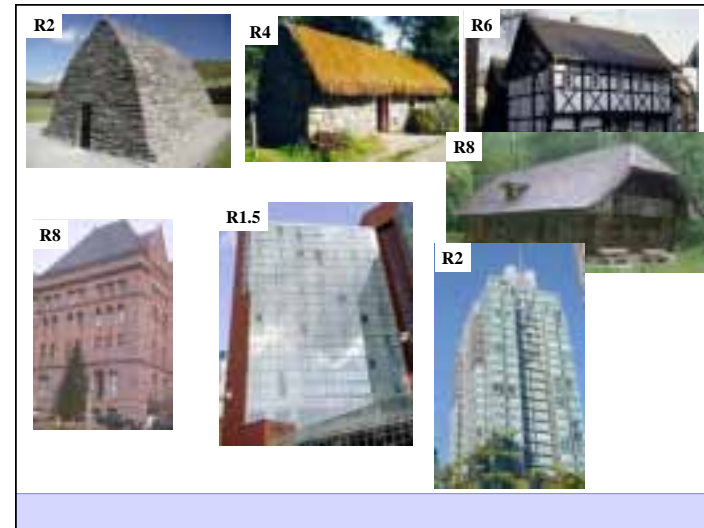


Joseph Lstiburek, Ph.D., P.Eng, ASHRAE Fellow

Building Science

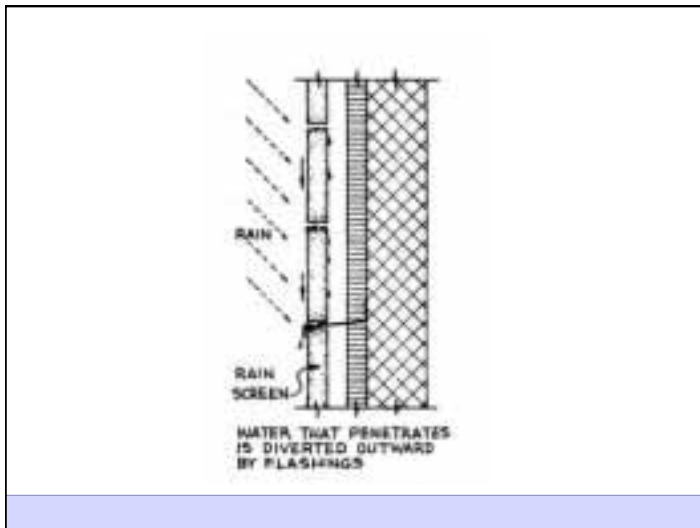
Green Construction

www.buildingscience.com

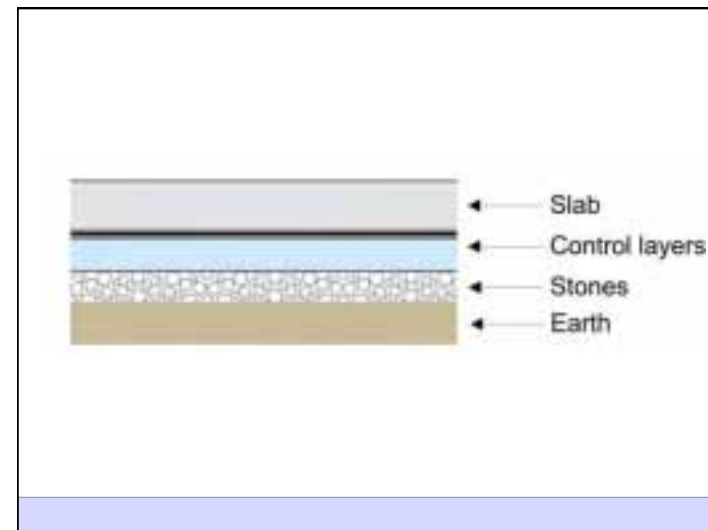
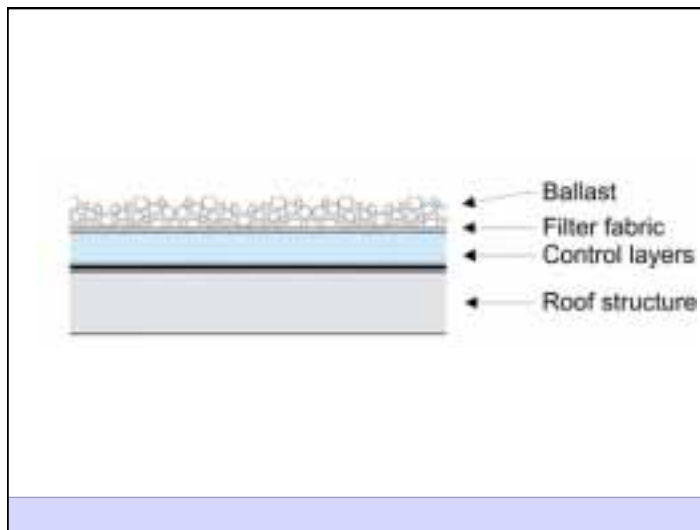
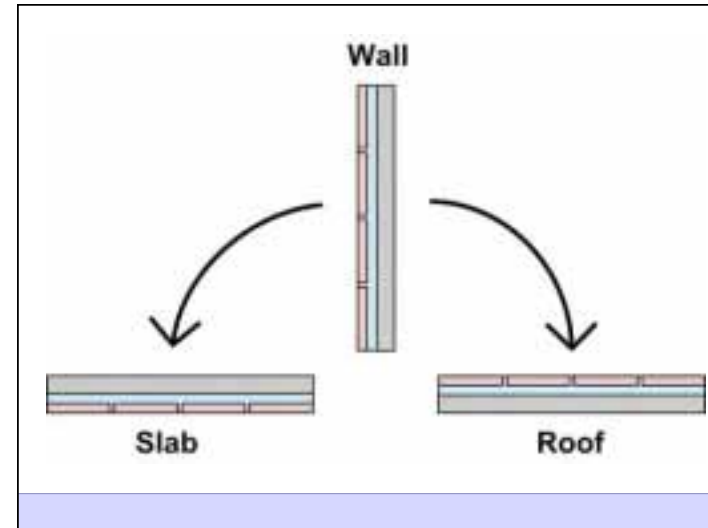
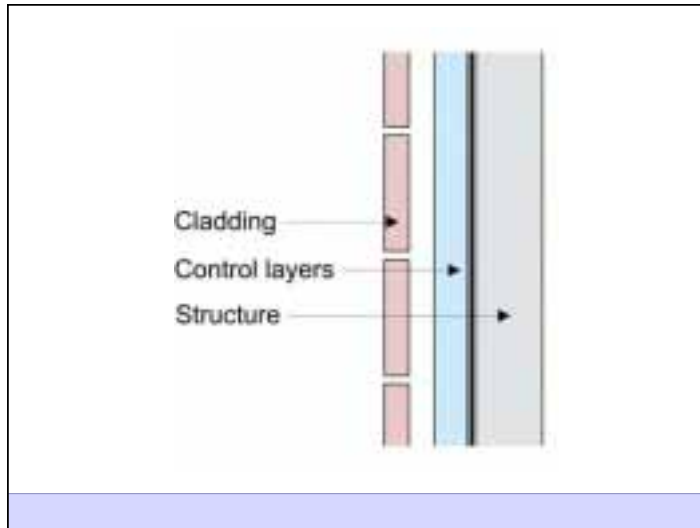


