MOISTURE TESTING

Presentation for:

AMERICAN SPORTS BUILDERS ASSOCIATION
Build it Right

Presented by: Peter Craig - FICRI

Concrete Constructives

Program Objectives

1. To understand why moisture-related flooring problems have become such a common and serious issue nationwide.

2. To learn how to properly evaluate the moisture condition of a concrete sub-floor.

What is the Common Denominator in these Flooring Problems?

Moisture Coming from, or Through a Concrete Sub-Floor

Moisture can . . . .

Cause a flooring problem

or,

be necessary to initiate other damage causing conditions.

Why Now ?

1. Fast-Track Construction Schedules

Why Now ?

2. Wetter Building Sites

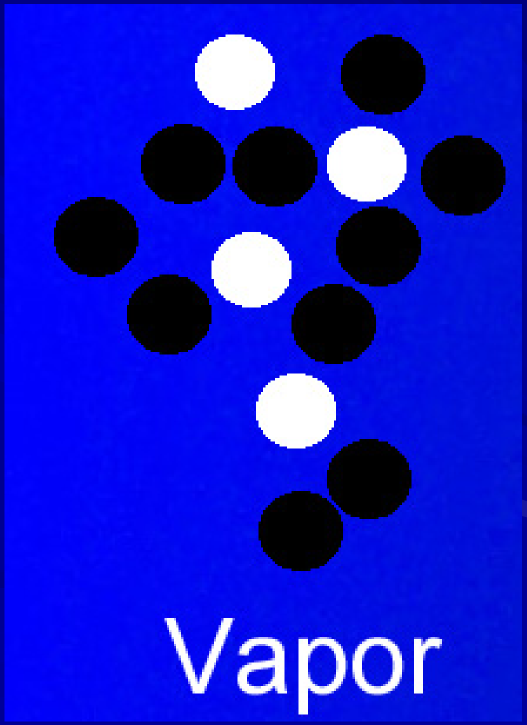
Why Now ?

1. Fast-Track Construction Schedules
2. Wetter Building Sites
3. Material Changes
4. Inadequate Sub-Slab Moisture Protection
5. Inaccurate, Insufficient or Misinterpreted Moisture Tests

Moisture 101

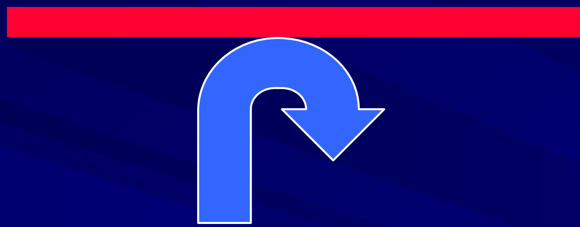
Water

Found naturally in three states ….



Where does the water / moisture come from ?

- Concrete




How much free water ?

Where does the moisture come from ?

Typical 4000 psi concrete

- ✓Water-to-cement ratio 0.50
- ✓33 gal of water/cu yd = 275 lbs/cu yd
- ✓ Water needed for hydration w/c 0.25 = 137.5 lbs
- ✓Leaves 137.5 lbs free water/yd

= 1697 lbs free-water/1000 sq ft (4” slab)

Where does the water / moisture come from ?

- Concrete

Where does the water / moisture come from ?

- Concrete
- Irrigation
- Broken Pipes
- Condensation

Dew Point Temperature - Fahrenheit

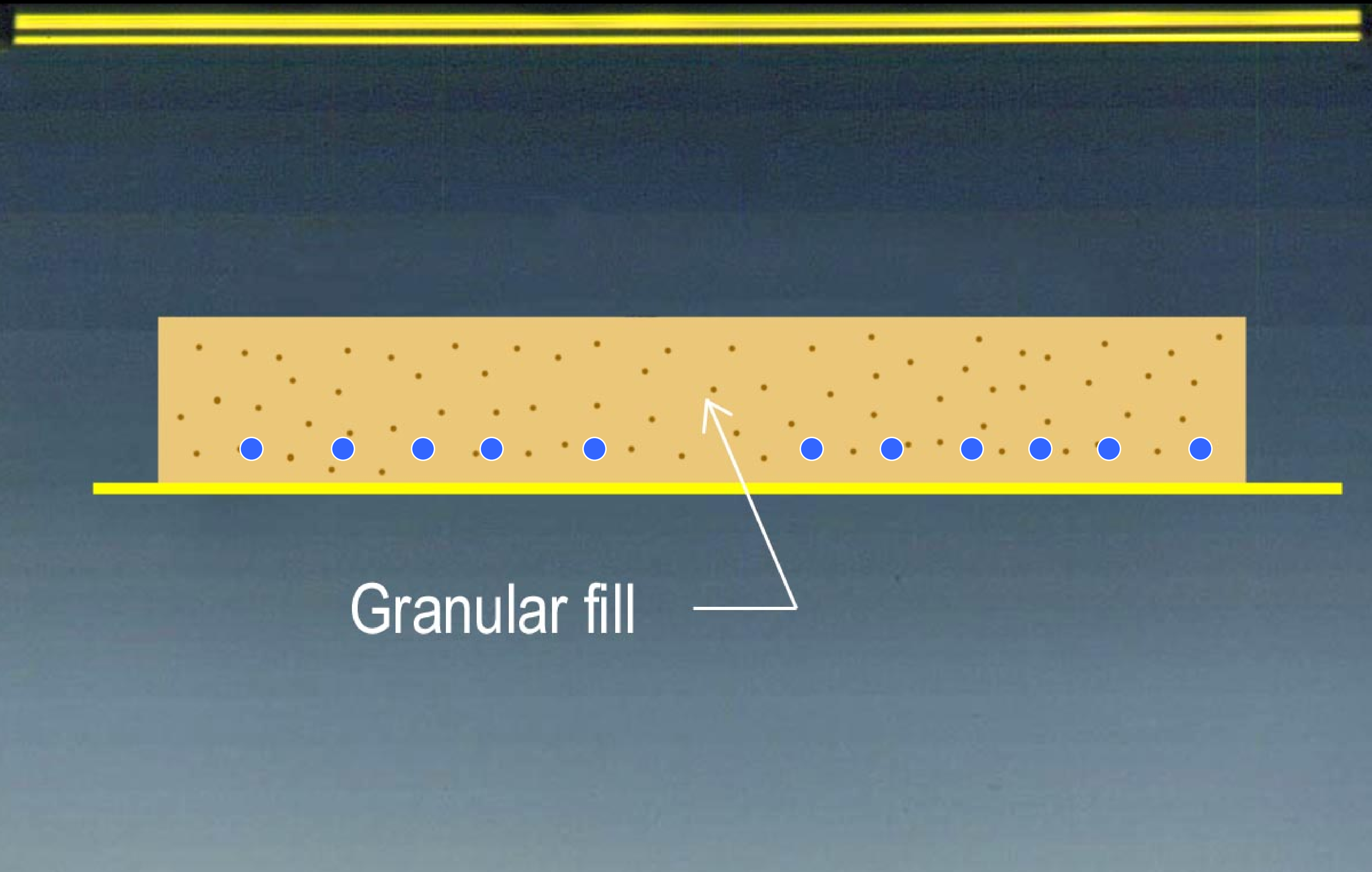
Relative Humidity

	10%	20%	30%	40%	50%	60%	70%	80%	90 %	100%
Air Temp (F)	Dew Point (Concrete Surface Temperature)									
40	5	8	14	18	24	28	31	34	37	40
45	5	9	16	23	28	32	36	39	42	45
50	6	13	21	27	33	36	40	44	47	50
55	8	16	25	31	36	41	45	49	52	55
60	9	20	29	35	41	46	50	54	57	60
65	10	24	33	40	46	51	55	58	62	65
70	13	28	37	45	50	55	60	64	67	70
75	17	31	42	49	55	60	64	68	72	75
80	20	35	46	53	60	65	69	73	77	80
85	24	40	50	58	64	69	74	78	82	85
90	27	43	54	62	69	74	79	83	87	90
95	30	48	59	67	73	79	84	88	92	95
100	34	52	62	71	78	83	88	93	97	100

Where does the moisture come from ?

- Concrete
- Irrigation
- Broken Pipes
- Condensation
- Fill Course

Fill Course Over Vapor Barrier/Retarder



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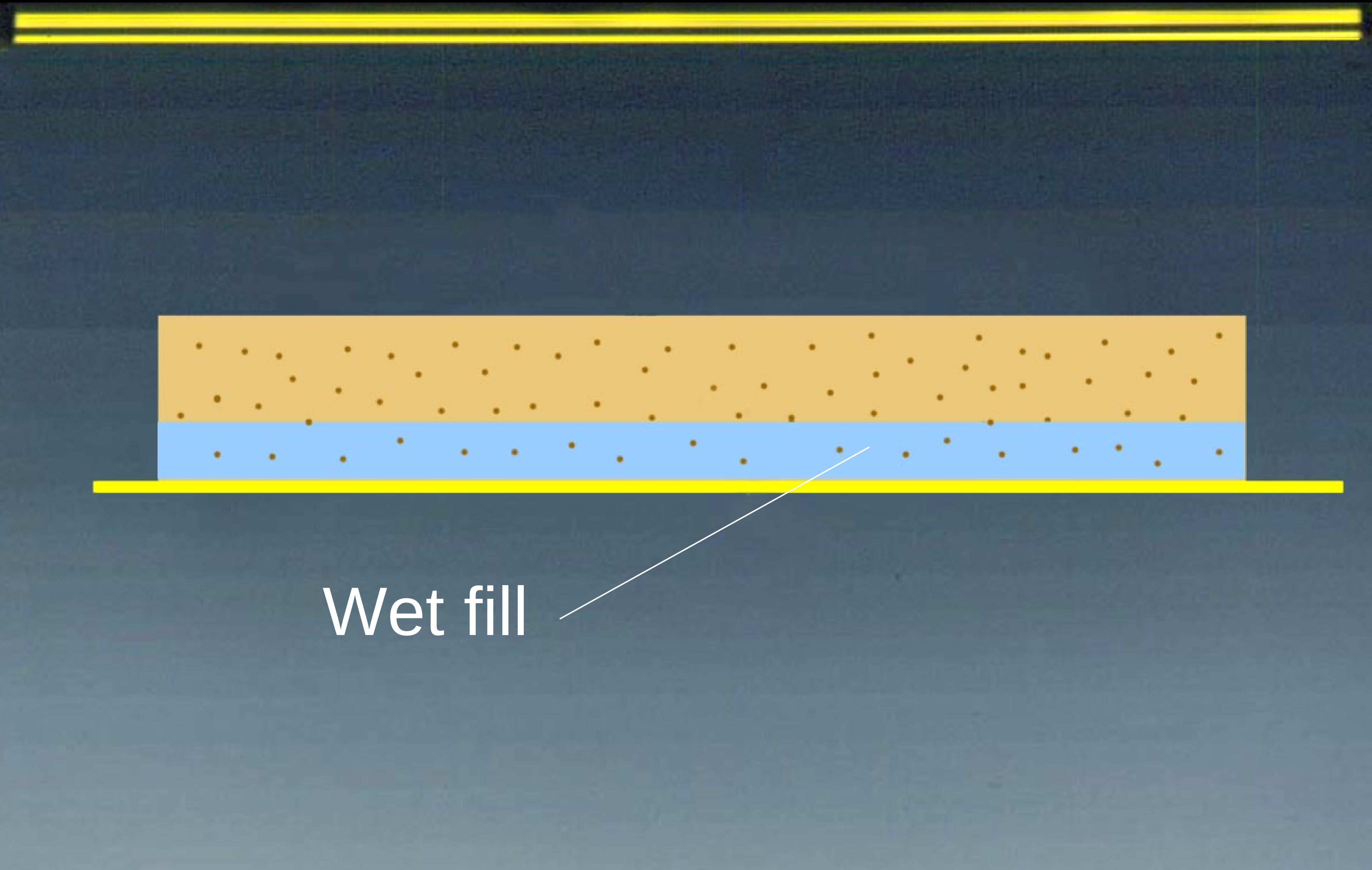


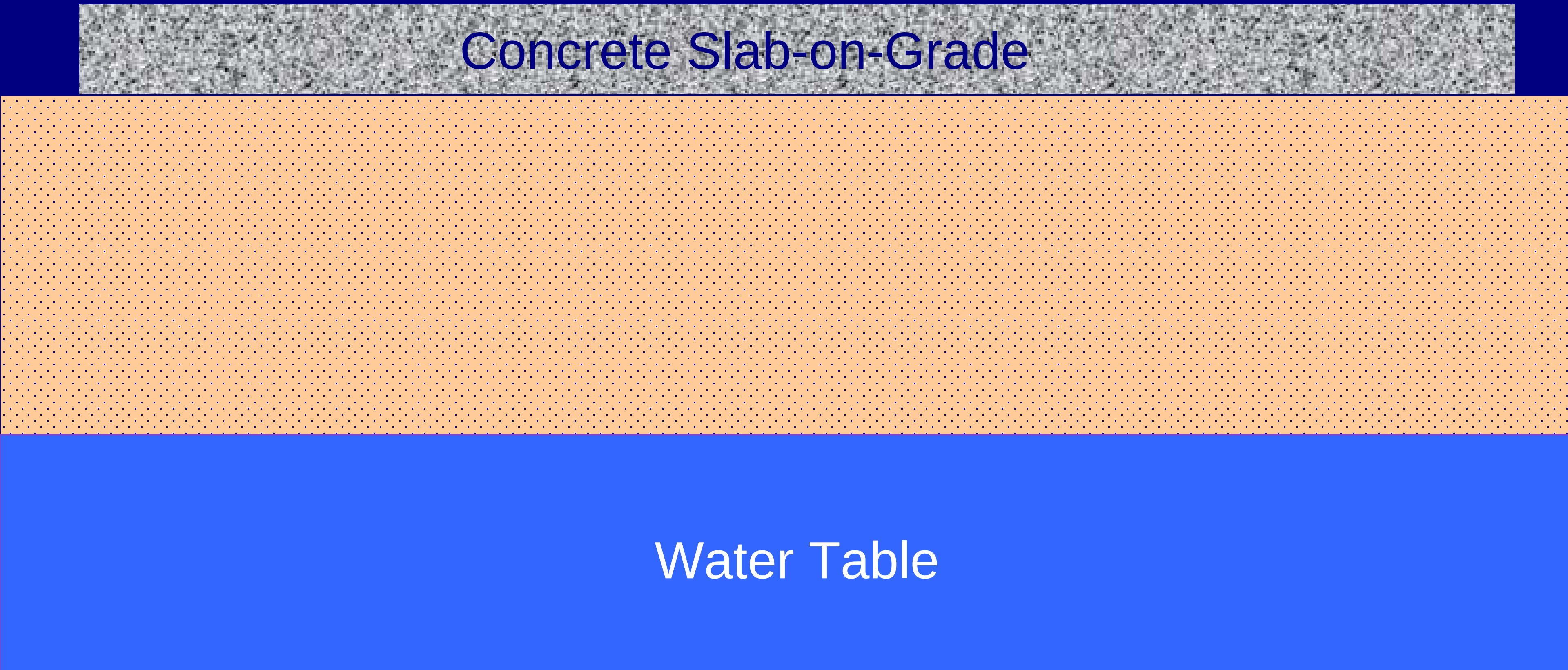
Where does the moisture come from ?

- Concrete
- Irrigation
- Broken Pipes
- Condensation
- Fill Course
- Adhesives
- Maintenance