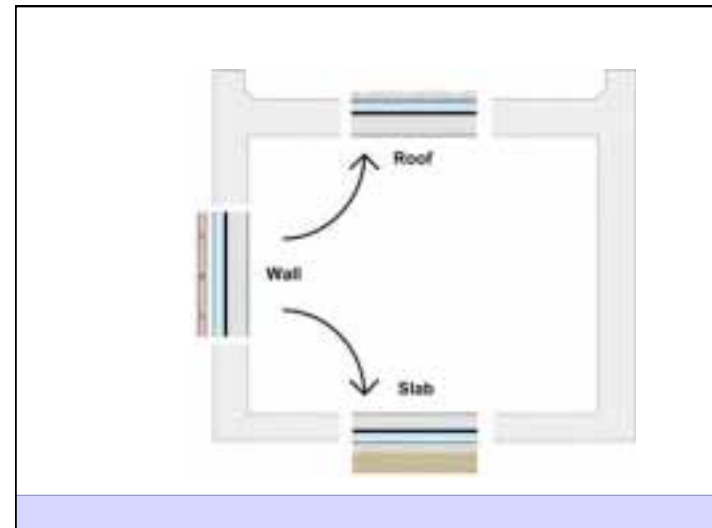
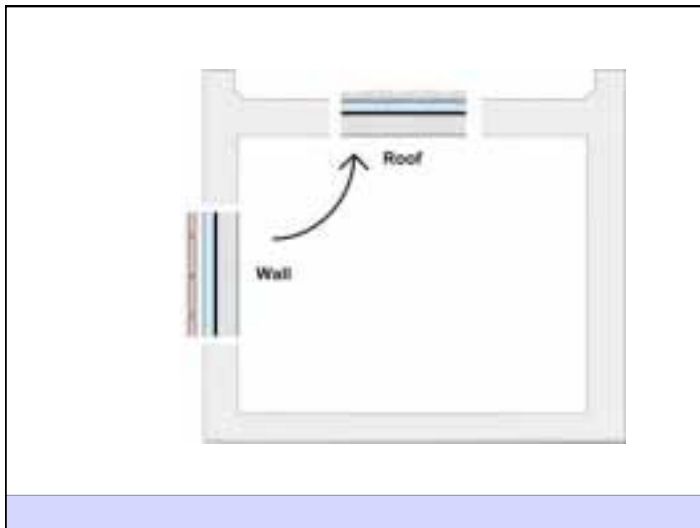
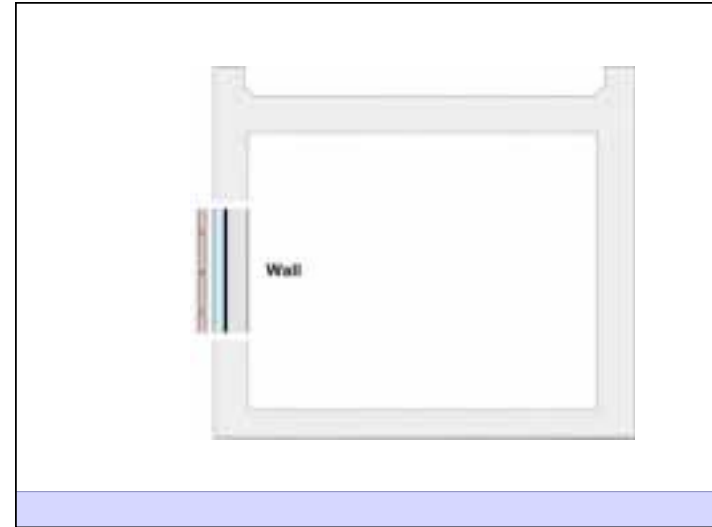
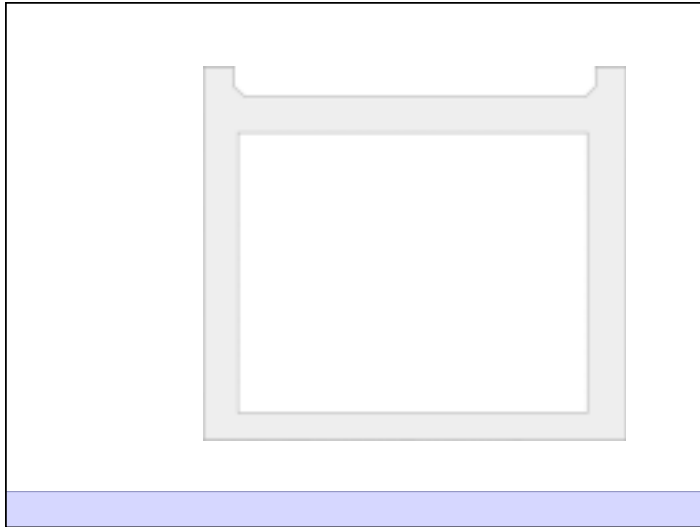
It's The Energy Stupid

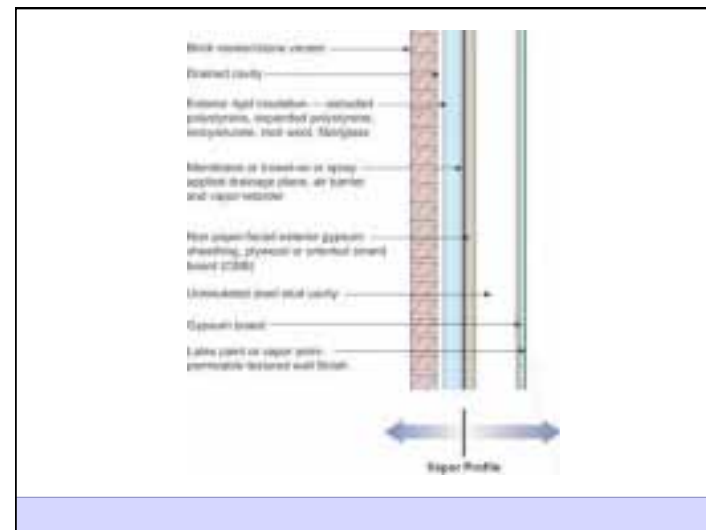
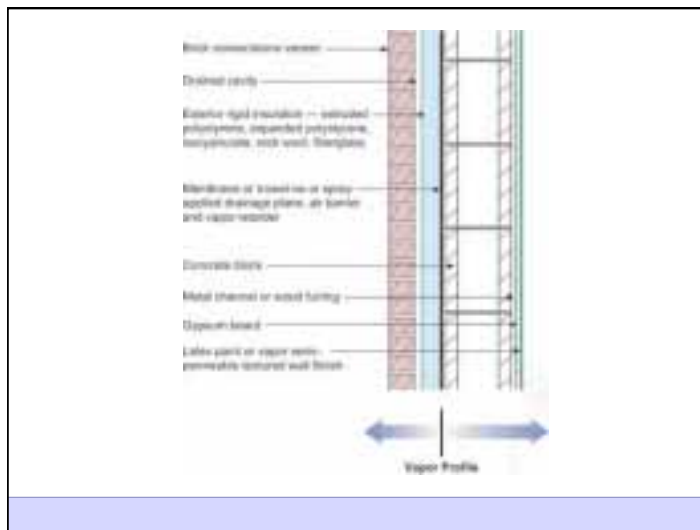
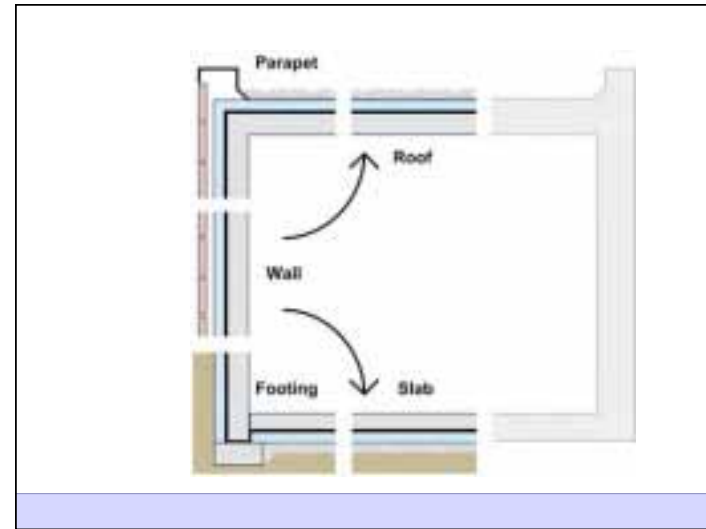
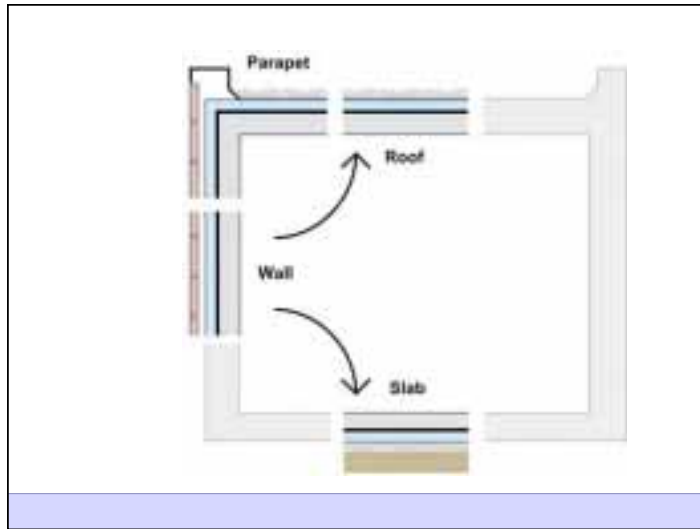
Buildings Are The Key To Energy Security
And Climate Change

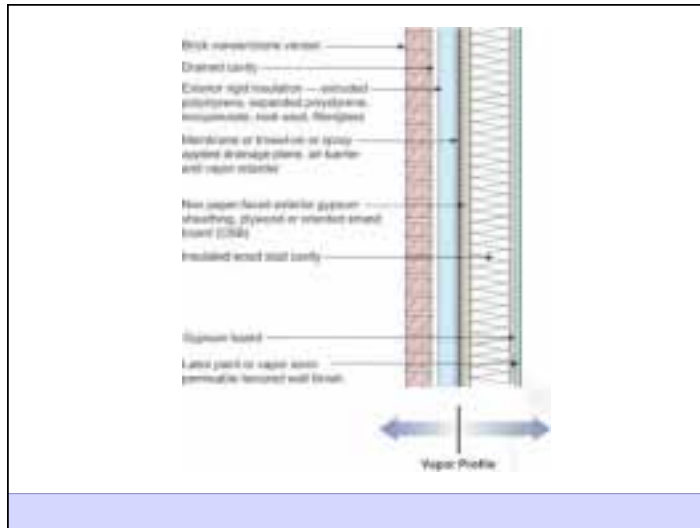


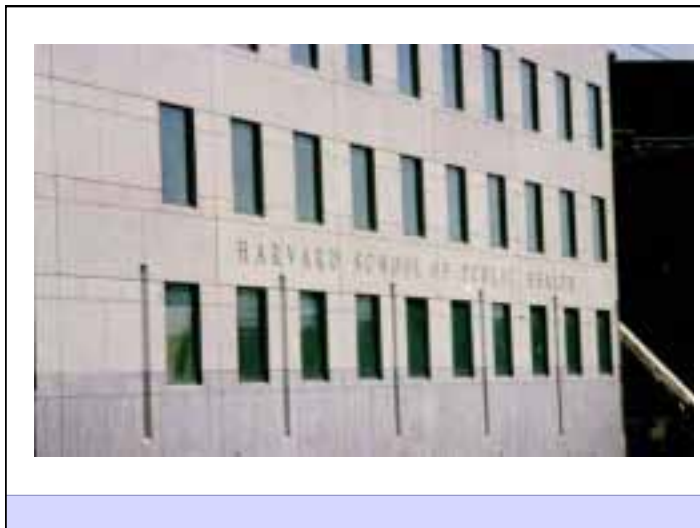
Rain Control Layer
Air Control Layer
Vapor Control Layer
Thermal Control Layer