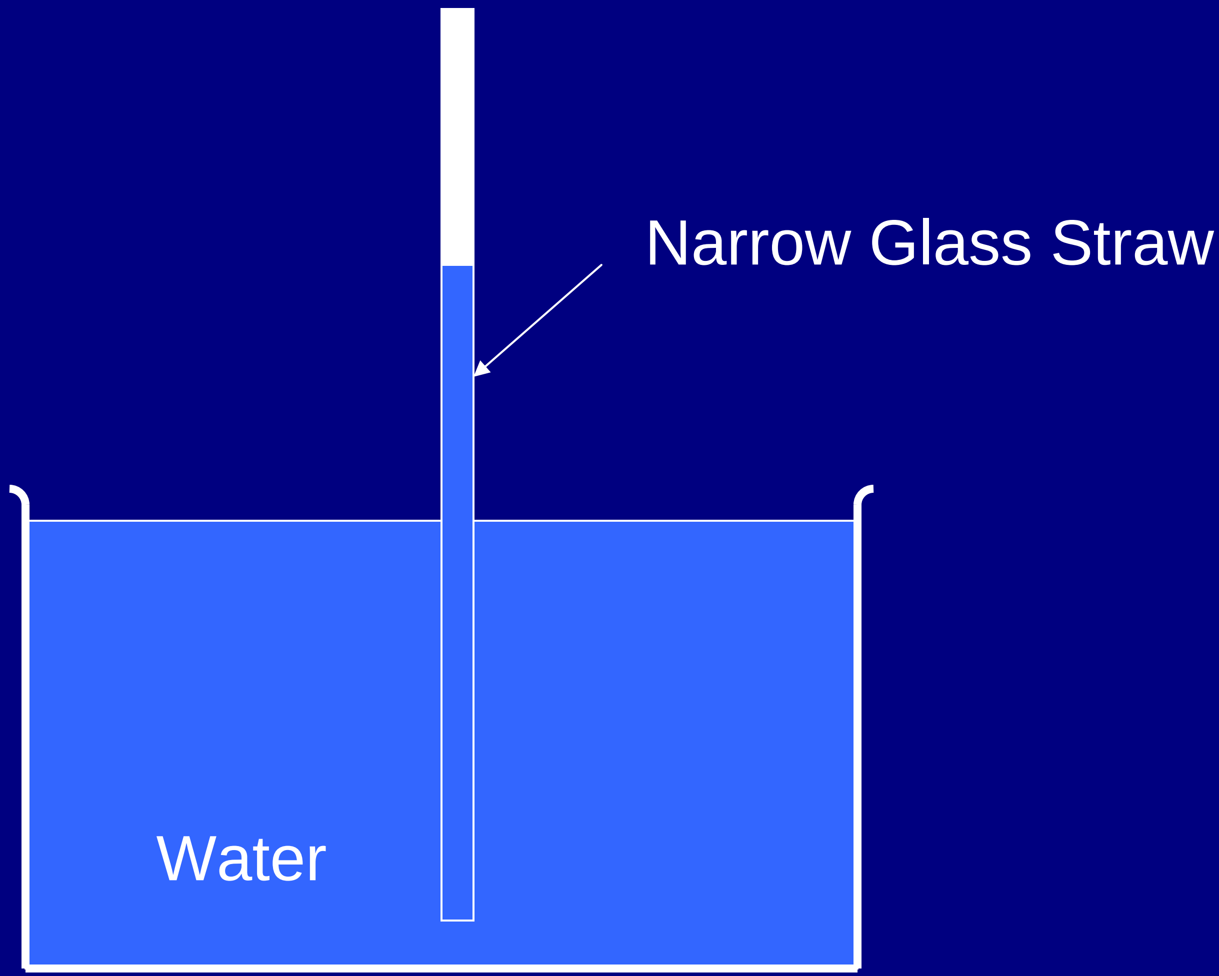
Groundwater Sources

- Hydrostatic Pressure
- Capillary Action
- Vapor Diffusion

Hydrostatic Pressure



Capillary Action



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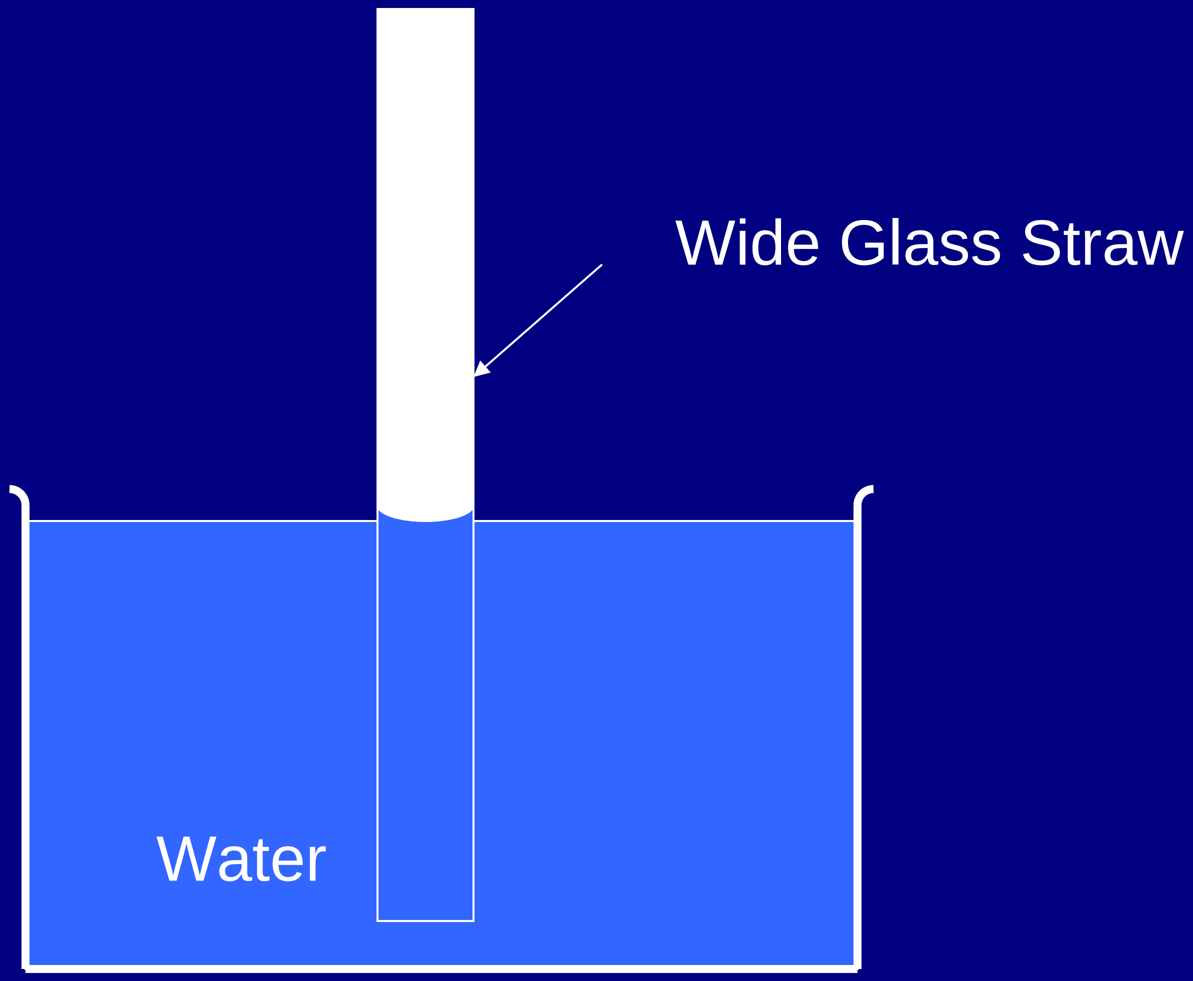
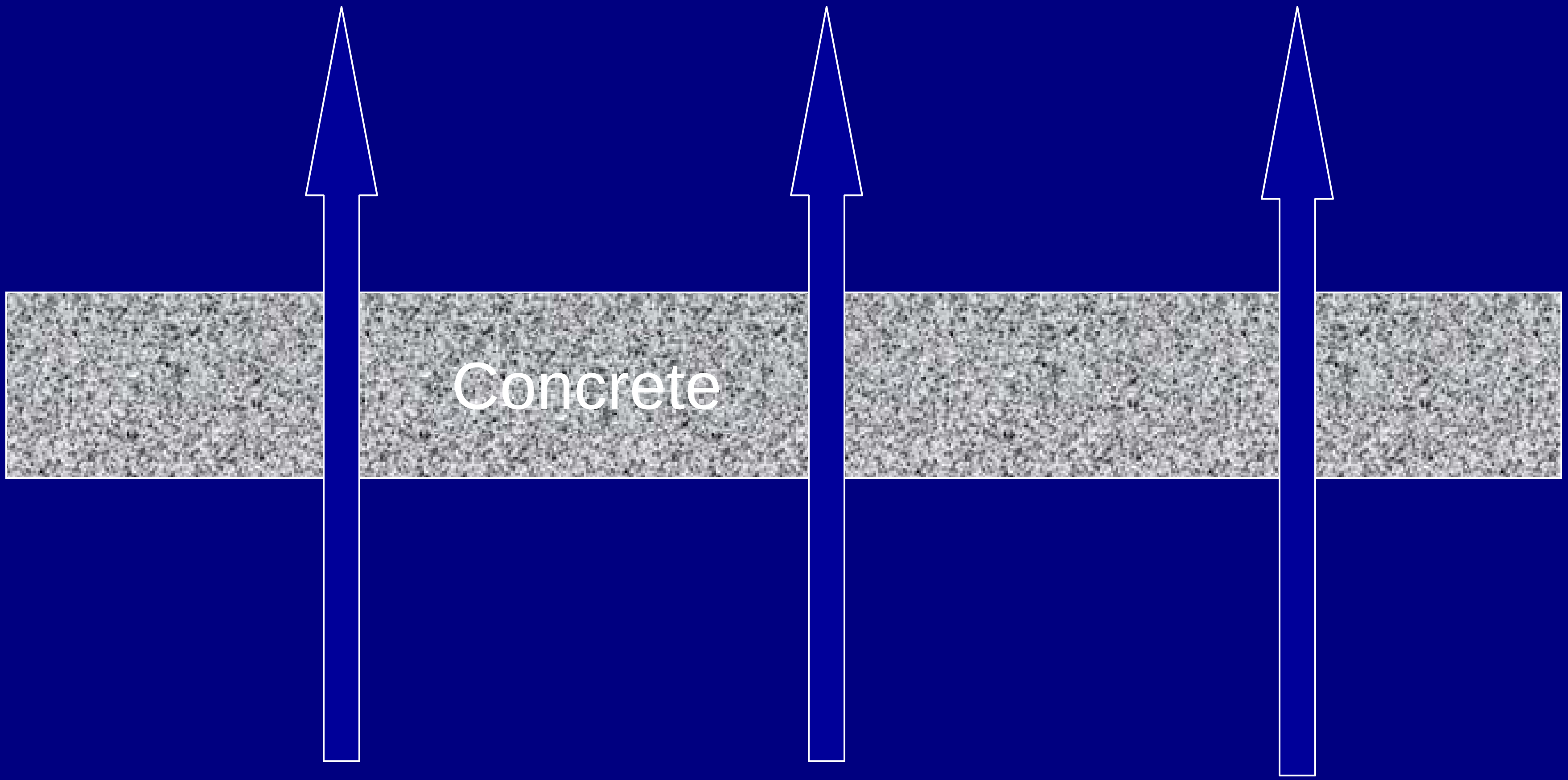


Vapor Diffusion

Lower Vapor Pressure



Higher Vapor Pressure

Vapor Pressure For Various Temperatures And Relative Humidities (Pounds Per Square Inch)

Dry Bulb Temperature	Relative Humidity (in percent)									
	100	90	80	70	60	50	40	30	20	10
°F.										
100	0.948	0.854	0.758	0.663	0.569	0.474	0.379	0.284	0.189	0.095
90	.698	.628	.558	.489	.419	.349	.279	.209	.140	.070
80	.506	.455	.405	.357	.303	.253	.202	.152	.101	.051
75	.429	.386	.343	.300	.258	.214	.172	.129	.086	.043
70	.362	.326	.290	.253	.217	.181	.145	.108	.072	.036
65	.305	.274	.244	.213	.183	.152	.122	.091	.061	.030
60	.256	.230	.205	.179	.153	.128	.102	.077	.051	.026
55	.214	.192	.171	.149	.128	.107	.085	.064	.042	.021
50	.178	.160	.142	.124	.107	.089	.071	.053	.036	.018
45	.147	.132	.118	.111	.088	.073	.059	.044	.029	.015
40	.122	.110	.098	.085	.073	.061	.049	.037	.024	.012
35	.100	.090	.080	.070	.060	.050	.040	.030	.020	.010
30	.080	.072	.064	.056	.048	.040	.032	.024	.016	.008
25	.063	.057	.050	.044	.037	.032	.025	.019	.012	.006
20	.052	.047	.042	.036	.031	.026	.020	.015	.010	.005
10	.031	.028	.025	.022	.018	.015	.012	.009	.006	.003
0	.018	.016	.014	.013	.010	.009	.007	.005	.003	.002
-10	.011	.010	.009	.008	.007	.006	.004	.003	.002	.001
-15	.008	.007	.006	.005	.005	.004	.003	.002	.002	.001

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Below Slab

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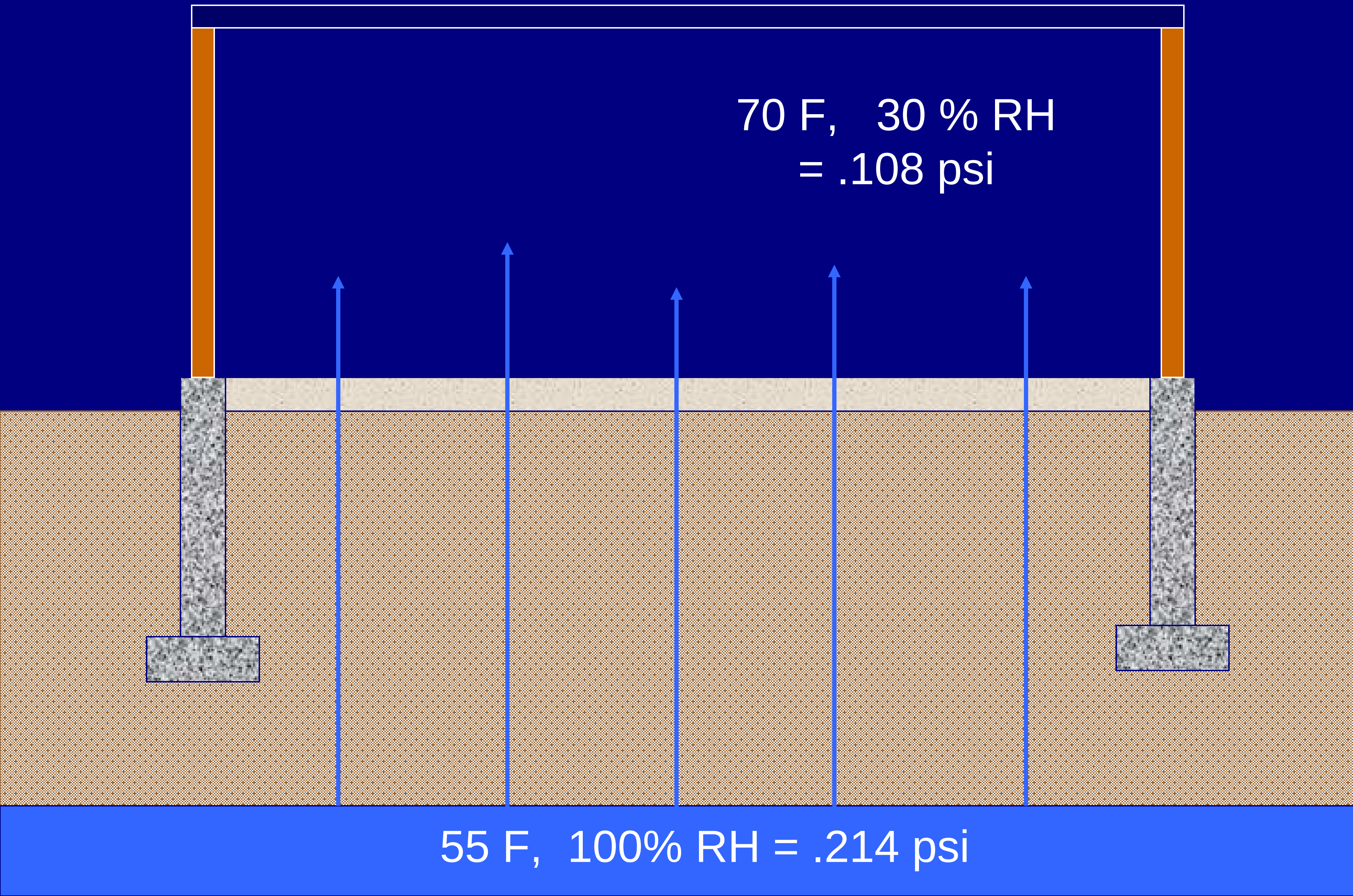
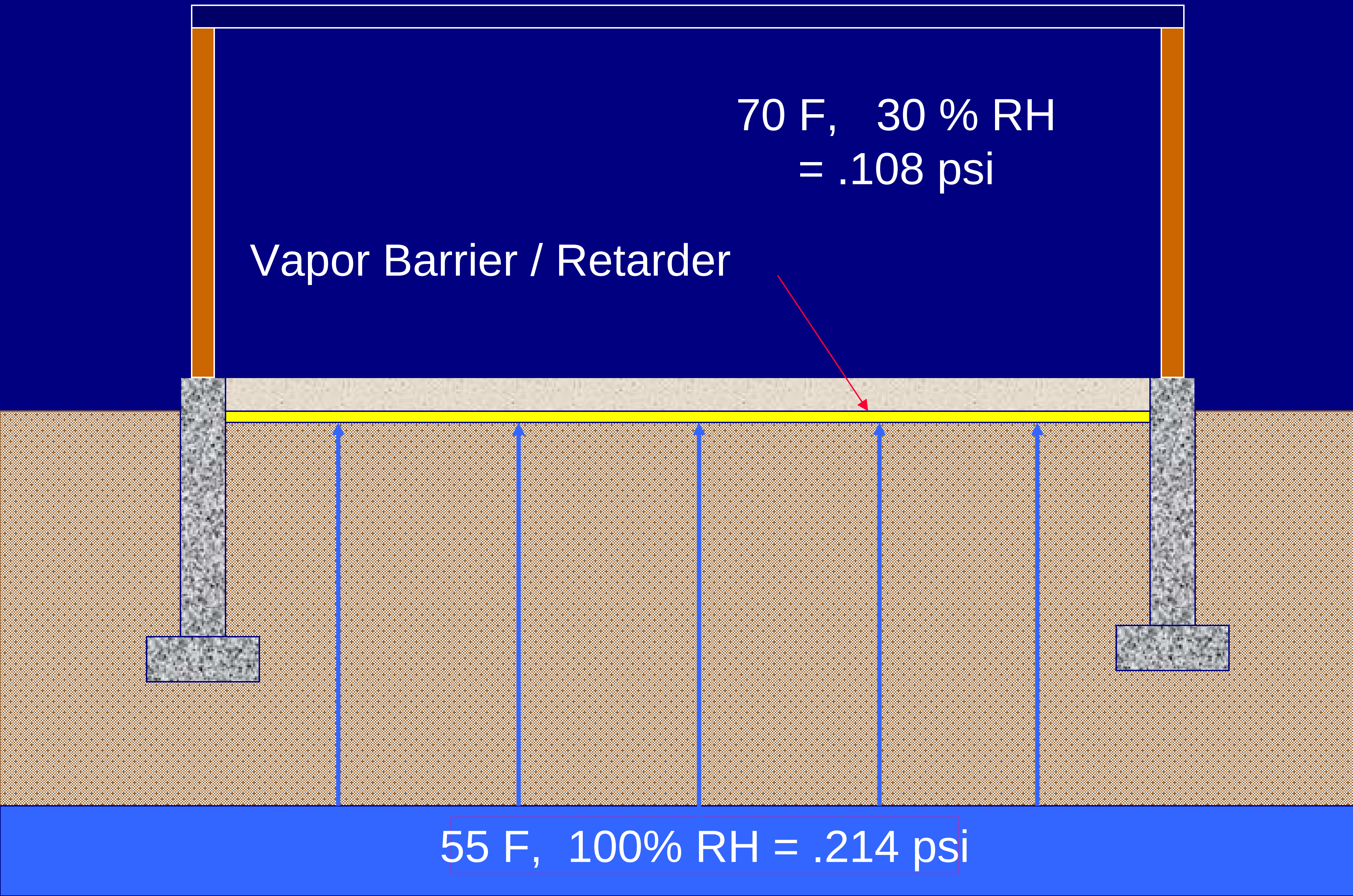
Below Slab