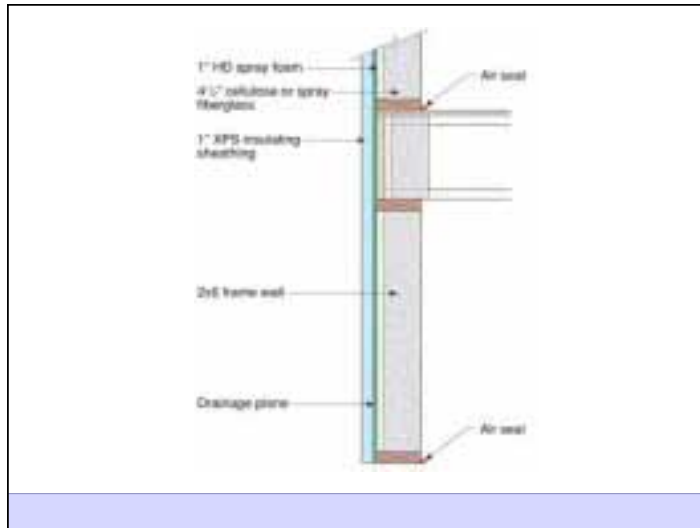












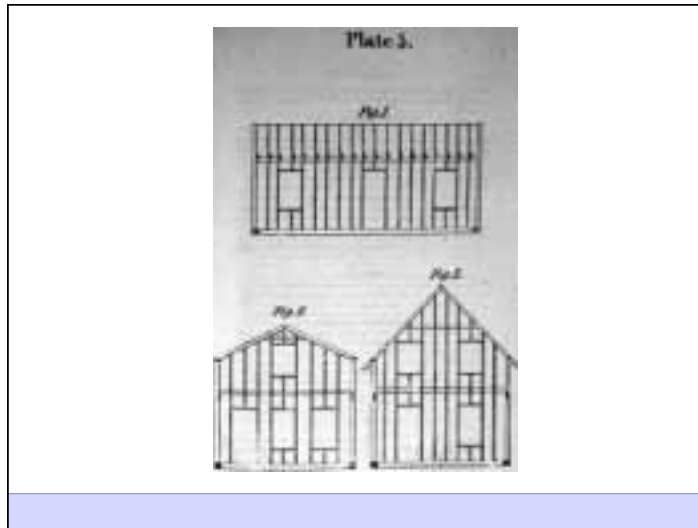




Advanced Framing
Use Less Stuff Better

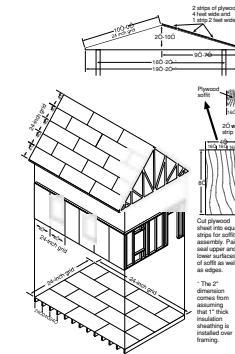
Where four is good... and five is better... Nine has got to be just great!

Three small photographs illustrating different framing techniques for a door or window opening. The first image shows a door frame with four studs. The second image shows a door frame with five studs. The third image shows a door frame with nine studs. Each image shows a person's hand pointing to the studs.



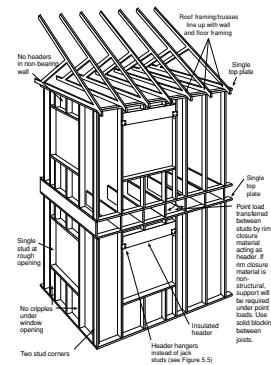
Design Issues

- Design buildings that coordinate advanced framing practices with material availability and integrate with building envelope design and mechanical system layout



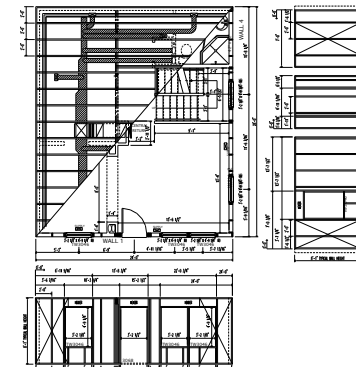
Advanced Framing System

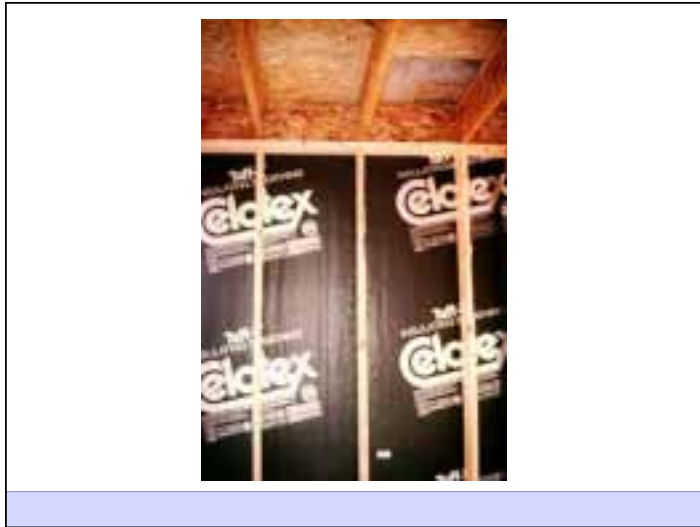
- Stack Framing Concept

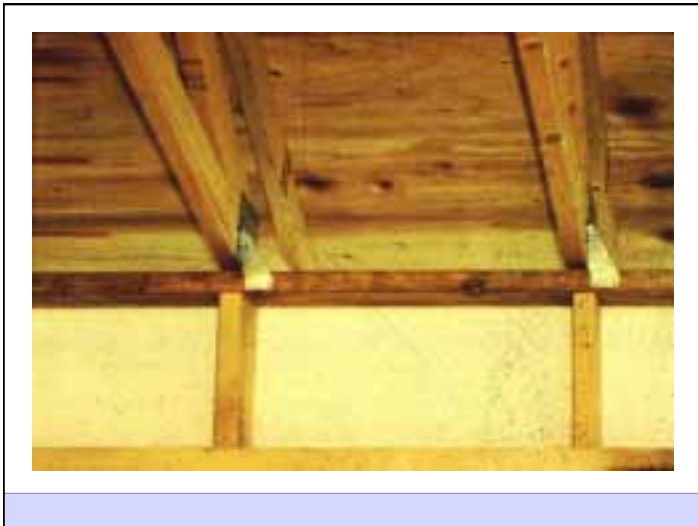
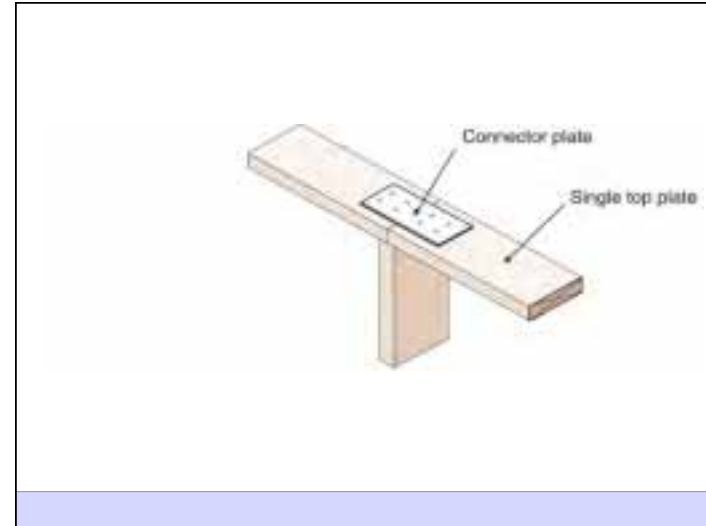


Design Issues

- Provide drawings that integrate advanced framing into complete building envelope design and mechanical system layout







Advanced Framing System

- 2 Stud Corners

The diagram illustrates two types of wood joints: "Corner framing" and "Top plate splice".

Corner framing: Shows a 90-degree corner joint. It includes labels for "Corner framing", "Two stud corner", "Clip support for system board", and "Alternative 1x4 support for system board".

Top plate splice: Shows a joint where two horizontal beams meet. It includes labels for "Top plate splice", "Connector plate", and "Single top plate".

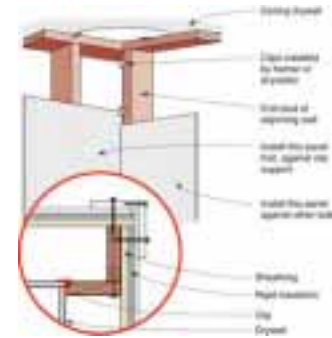
Advanced Framing System

- Insulated headers
- No header necessary at non-bearing walls



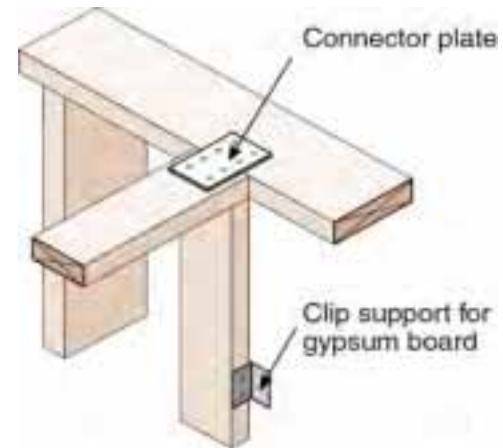
Advanced Framing System

- Drywall clips allow for better installation with less drywall cracking



Advanced Framing System

- Drywall clips at corner and intersecting wall



CASE STUDY

- HOUSE SPECIFICATIONS
 - Conditioned Floor Area 2,495 sq ft
 - Total Floor Area 2,910 sq ft
 - Typical Wall Height 9'-11 1/2"
 - Total Conditioned Volume 24,850cu ft
 - Length of Exterior Wall 252 In ft
 - Length of Interior Wall 340 In ft

CASE STUDY

- 2x4 16" oc WALL

| | 8' Studs | Bd Ft | Cost |
|-------------------------|----------|------------|--------|
| - Ext Wall | 467 | 1634 bd ft | \$ 866 |
| - Ext Plate | 95 | 331 bd ft | \$ 175 |
| - Int Wall | 715 | 2502 bd ft | \$1326 |
| - Int Plate | 126 | 446 bd ft | \$ 237 |
| - Header | | 273 bd ft | \$ 145 |
| - TOTAL WALL FRAME COST | | \$2749 | |

CASE STUDY

- 2x6 24" oc ADVANCED FRAME WALL

| | 8' Studs | Bd Ft | Cost |
|-------------------------|----------|------------|-------|
| - Ext Wall | 238 | 1312 bd ft | \$695 |
| - Ext Plate | 63 | 347 bd ft | \$183 |
| - Int Wall | 279 | 977 bd ft | \$518 |
| - Int Plate | 85 | 298 bd ft | \$158 |
| - Header | | 148 bd ft | \$78 |
| - TOTAL WALL FRAME COST | | \$1632 | |

CASE STUDY

- WOOD FRAME WALL SUMMARY

| | 2x4 | 2x6 | REDUCED BY |
|------------|--------|--------|------------------|
| - 8' Studs | 1403 | 665 | (-738 / -52%) |
| - Bd Ft | 5186 | 3082 | (-2104 / -40%) |
| - COST | \$2749 | \$1632 | (-\$1117 / -40%) |

Shear Panel



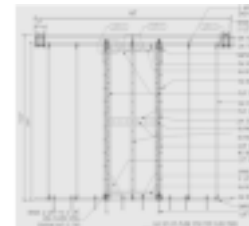
Shear Panel

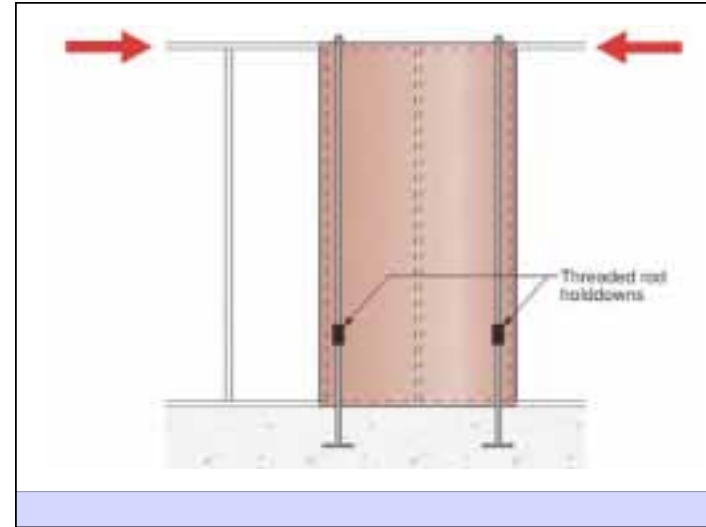
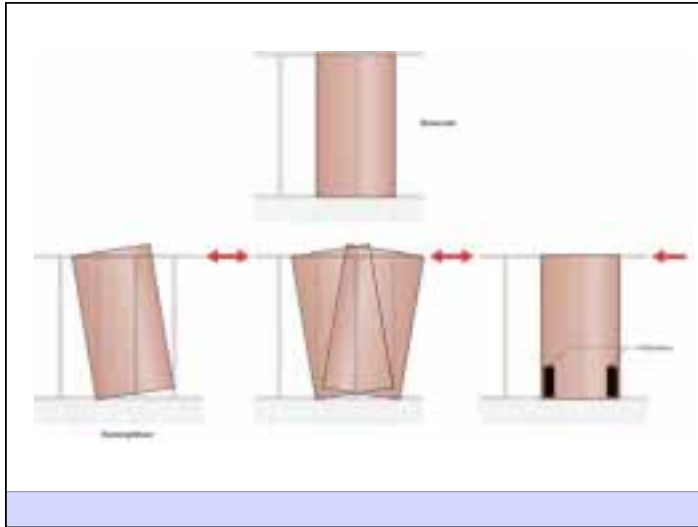


Seismic Testing

•Work with CERL (the US Army research laboratory), and BSC to facilitate code approval of advanced framing techniques by the Division of the State Architect in California, and other earthquake and high wind loading locations.

•Full scale assemblies have been tested under the new dynamic seismic loading protocols developed after the Northridge earthquake. New non-proprietary shear panels are now available for use that allow for advanced envelope design