Water Vapor Movement



Water Vapor Movement



Causes of Flooring Problems

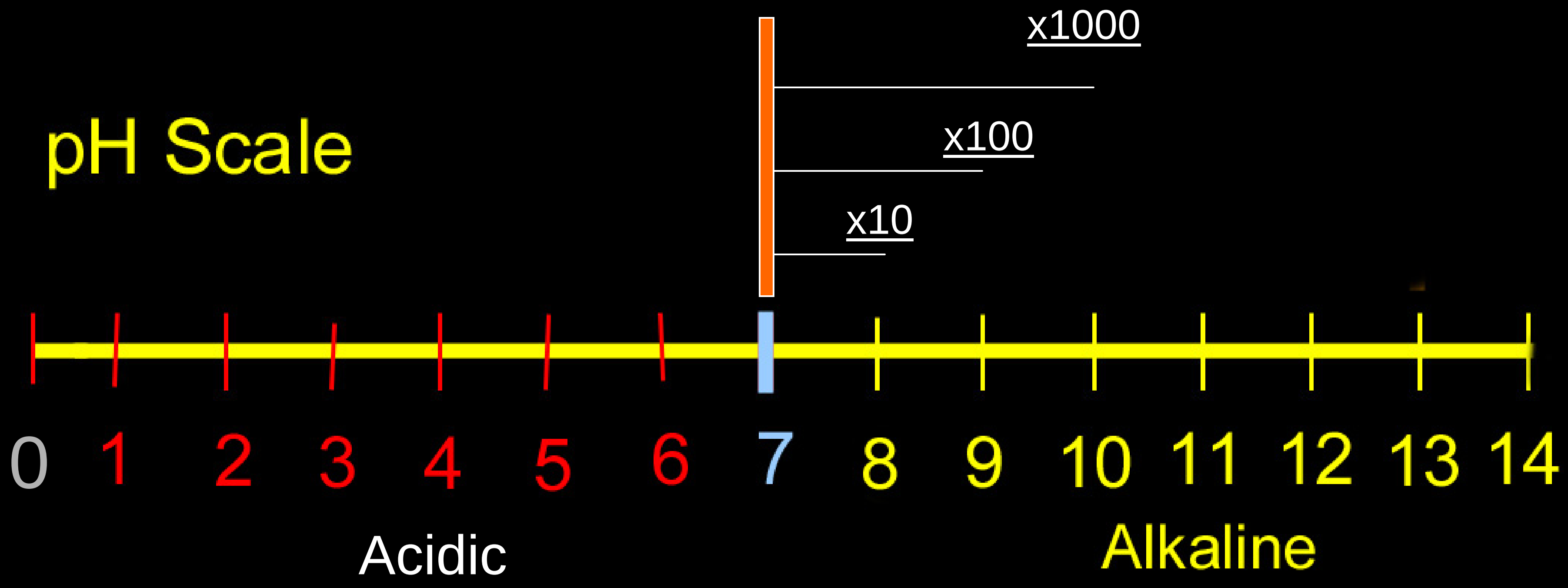
- Excessive Moisture

Causes of Flooring Problems

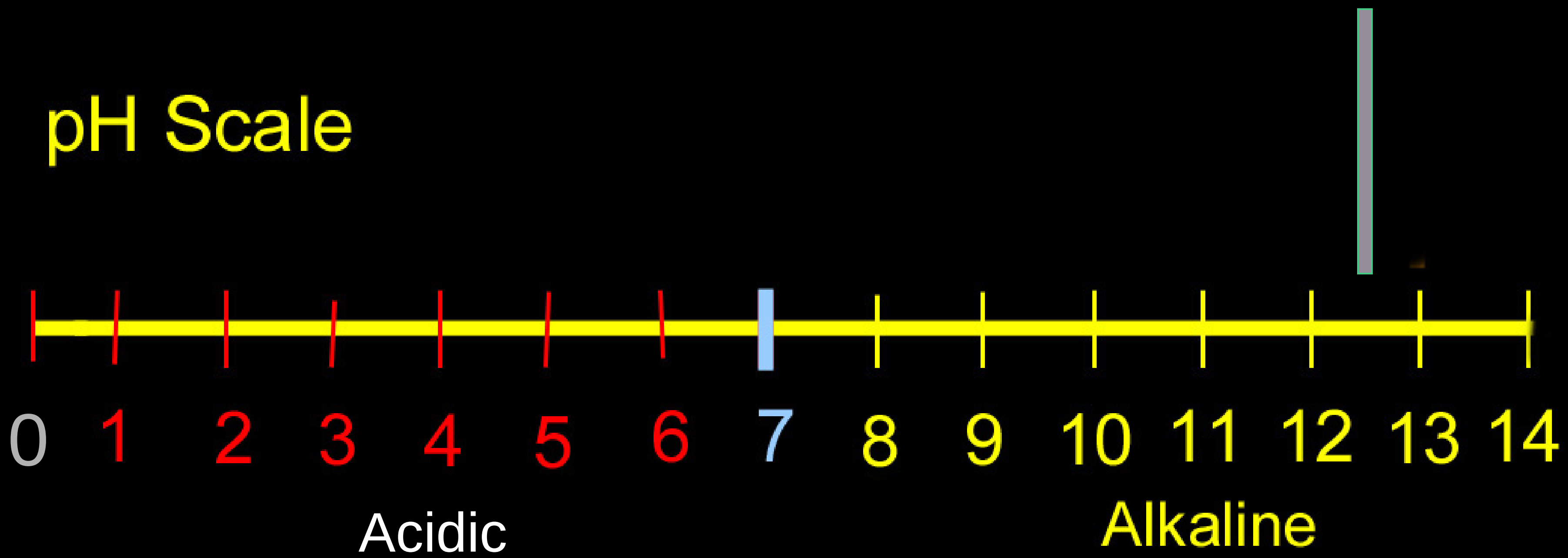
- Excessive Moisture
- High pH Levels

pH

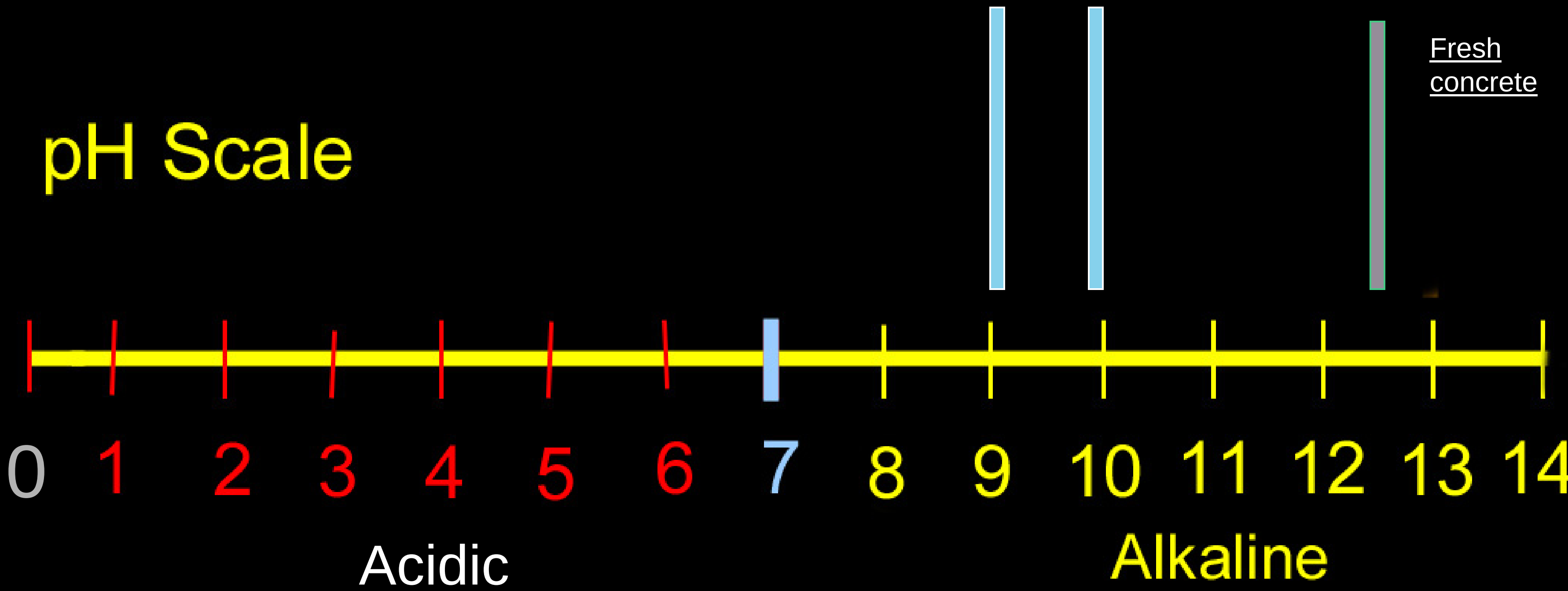
Hydronium (hydrogen) ions in solution.


pH Scale
x1000
x100
x10
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Acidic
Alkaline

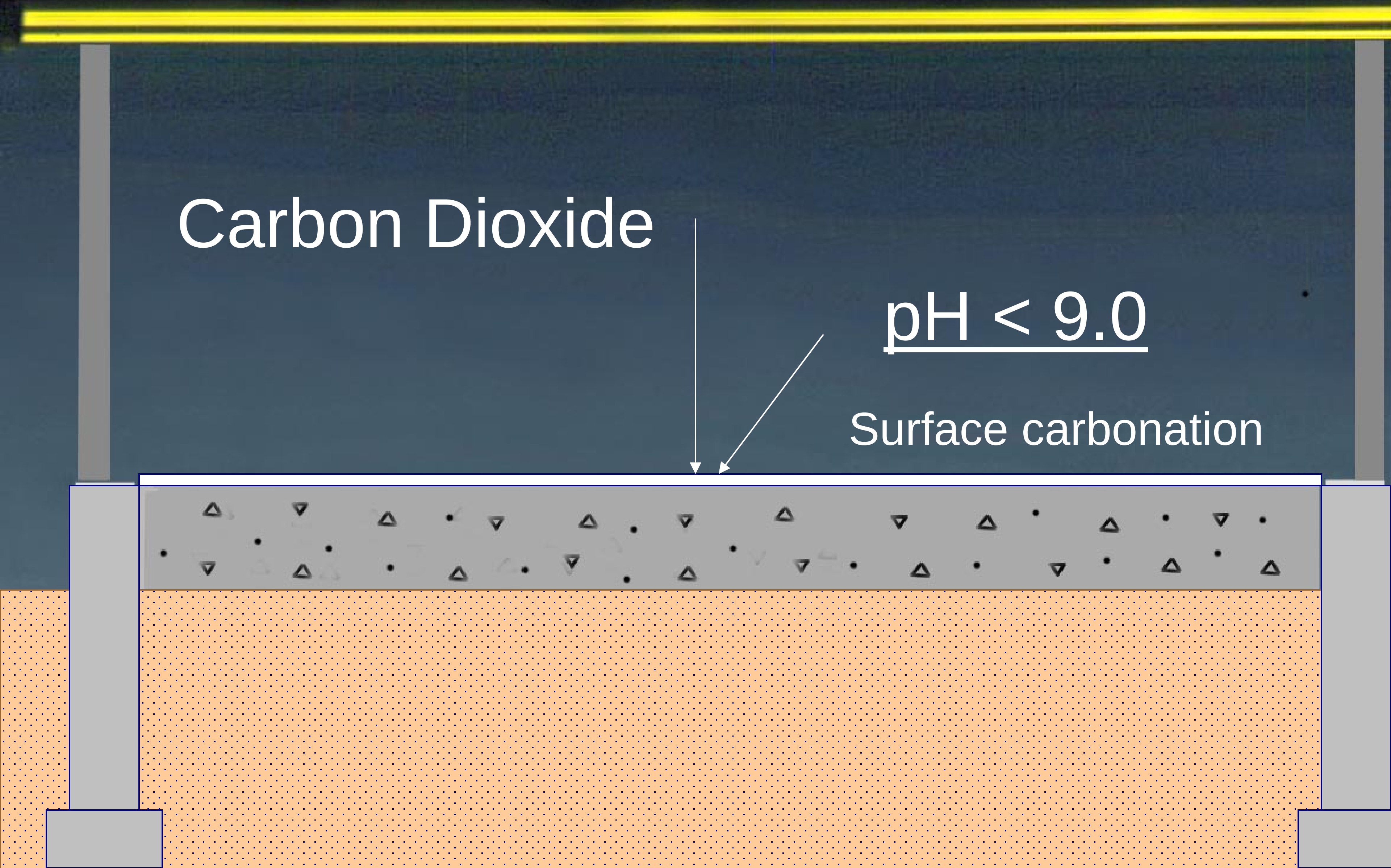
What is the pH of fresh concrete?



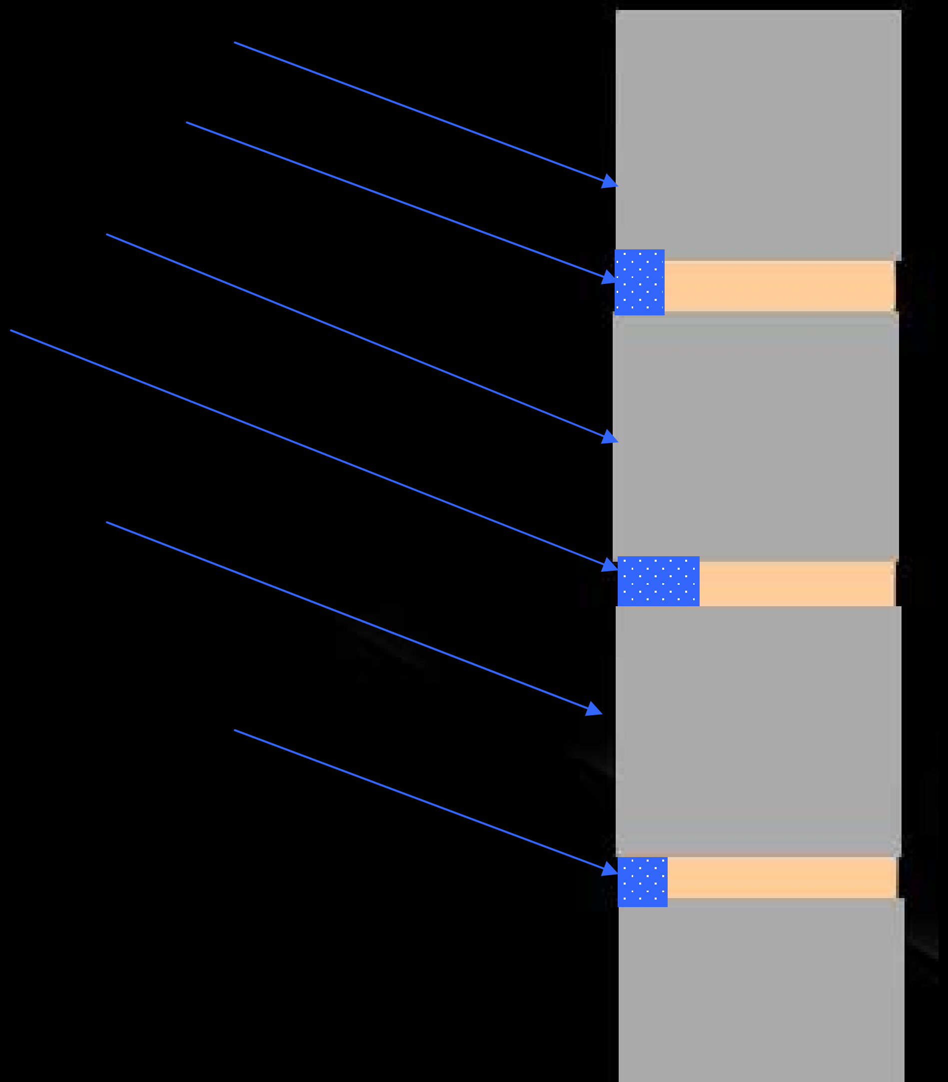
What is the highest pH level that most adhesives can tolerate?



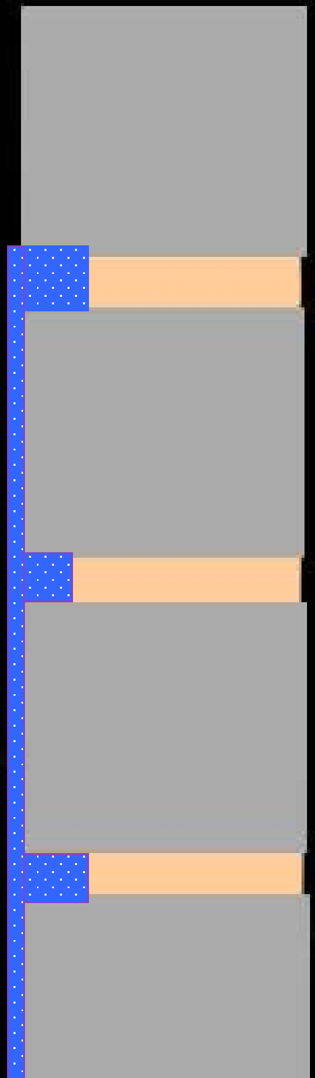
Carbonation



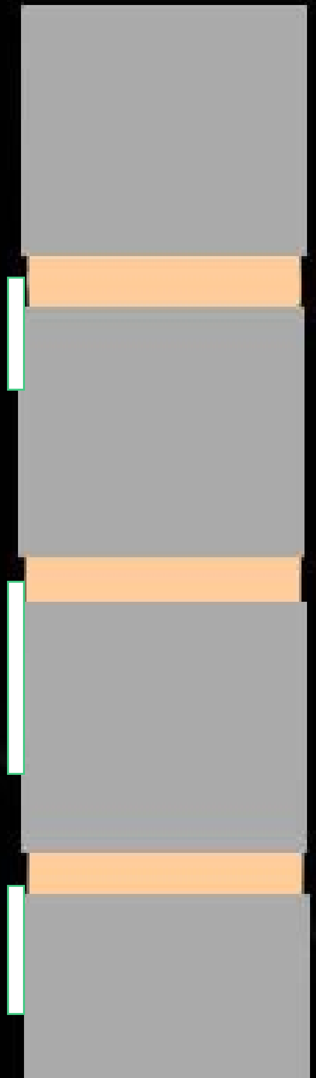
Masonry wall



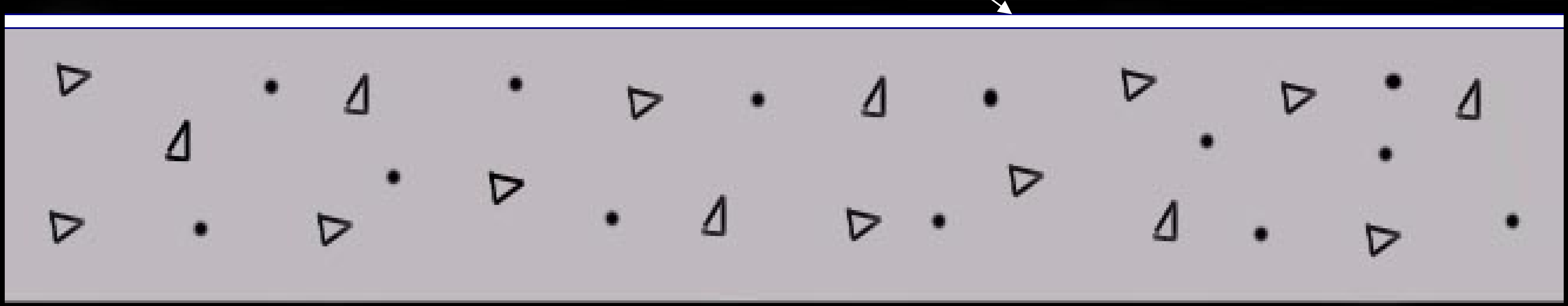
Masonry wall

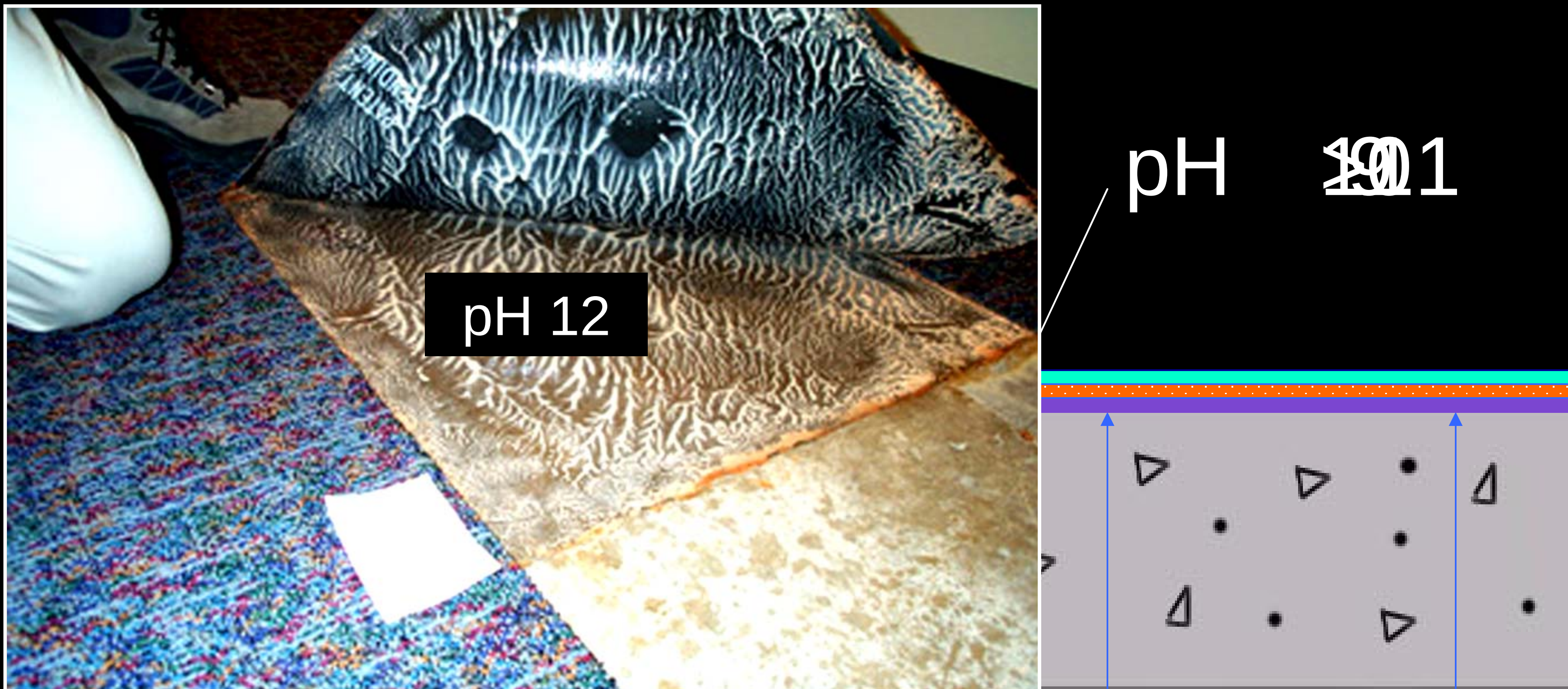


Masonry wall



Surface carbonation





Moisture Diffusion

Some people make a big deal over pH

But Truth is:

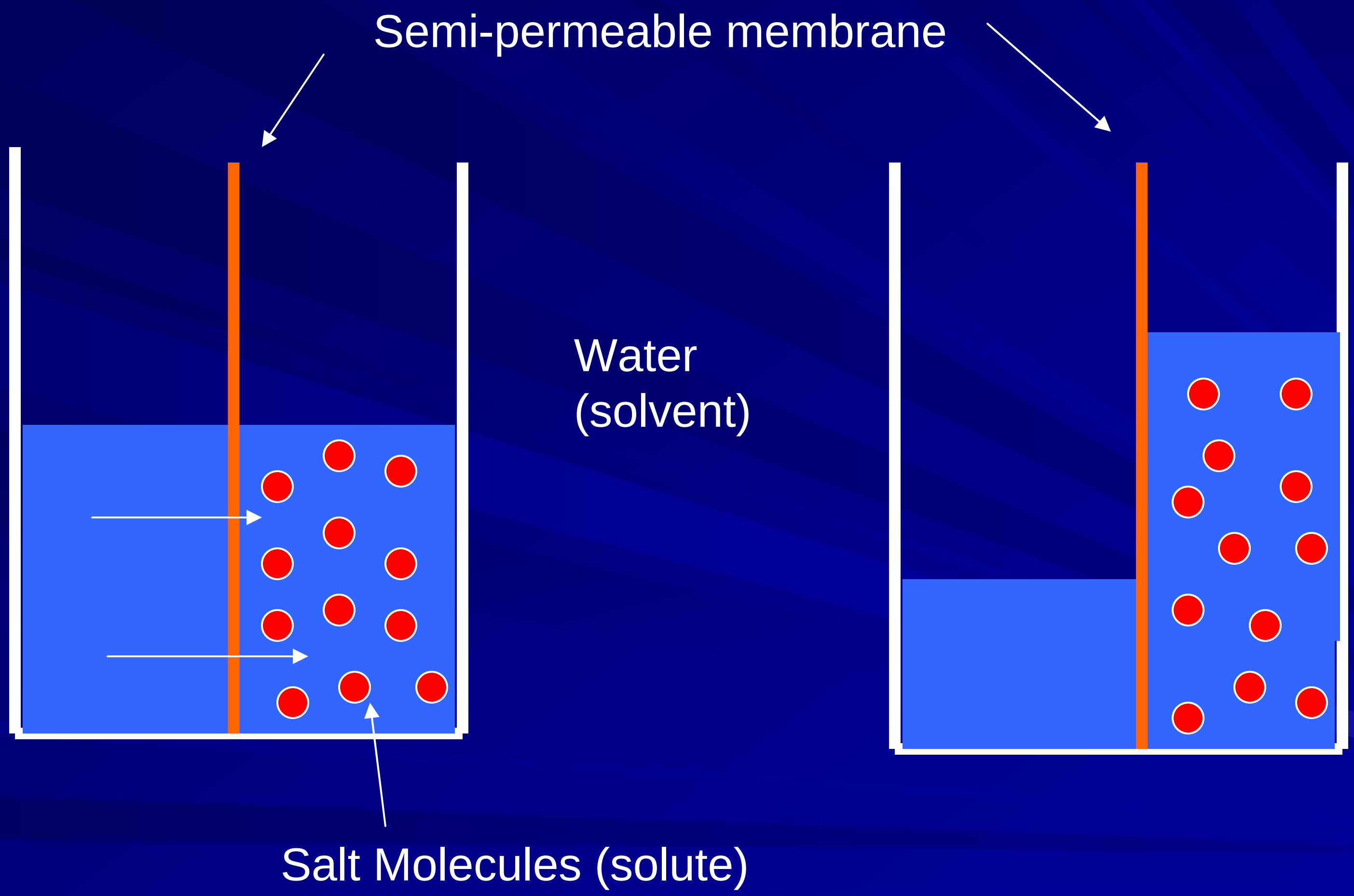
Get rid of the water and soluble alkali salts do not enter into solution.

Get rid of the water – pH is not an issue

Causes of Flooring Problems

- Excessive Moisture
- High pH Levels
- Osmosis

Osmosis


Semi-permeable membrane
Water
(solvent)
Salt Molecules (solute)

Example of Osmosis in Nature – Cherry Bursting

Skin of the cherry acts as a semi-permeable membrane

Osmosis

How much pressure can an osmotic cell develop?

- ✓ Vapor Pressure less than 1.0 psi
- ✓ Osmotic pressure can exceed 300 psi

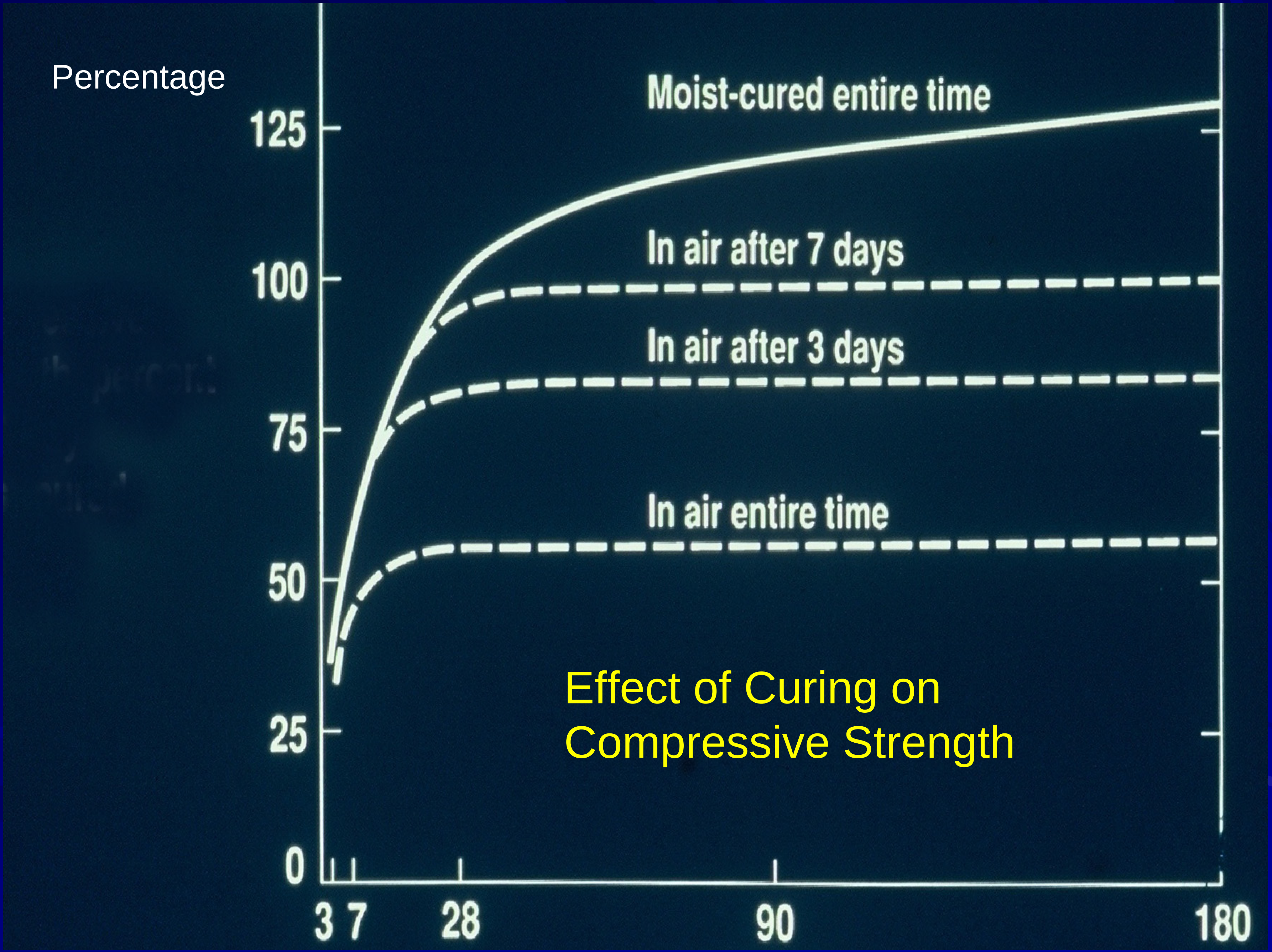
Causes of Flooring Problems

- Excessive Moisture
- High pH Levels
- Osmosis
- Material Issues – Plasticizer Migration
- Incompatibility with Curing Compounds

Causes of Flooring Problems

Curing Compounds

- Curing compounds are inexpensive, spray or rolled on liquid treatments applied to the surface of freshly finished concrete to retard the loss of moisture needed for proper cement hydration.



Effect of Curing on Compressive Strength

Causes of Flooring Problems

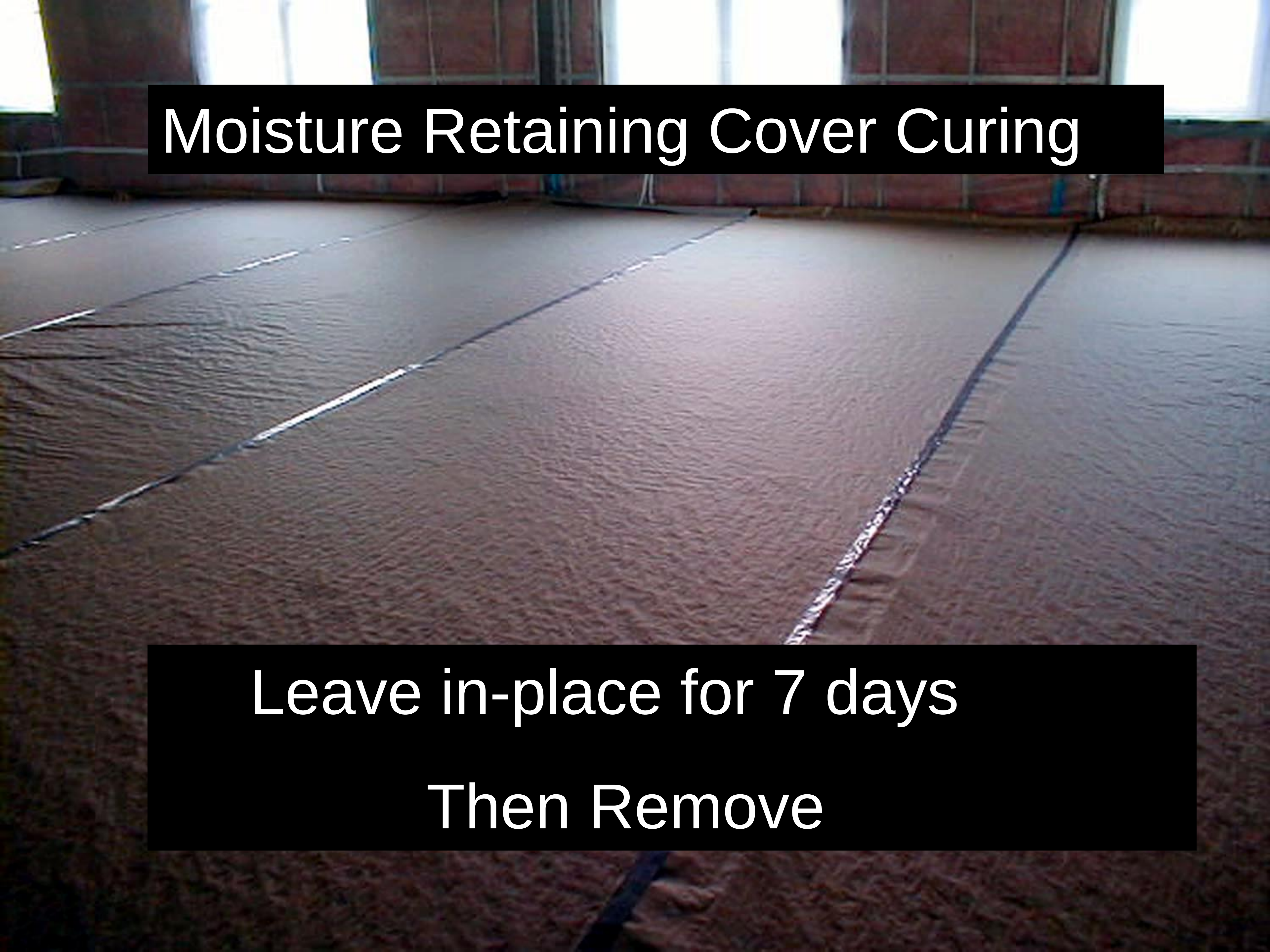
Curing Compounds

- Curing compounds are inexpensive, spray or rolled on liquid treatments applied to the surface of freshly finished concrete to retard the loss of moisture needed for proper cement hydration.

- Curing compounds do not simply disappear after 7 days

- Curing compounds may adversely affect adhesive bond

- Curing compounds cost far more to properly remove than using and alternative curing method

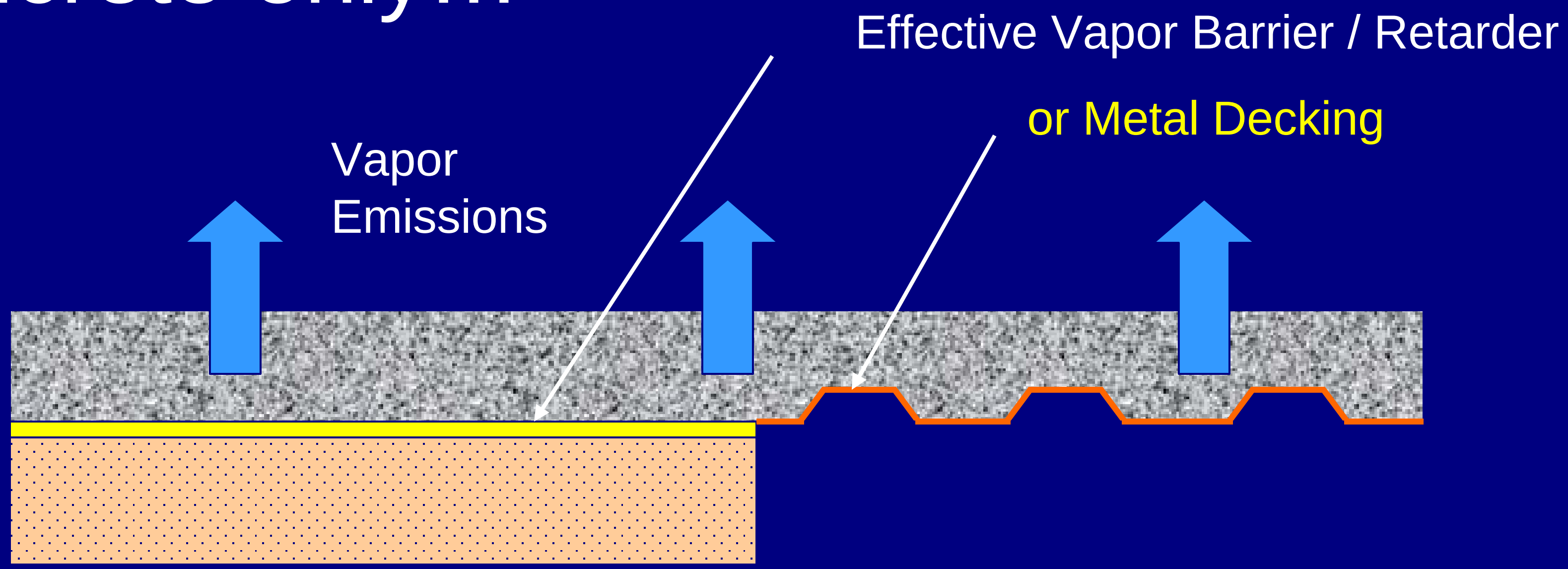

Moisture Retaining Cover Curing
Leave in-place for 7 days
Then Remove

There are Two Potential Sources of Concrete Sub-Floor Moisture . .