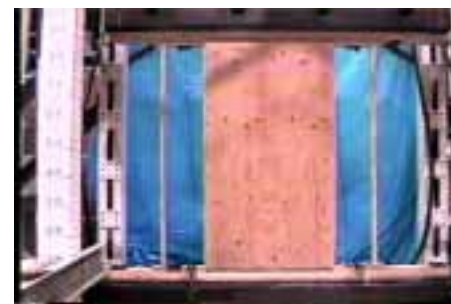


2 Story Aligned

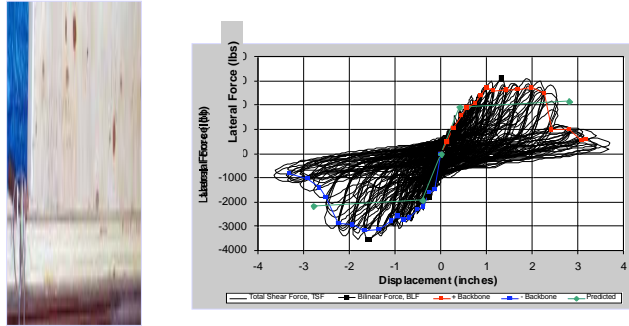


Standard Plywood Panel

2x4 panel with plywood to establish baselines



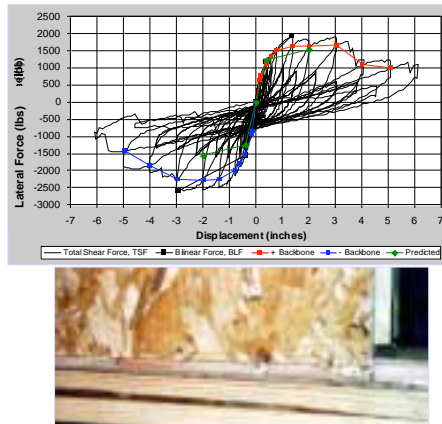
Standard Plywood Panel Performance

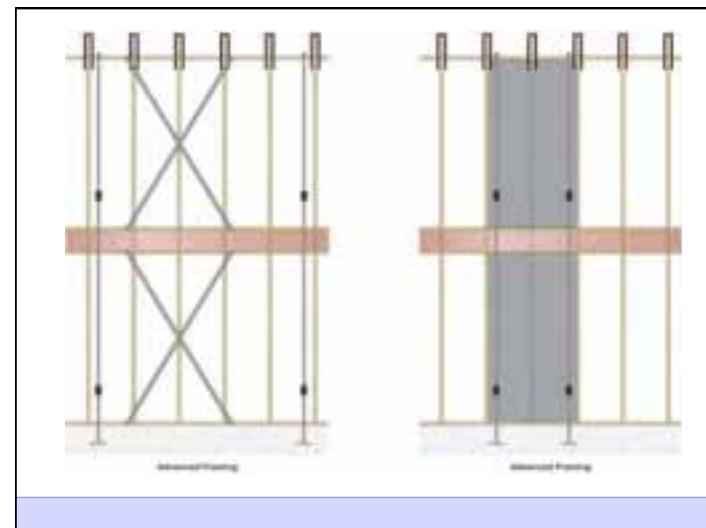
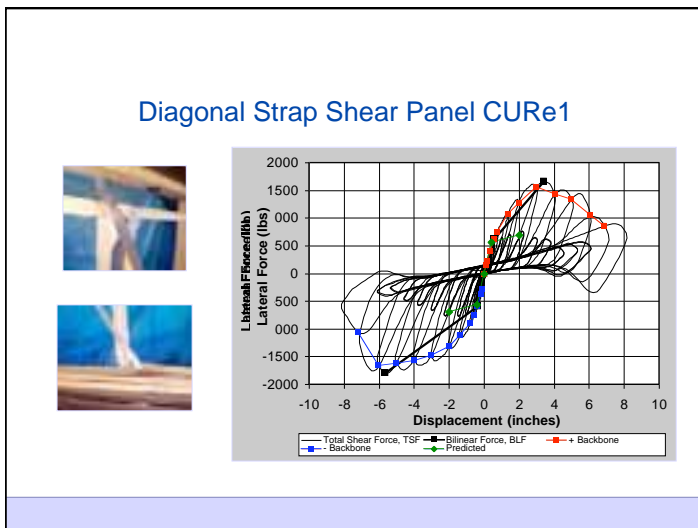


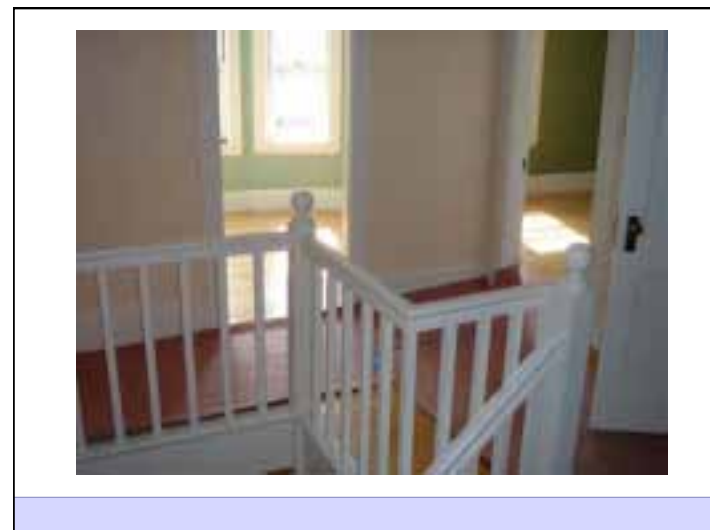
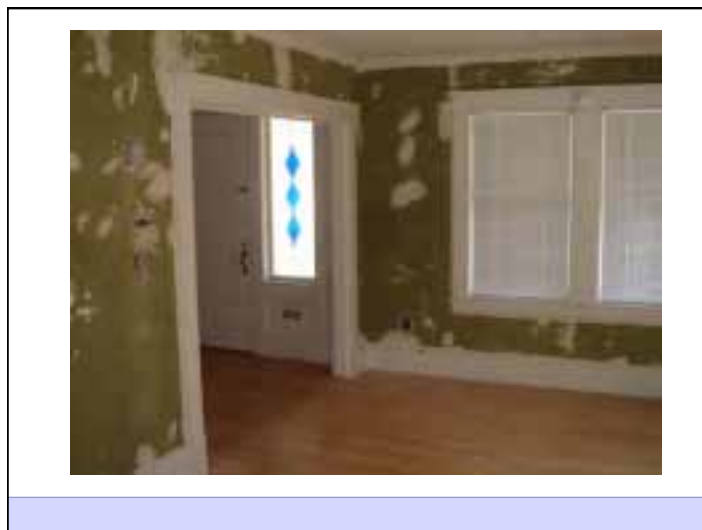
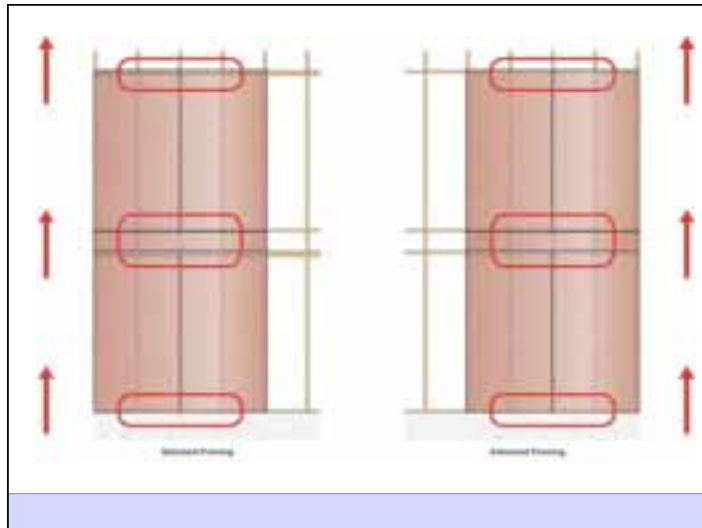
Standard OSB Panel