- Moisture from within the Concrete itself.
- Moisture Transmitting through the Concrete from Below.

Moisture from a Concrete Sub-floor..

1. Moisture from within the Concrete only…

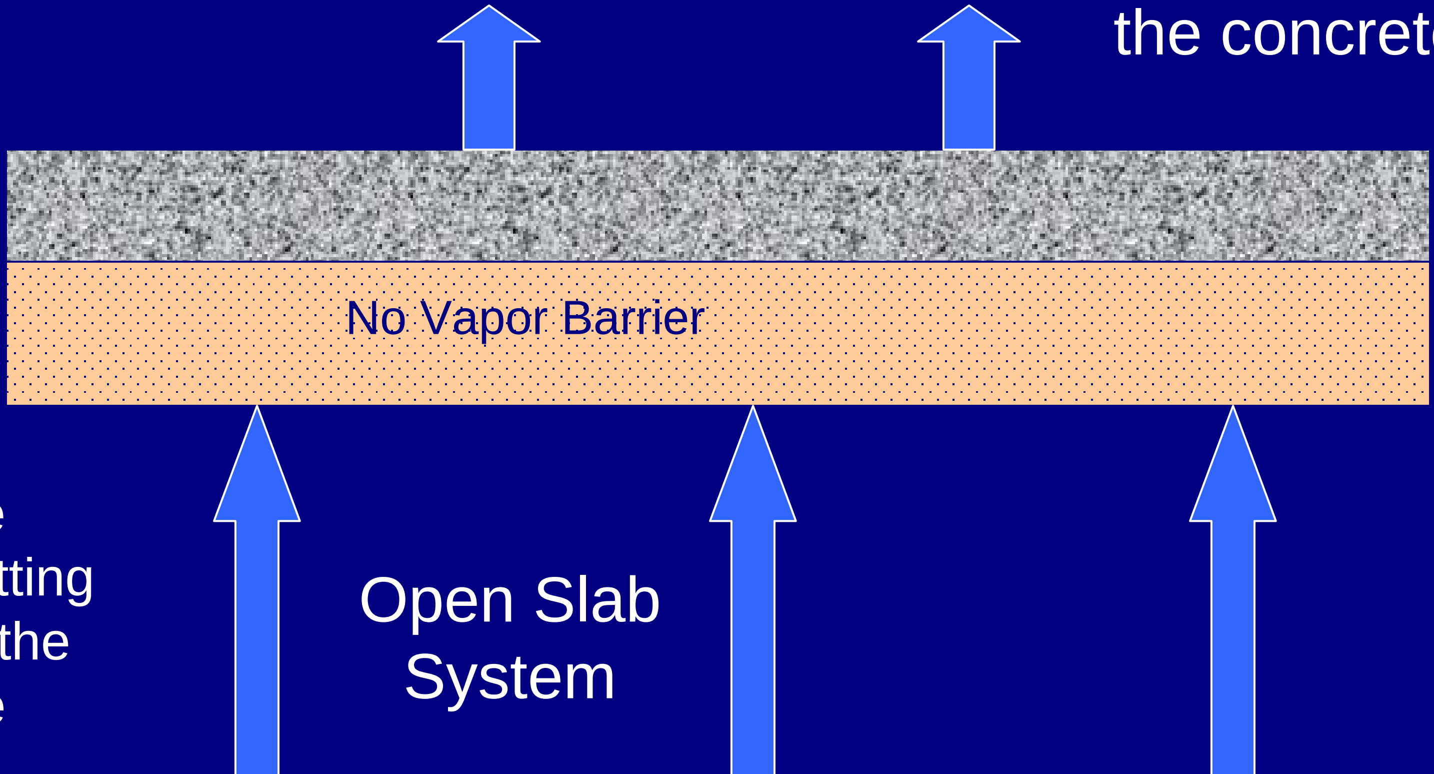


Closed Slab System

Moisture from a Concrete Sub-floor

2. Moisture Transmitting Through the Concrete from below…

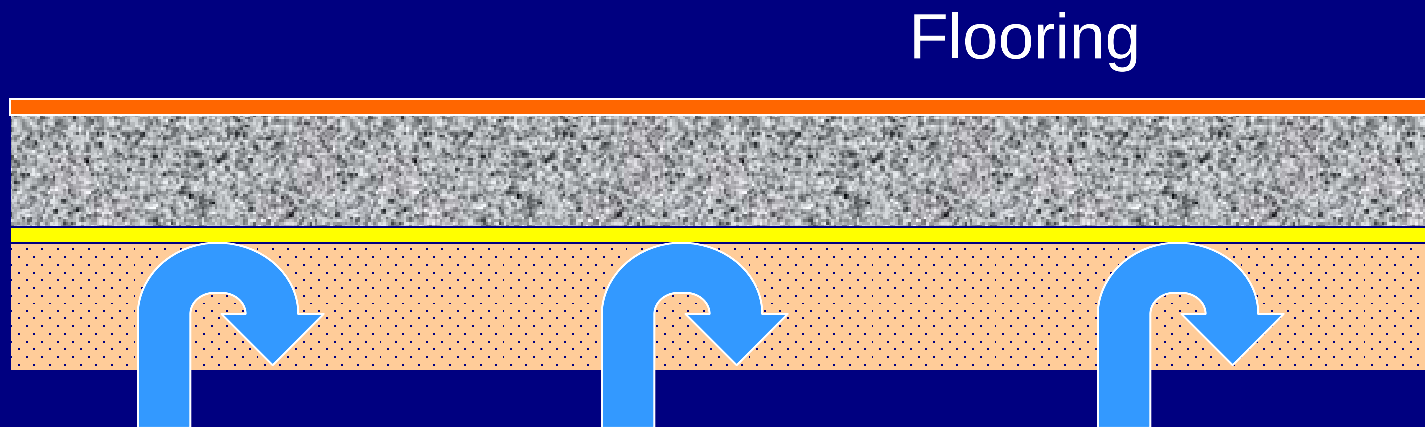
Moisture Emitting from the concrete



Moisture Transmitting through the concrete

Moisture from a Concrete Sub-floor

A Low-Permeance Vapor Barrier / Retarder can Effectively keep Below-Slab Moisture from Reaching the Flooring System ….



Moisture Testing

Why Measure Moisture?

Objectives:

- Meet Flooring Manufacturer's Requirements
- Conform to Industry Standards ASTM F 710
- Comply with Project Specifications

All intended to help reach

the real objective of…..

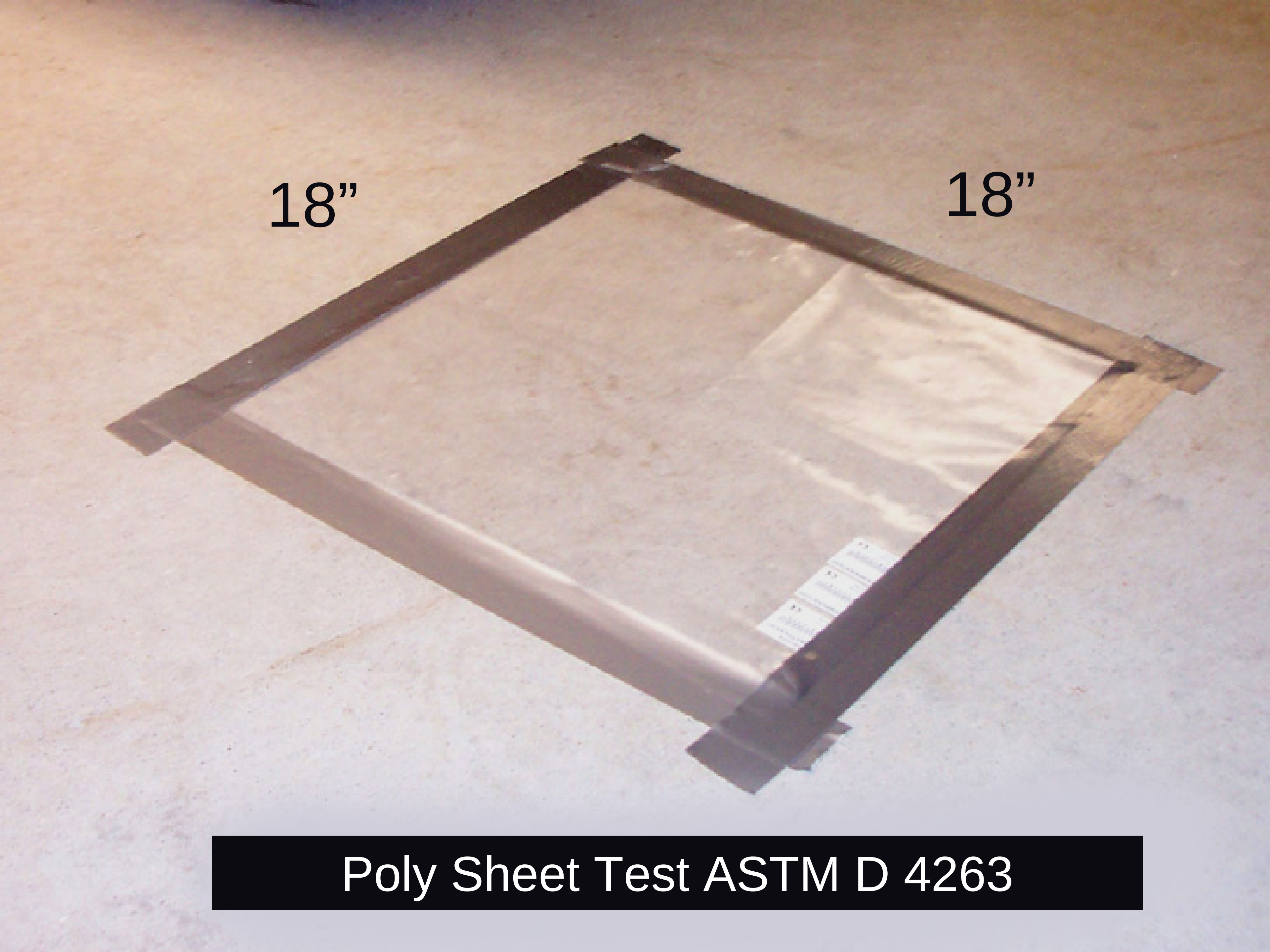
Why Measure Moisture?

Avoid Flooring Problems

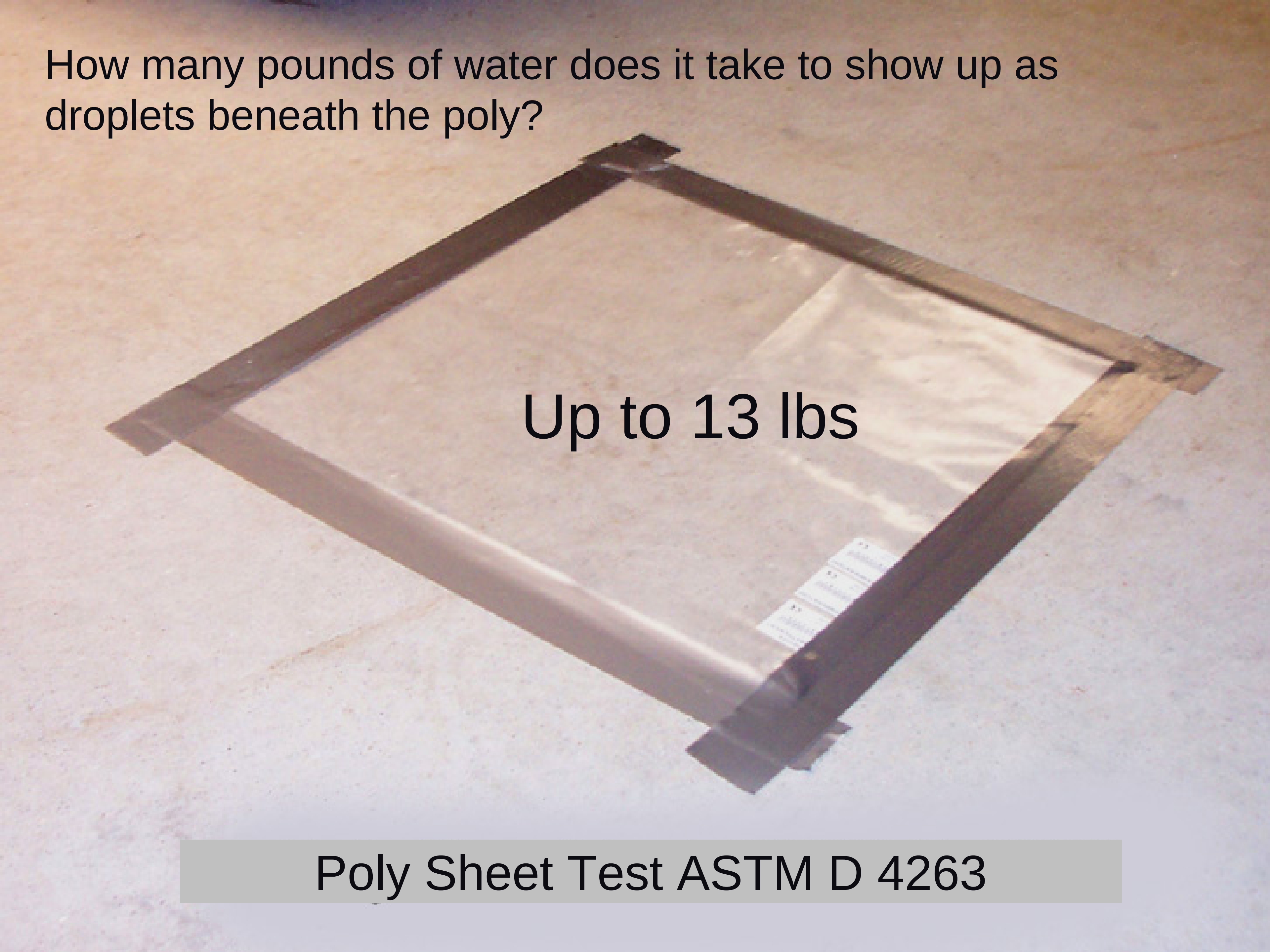
Moisture Testing Methods

- Qualitative
  - Plastic Sheet
  - Mat Bond Test
  - Electrical Resistance
  - Electrical Impedance
- Quantitative
  - Moisture Vapor Emission Rate
  - Relative Humidity

Qualitative Techniques



Poly Sheet Test ASTM D 4263


How many pounds of water does it take to show up as droplets beneath the poly?
Up to 13 lbs
Poly Sheet Test ASTM D 4263

Mat Bond Test

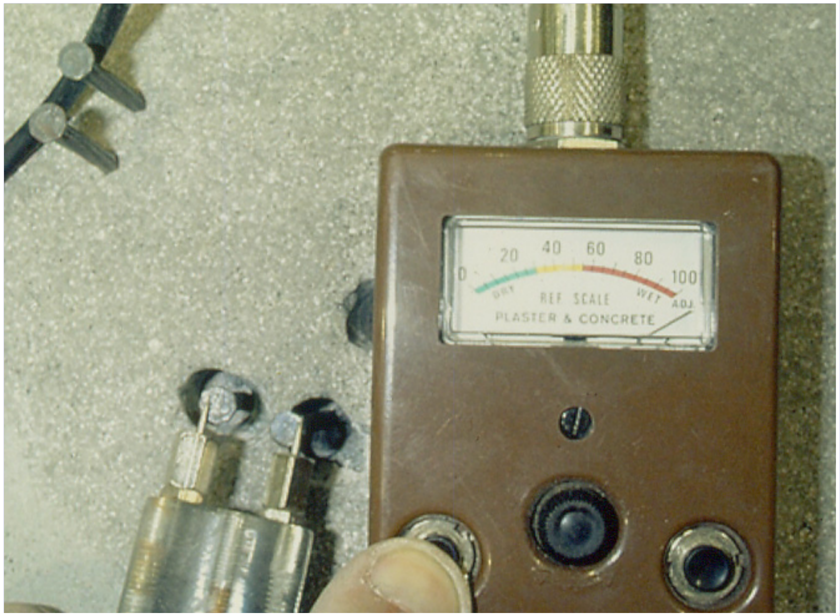
"Material can be considered *securely bonded* if an unusual amount of force is required to lift it from the subfloor."

Unusual to Who ?