Standard OSB Panel Performance

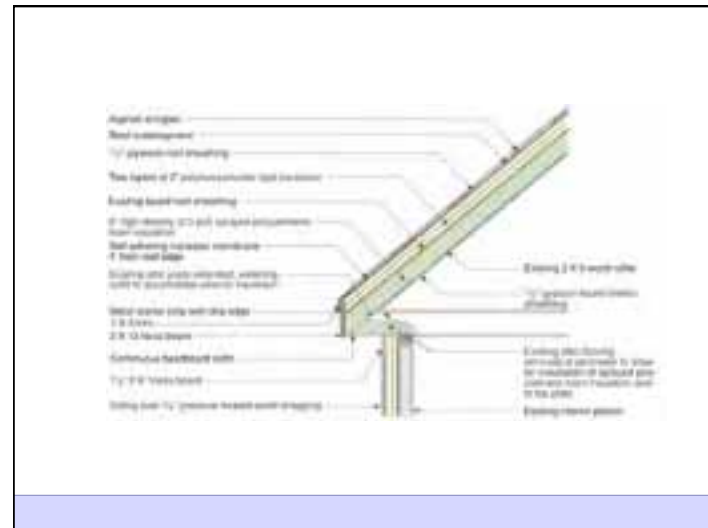
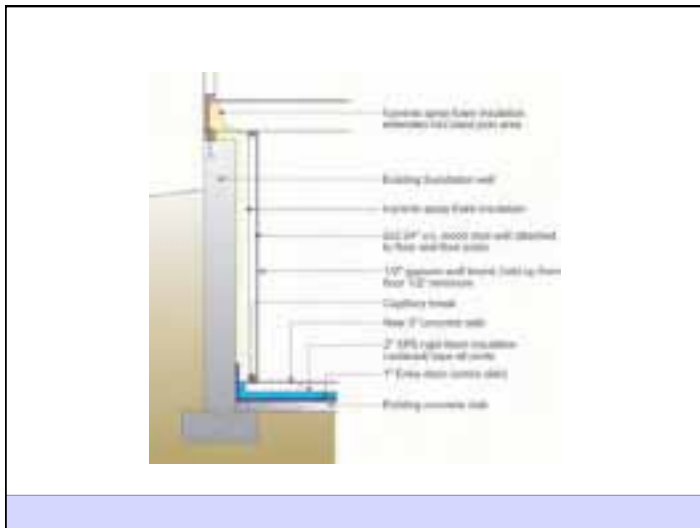