Electrical Resistance

Relative Scale

Readings affected by presence of alkali, carbonation & chlorides



Electrical Impedance

- Useful for relative comparisons, mapping, selecting sites for further tests

Quantitative Techniques

Moisture Vapor Emission Rate (MVER)

ASTM F 1869

Calcium Chloride Test Procedure

1. Clean Slab Surface

Calcium Chloride Test

2. Weigh Calcium Chloride Dish

Field Scale

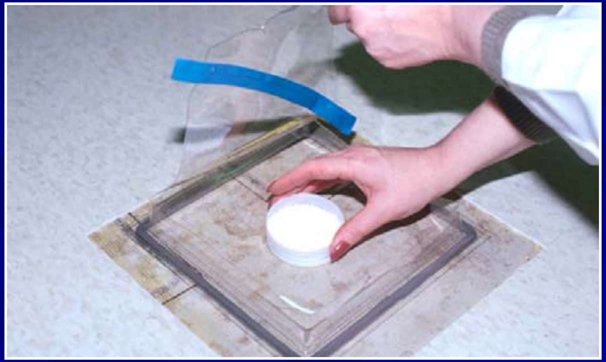
Calcium Chloride Test Procedure

1. Clean Surface

2. Weigh Dish

3. Install Test Kit

4. Remove after 60 to 72 hours

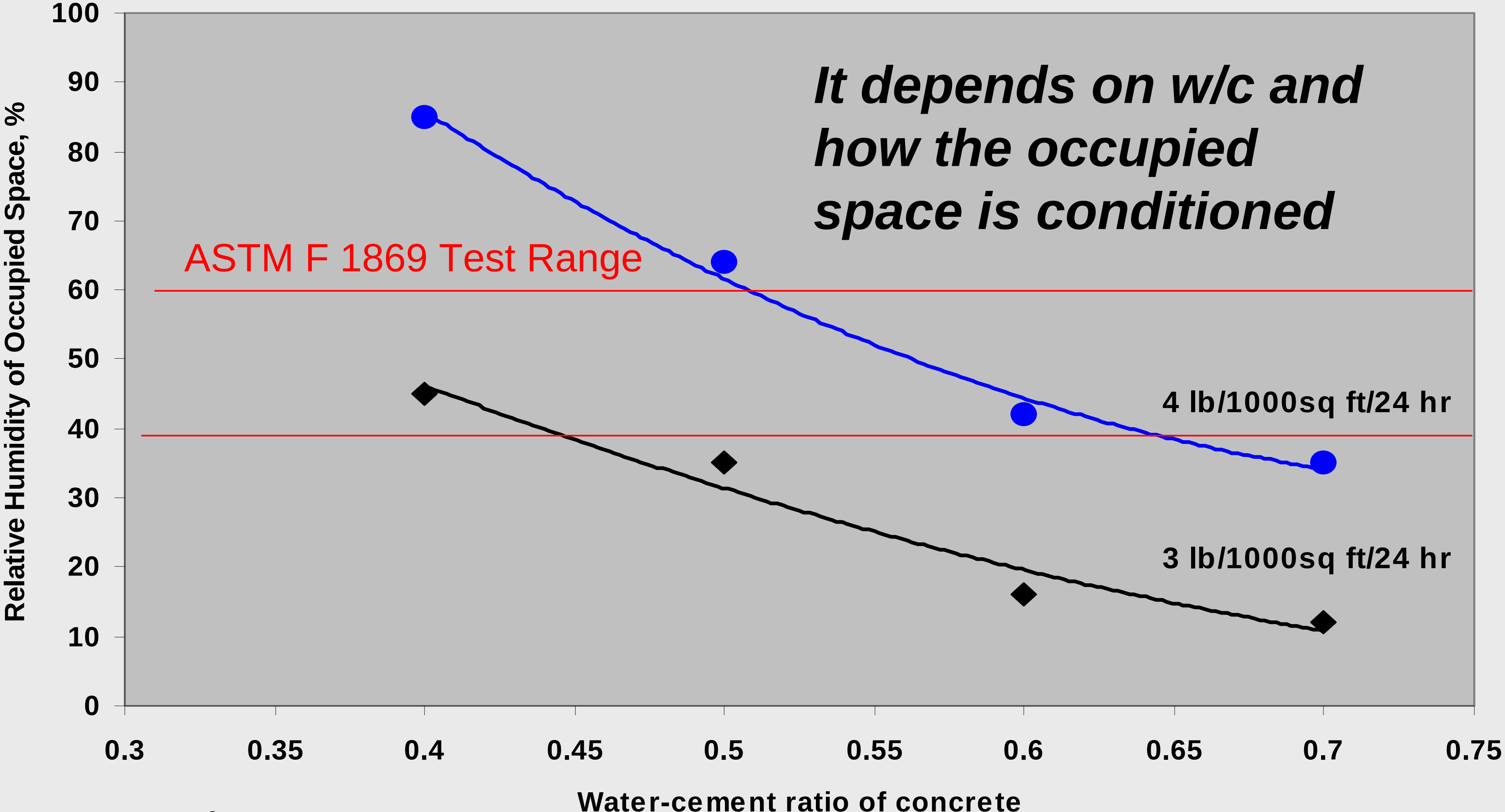


5. Reseal & Weigh

Building Conditions Affect MVER

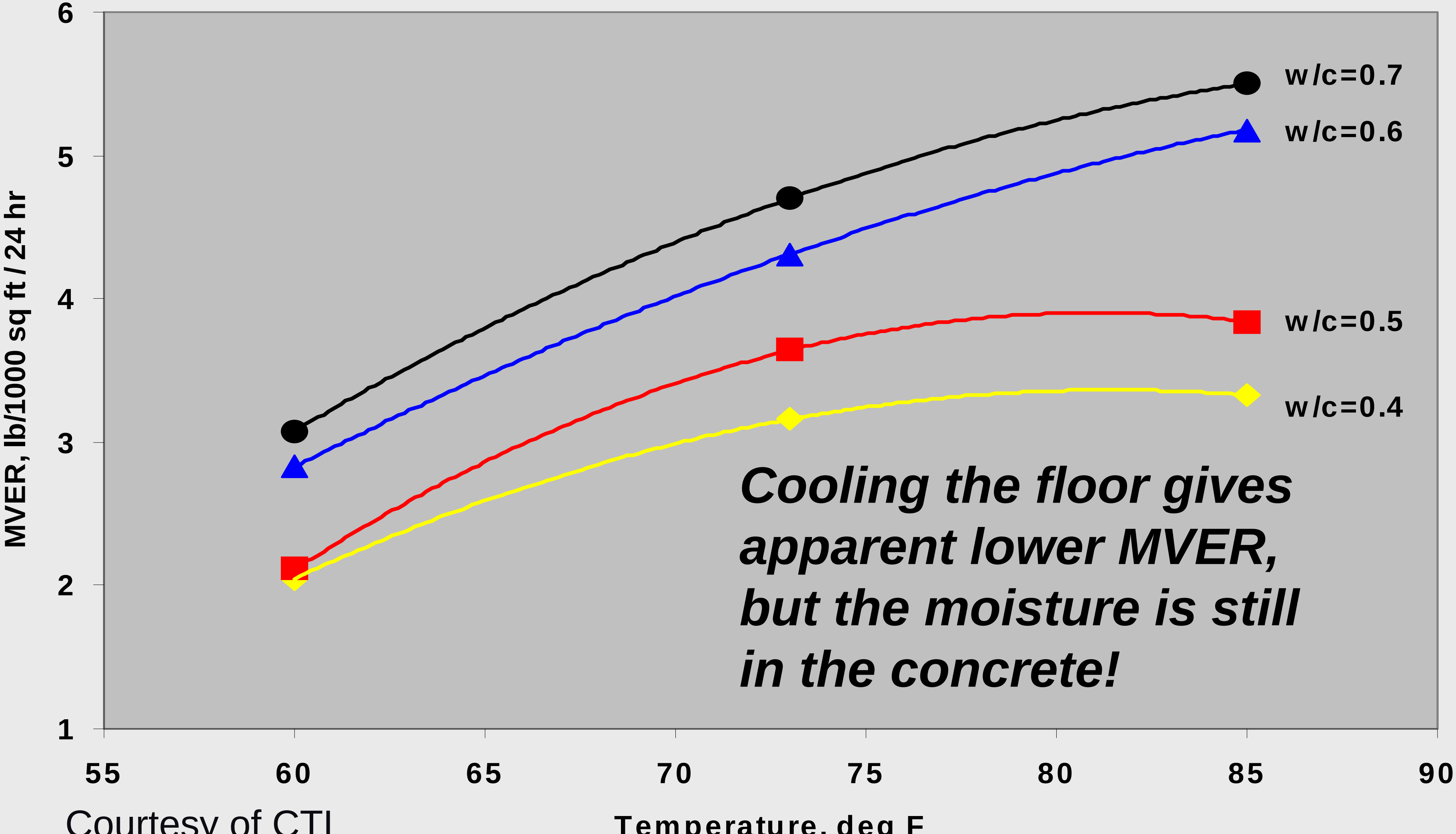
- Effect of ambient air temperature and RH
  - Higher RH & T = Higher Apparent MVER
- Effect of floor temperature
  - Higher T = Higher MVER
  - Lower T = Lower MVER
- Effect of sealers / curing compounds
  - Reduces MVER

Can We Achieve 3lb?



Courtesy of CTL

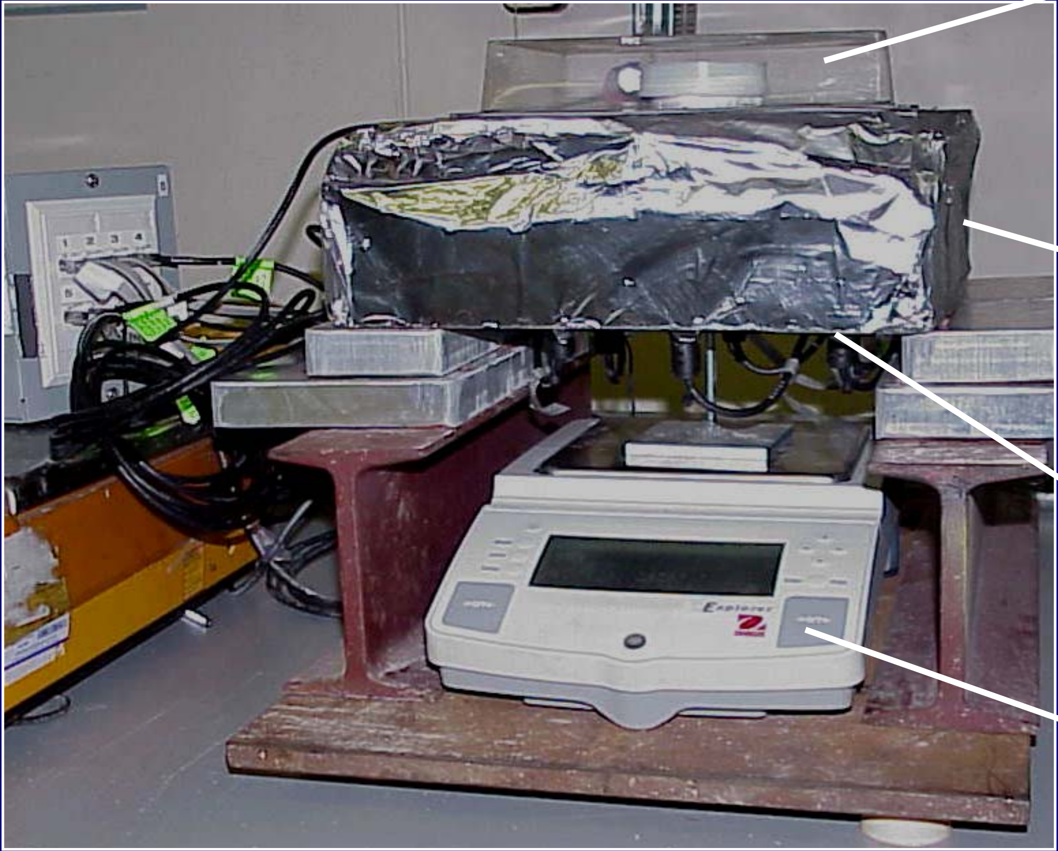
Effect of Air and Floor Temperature at 50% RH



Courtesy of CTL

What Moisture Does the Calcium Chloride Method Actually Measure ?

CTL MVER Uptake Study



$CaCl_2$ kit, dish on balance pan

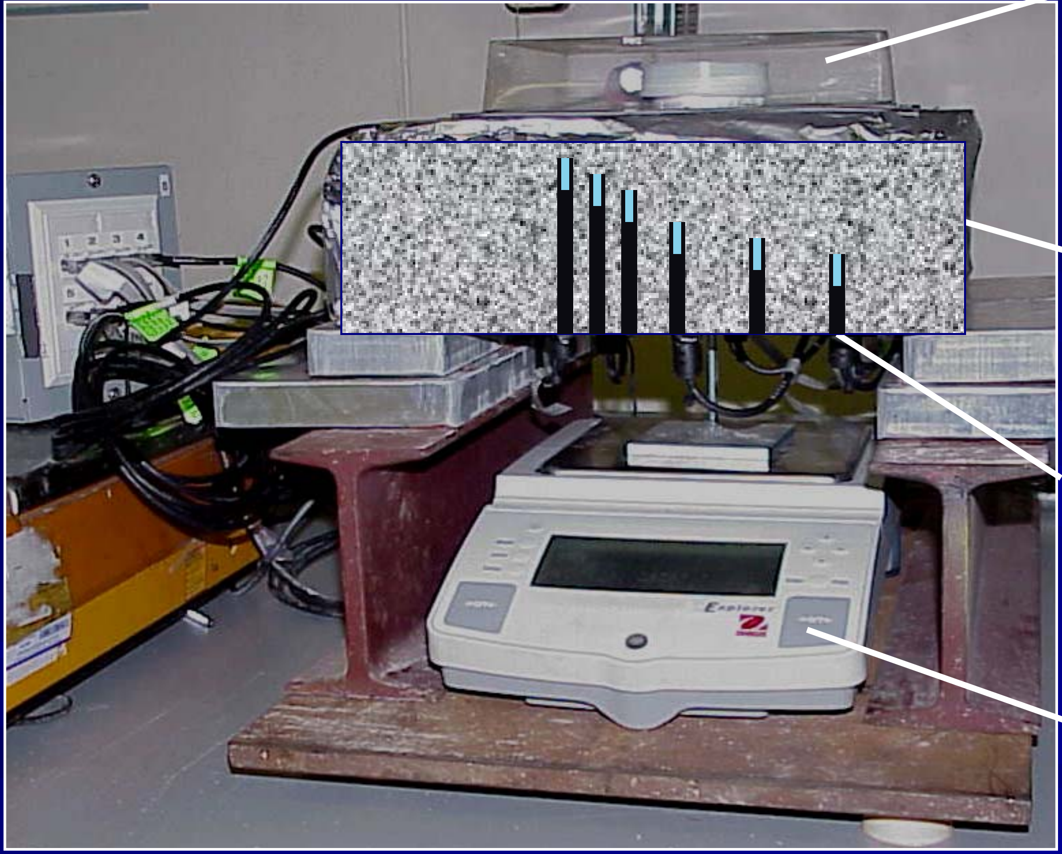
4-in concrete slab (0.4 w/c) with sealed surfaces

RH probes to datalogger

Balance weighs $CaCl_2$ dish

Courtesy of CTL

CTL MVER Uptake Study



$CaCl_2$ kit, dish on balance pan

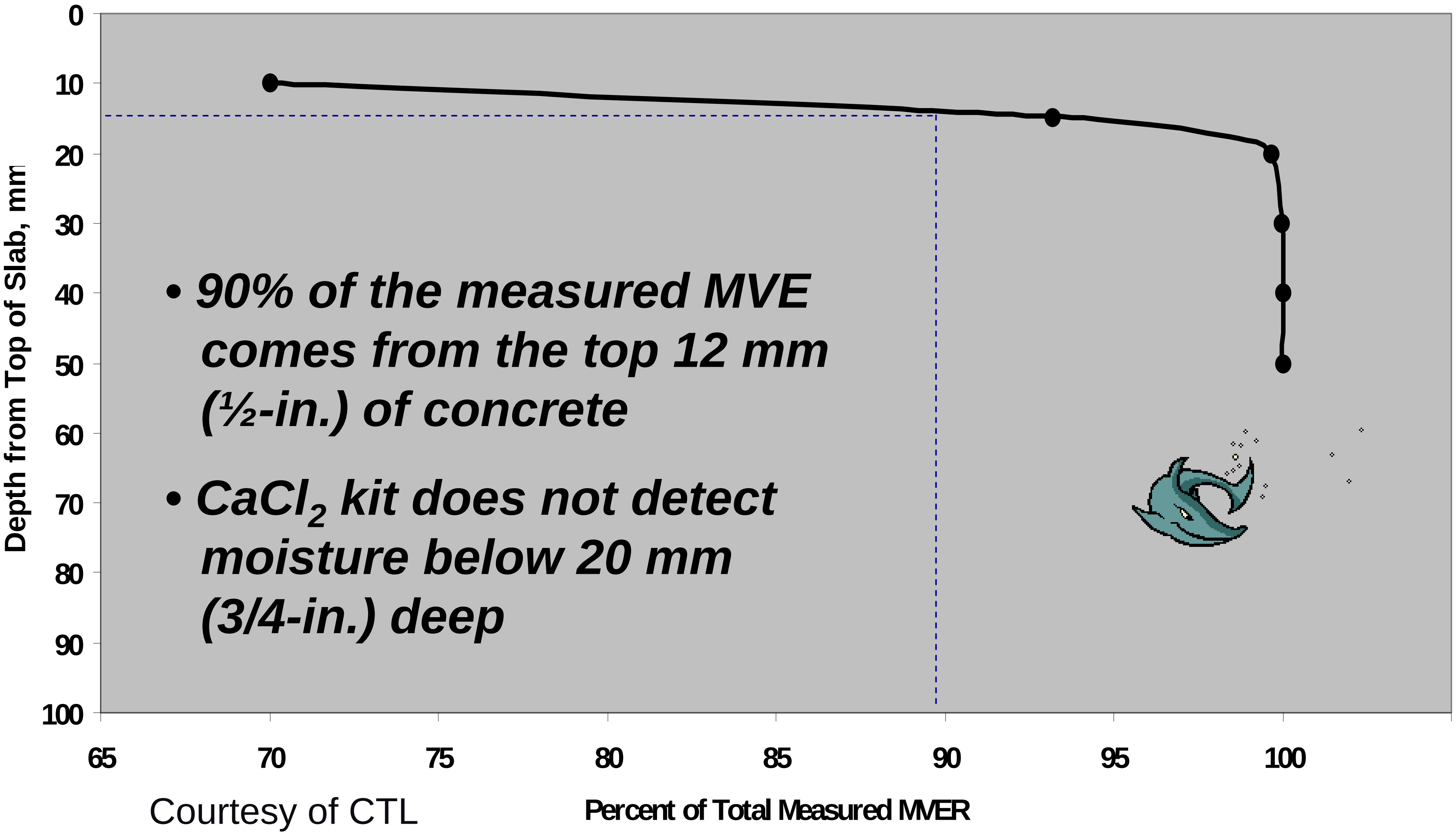
4-in concrete slab (0.4 w/c) with sealed surfaces

RH probes to datalogger

Balance weighs $CaCl_2$ dish

Courtesy of CTL

MVER Comes From How Deep?

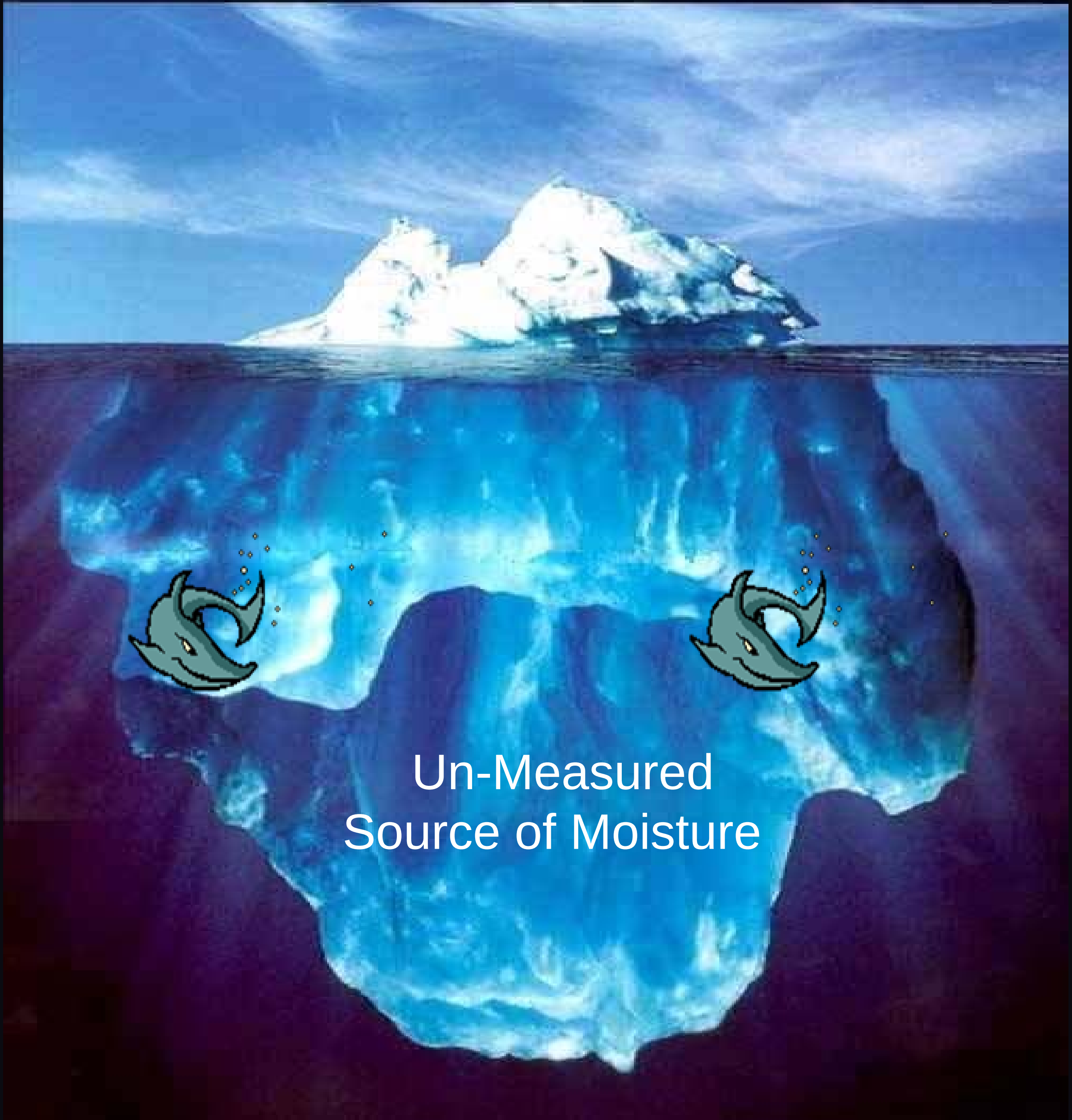


- ***90% of the measured MVE comes from the top 12 mm (½-in.) of concrete***
- ***$CaCl_2$ kit does not detect moisture below 20 mm (3/4-in.) deep***

Courtesy of CTL

Calcium Chloride Testing is an indicator of moisture in the top ½” to ¾” of the concrete only …..

Properly conducted, the test does provide useful information, however the results do not tell the whole story……


Un-Measured
Source of Moisture

Fact

If the only piece of information one has is a calcium chloride MVER, it is insufficient information upon which to base an installation decision upon.

How can MVER Testing be Improved ?

Un-Vented MVER Testing …

Perform MVER testing in an unvented manner where the test sites are prepared and then covered for at least a two week period prior to conducting the MVER tests.

PVC Backed Carpet tile over Poly

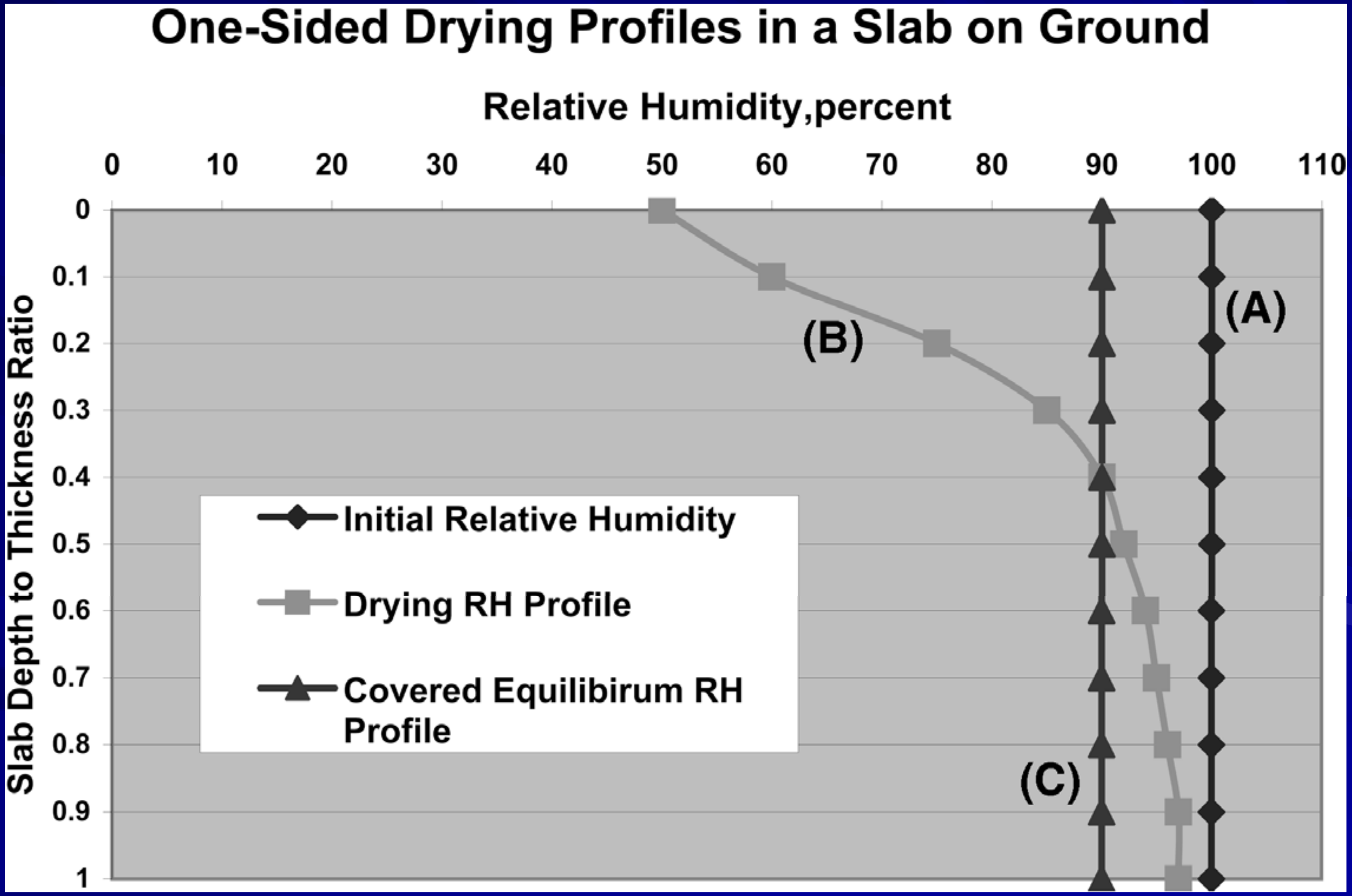
Aluminum foil

How else should we measure moisture ?

Concrete Internal Relative Humidity

ASTM F 2170

Slabs Drying from One Face Only - Measure at 40% of Slab Thickness



Relative Humidity Testing

1. Drill Hole

2. Vacuum

3. Insert Liner

4. Insert Probe

5. Take Reading

Interpretation of Results

- USA Standard

Test Method: ASTM F 2170

Requirements: - ASTM F 710

< 75% after 72 hours at 40% slab depth.

But Remember !

Interpretation of Results

- USA Standard

Test Method: ASTM F 2170

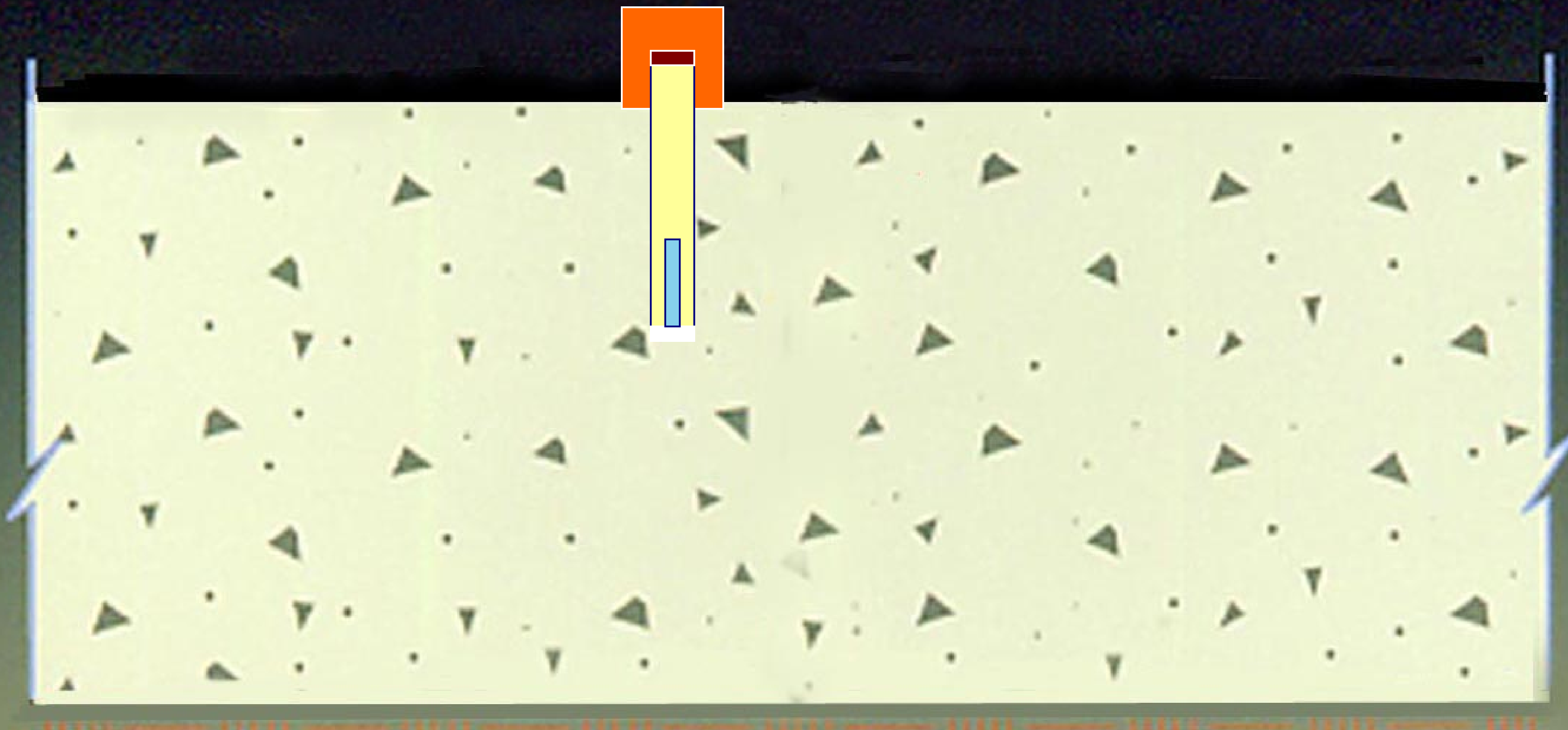
Requirements: - ASTM F 710

< 75% after 72 hours at 40% slab depth.

Without an effective vapor retarder directly beneath the slab, moisture within the slab will increase above the tested level once the flooring is installed.

Internal Concrete Humidity Test ASTM F 2170

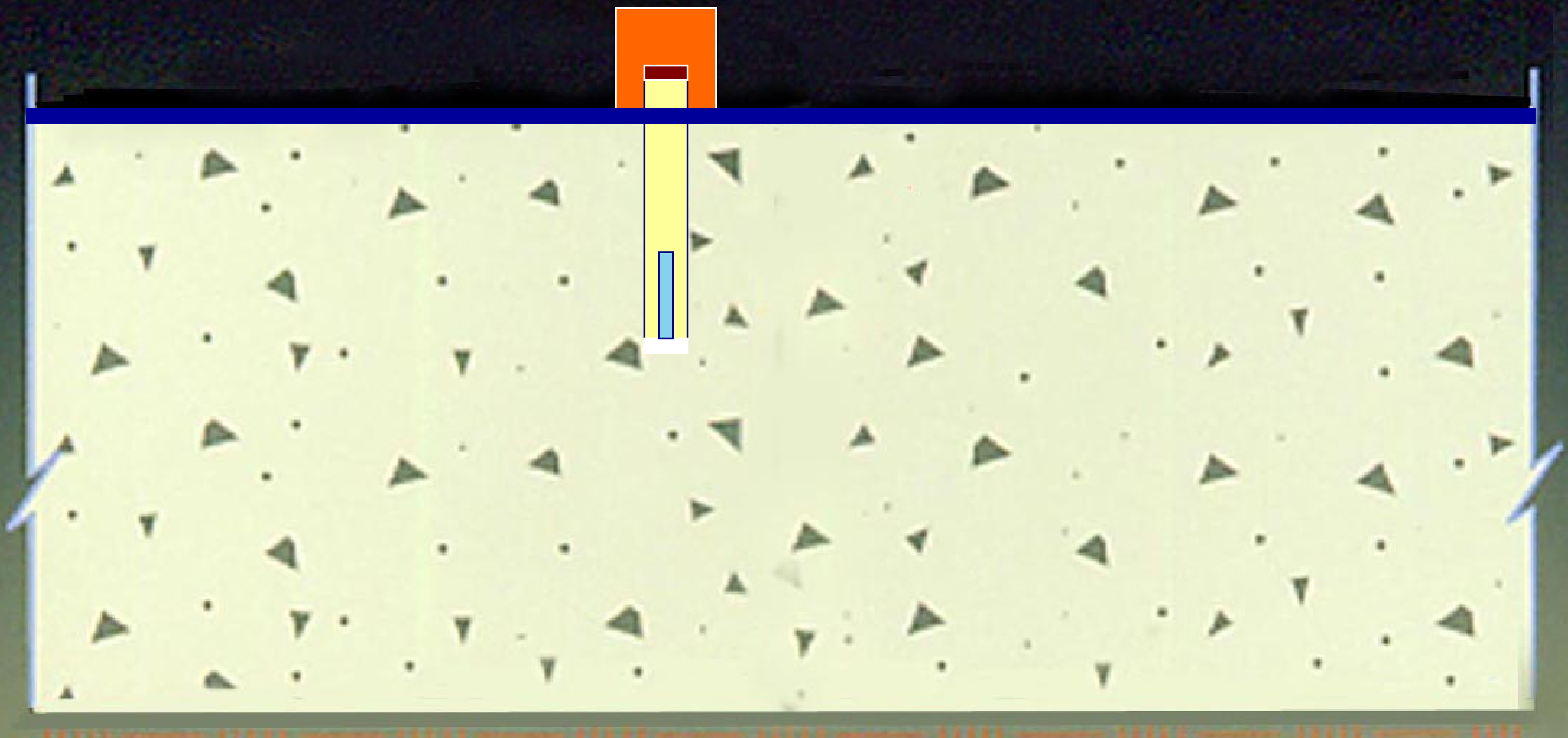
Target < 75 % RH



No Vapor Retarder or Inadequate Level of Protection

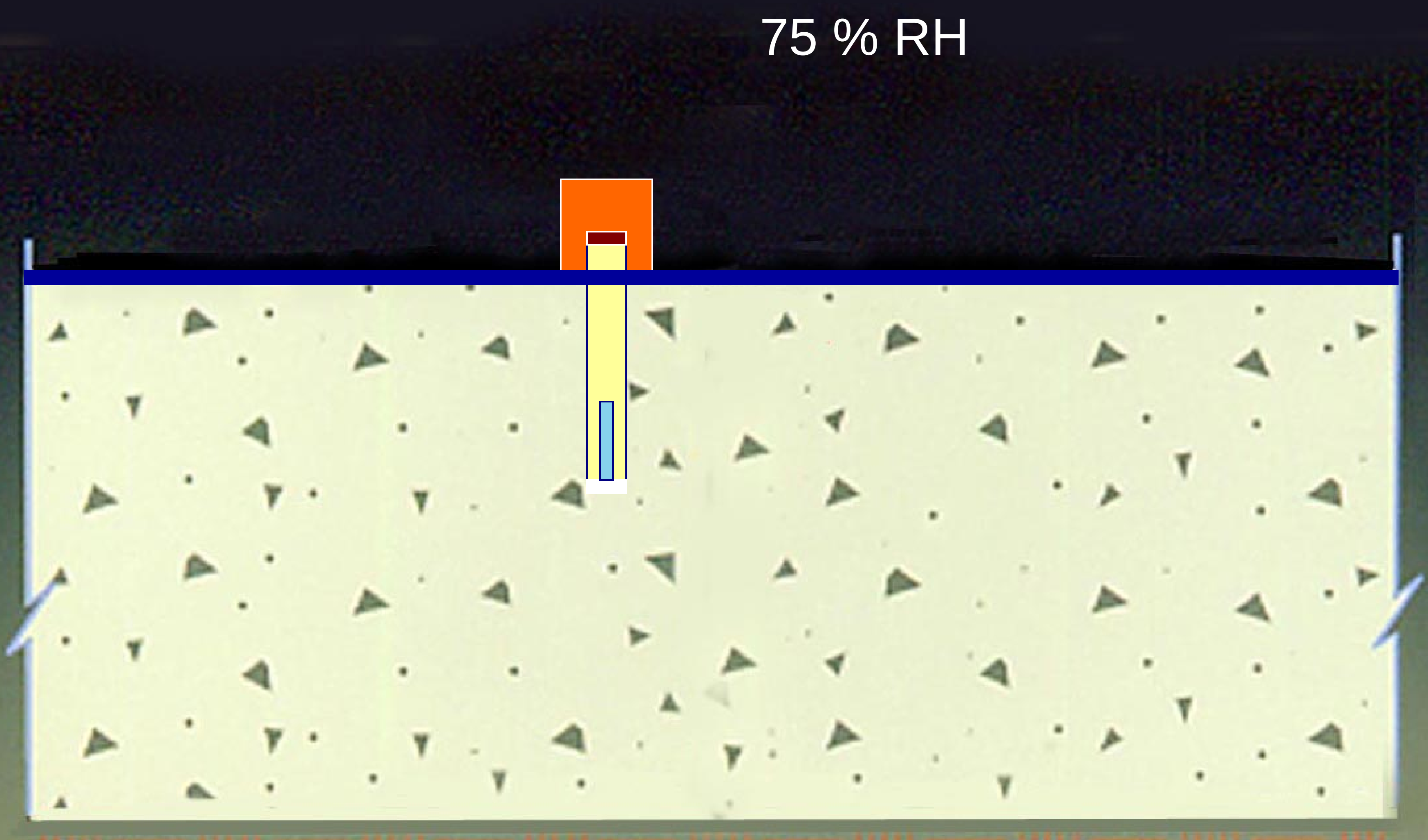
Internal Concrete Humidity Test ASTM F 2170