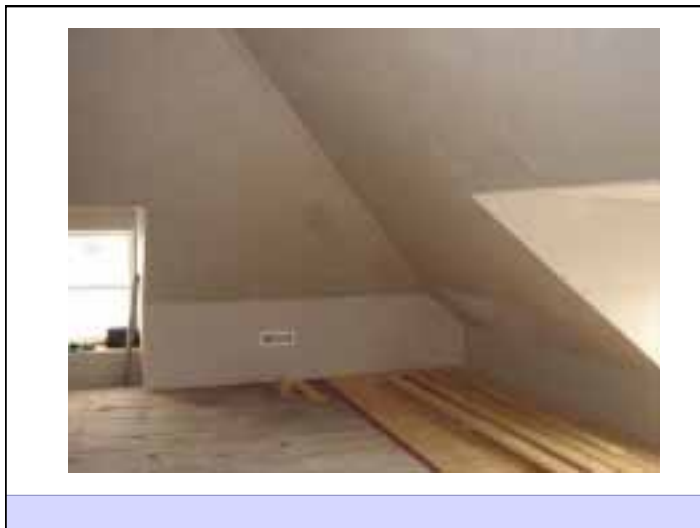




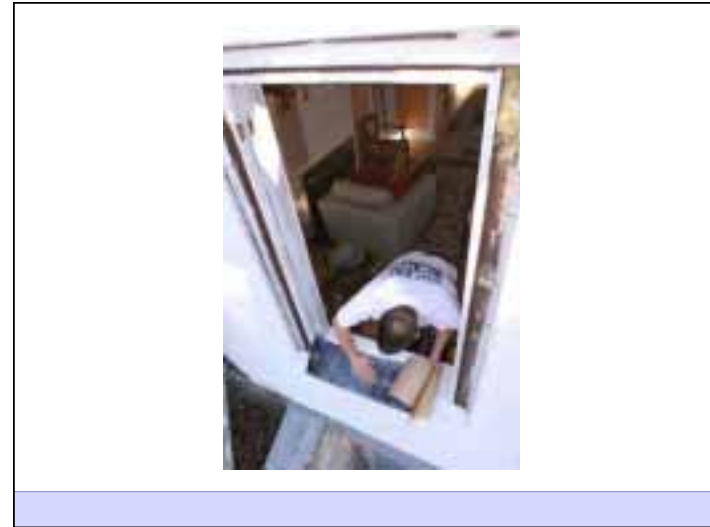


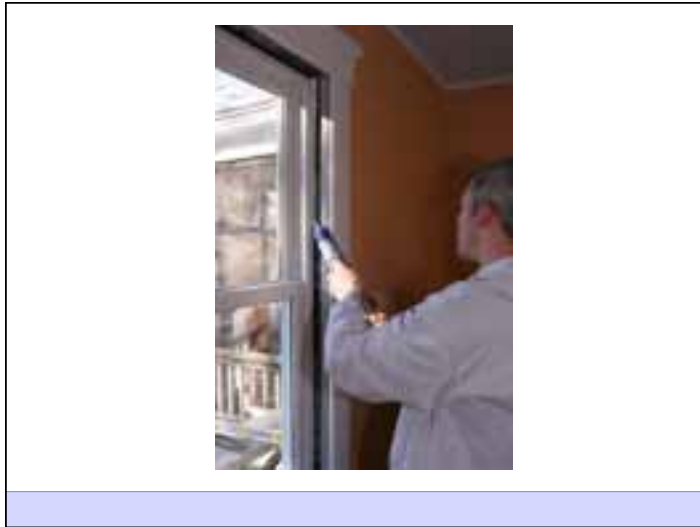




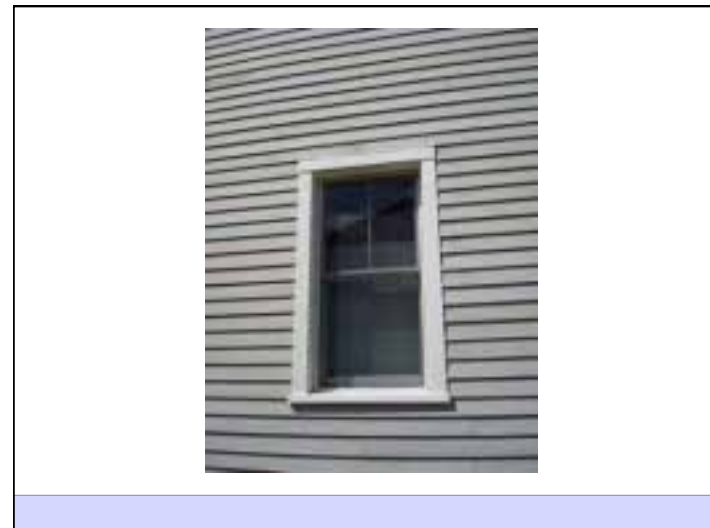


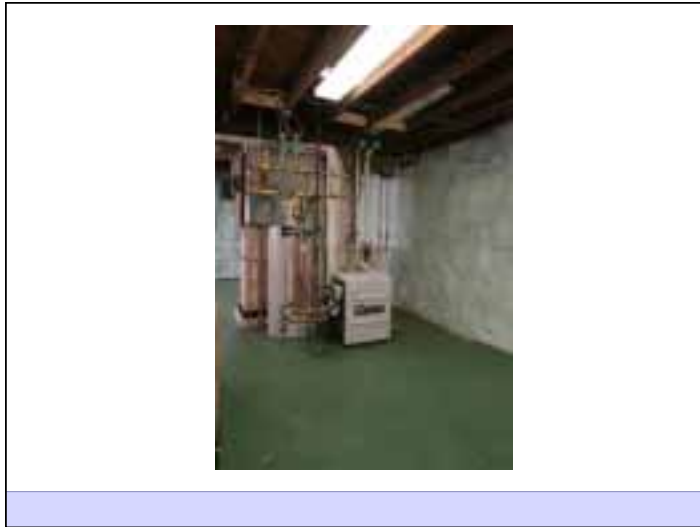


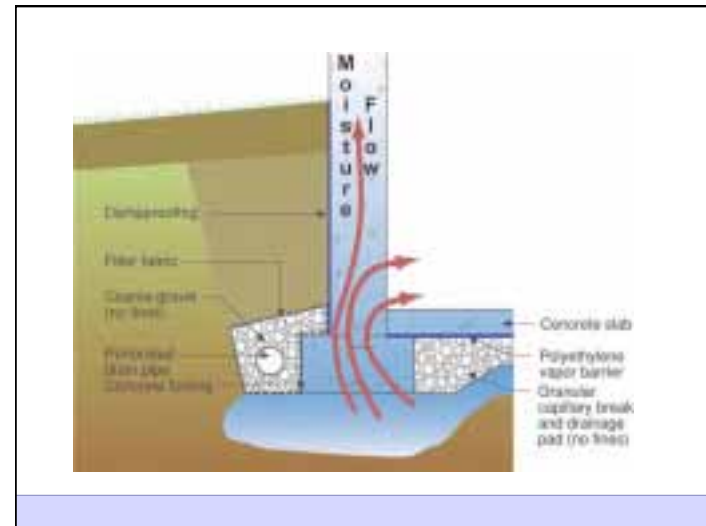
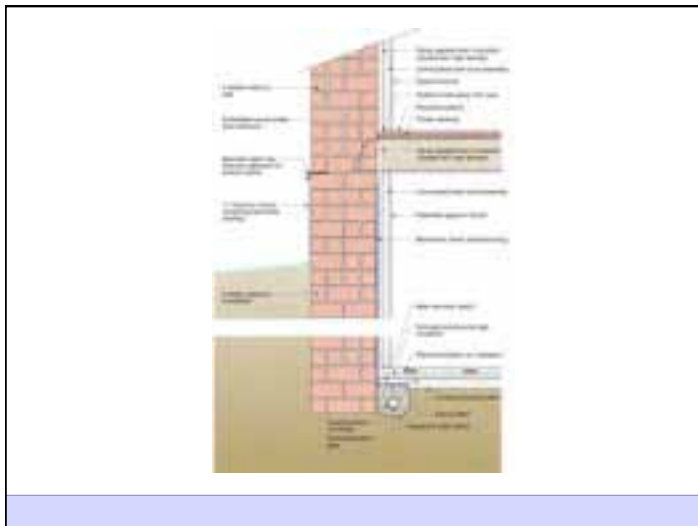
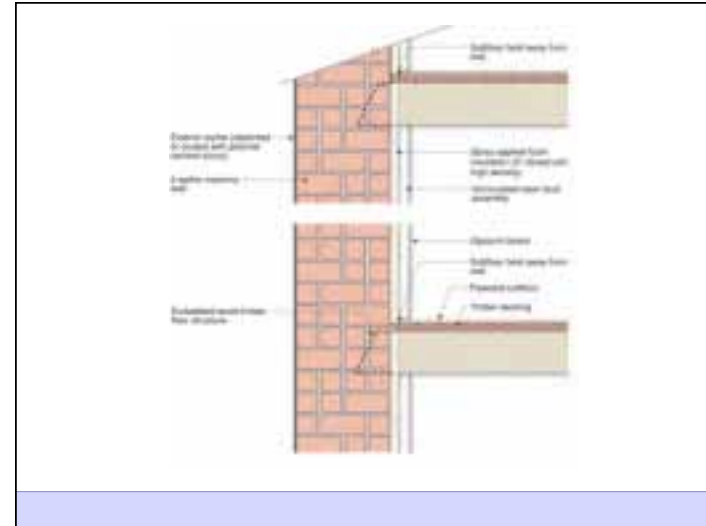


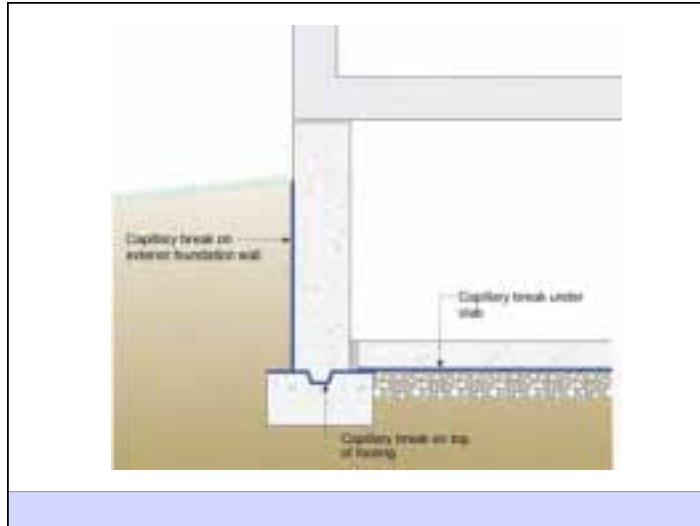












Capillarity + Salt = Osmosis

- Mineral salts carried in solution by capillary water
- When water evaporates from a surface the salts left behind form crystals in process called efflorescence
- When water evaporated beneath a surface the salts crystallize within the pore structure of the material in called sub-efflorescence
- The salt crystallization causes expansive forces that can exceed the cohesive strength of the material leading to spalling



Diffusion + Capillarity + Osmosis = Problem

- Diffusion Vapor Pressure 3 to 5 psi
- Capillary Pressure 300 to 500 psi
- Osmosis Pressure 3,000 to 5,000 psi