Flooring Applied



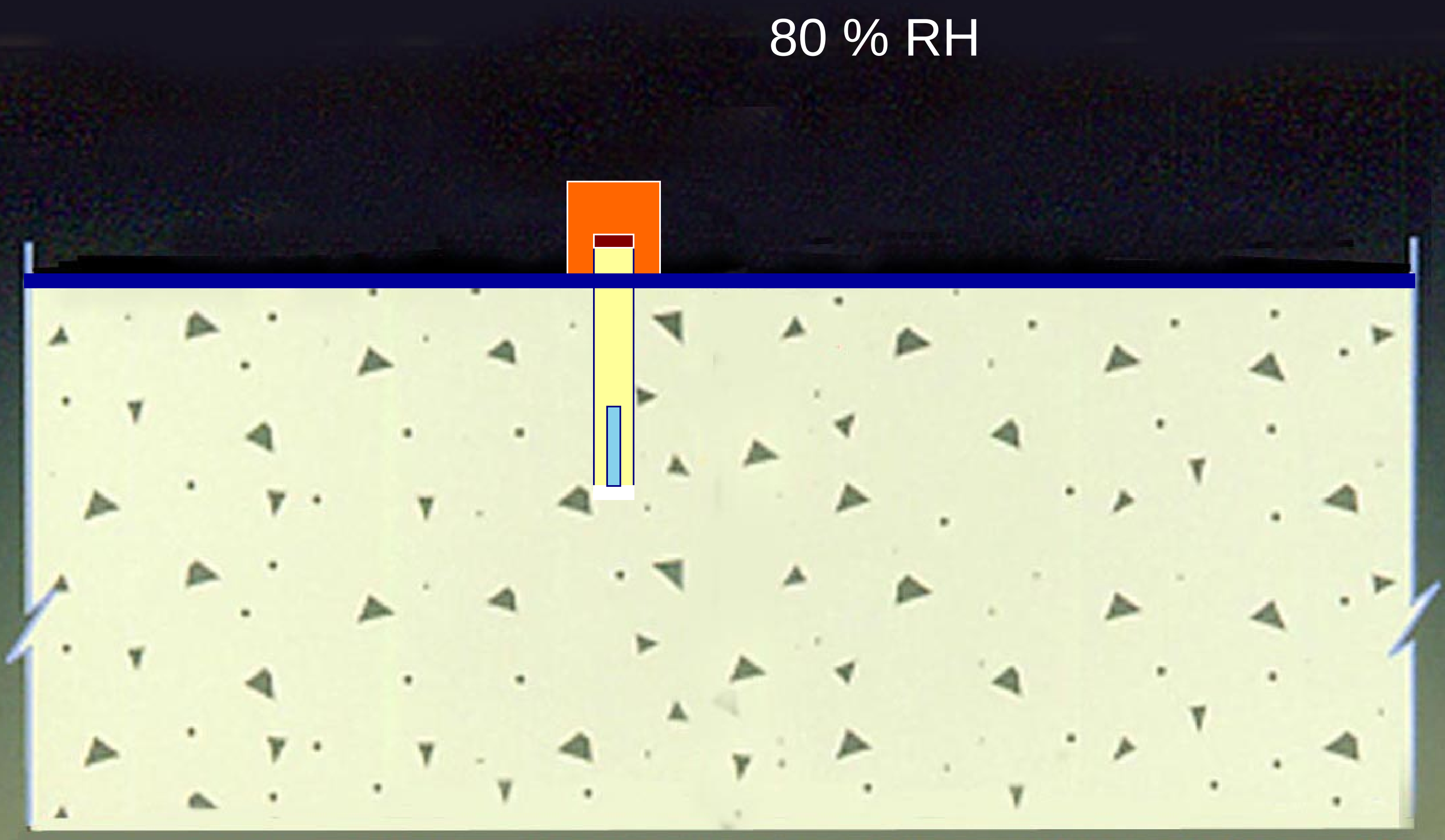
No Vapor Retarder or Inadequate Level of Protection

Internal Concrete Humidity Test ASTM F 2170



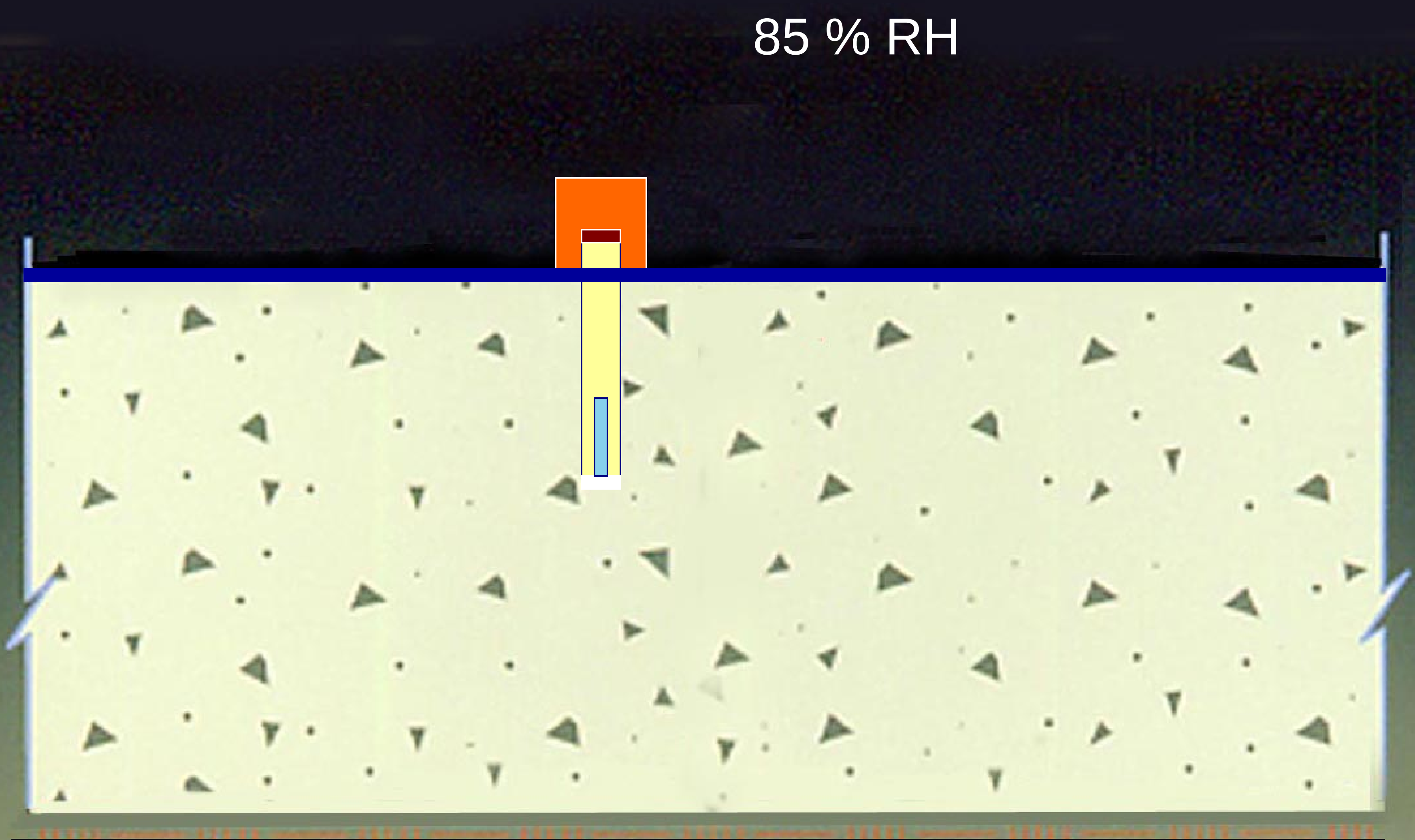
No Vapor Retarder or Inadequate Level of Protection

Internal Concrete Humidity Test ASTM F 2170



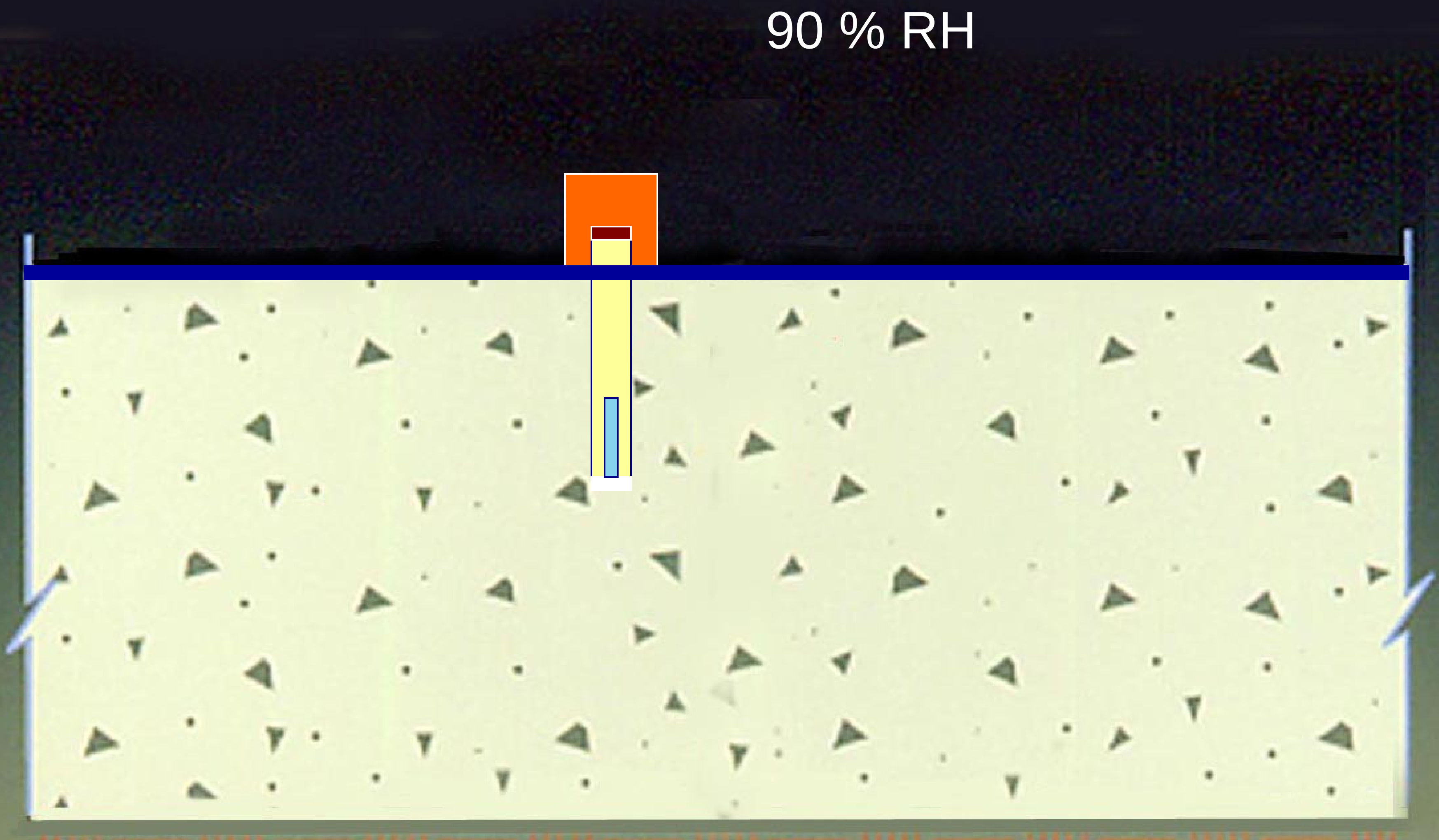
No Vapor Retarder or Inadequate Level of Protection

Internal Concrete Humidity Test ASTM F 2170



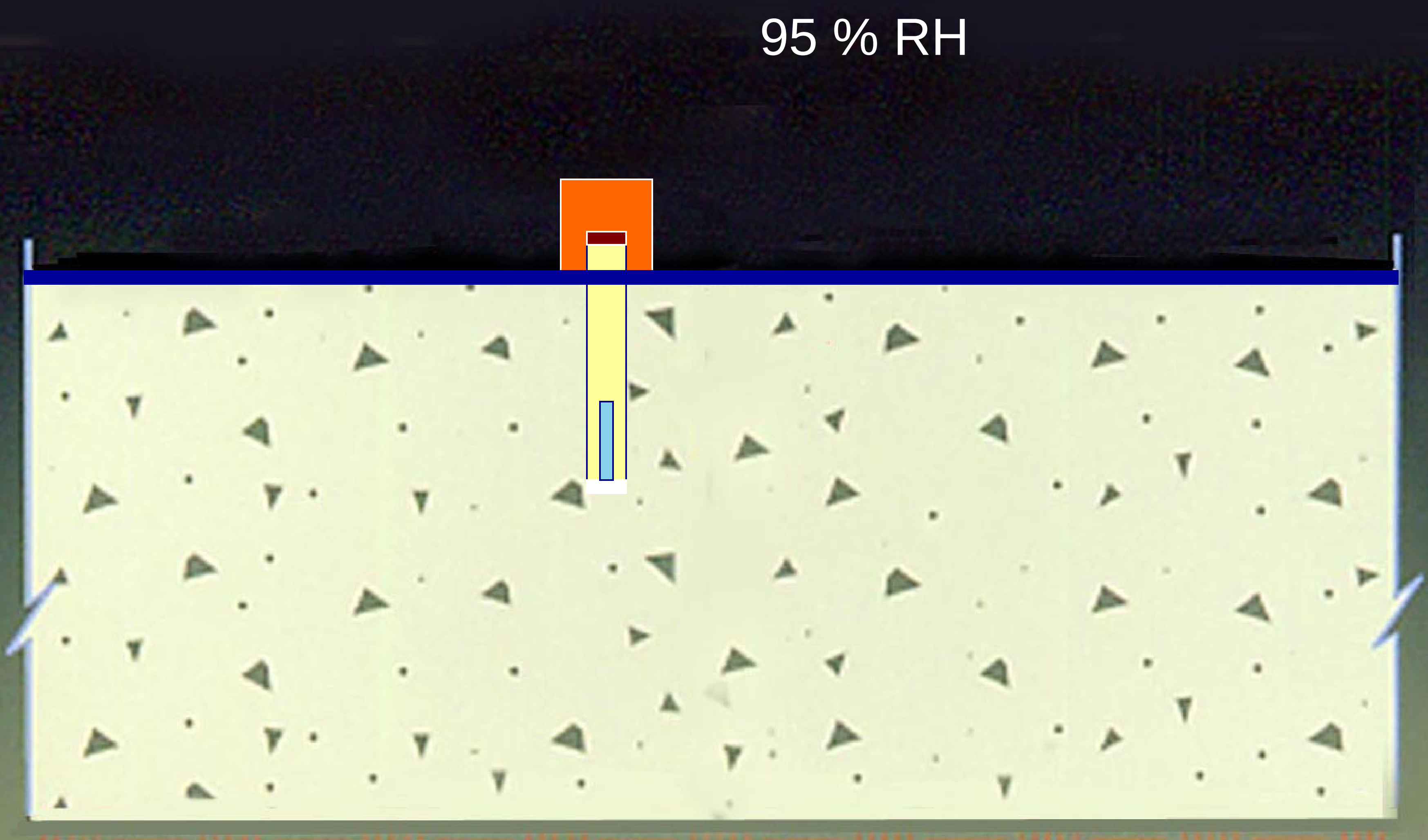
No Vapor Retarder or Inadequate Level of Protection

Internal Concrete Humidity Test ASTM F 2170



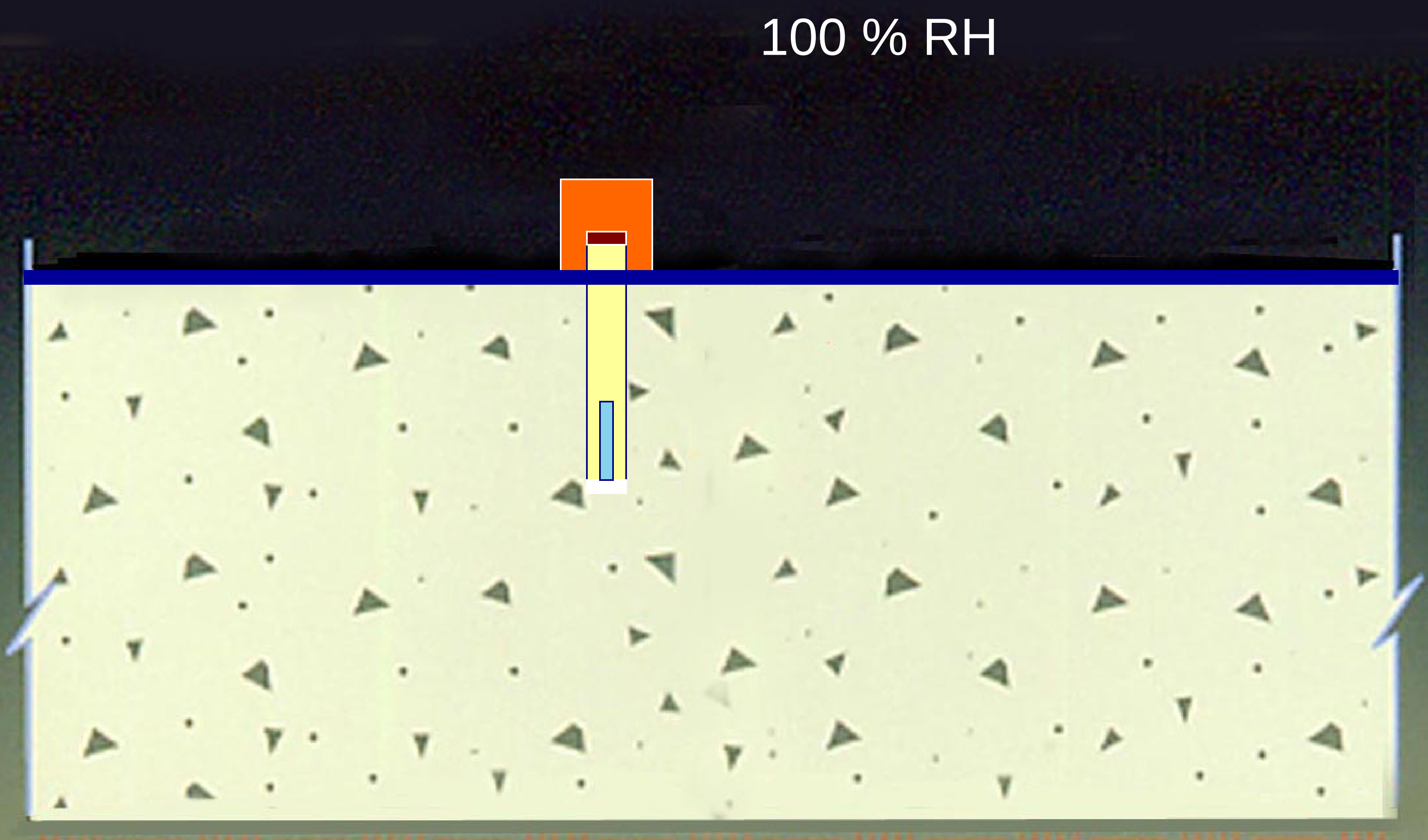
No Vapor Retarder or Inadequate Level of Protection

Internal Concrete Humidity Test ASTM F 2170



No Vapor Retarder or Inadequate Level of Protection

Internal Concrete Humidity Test ASTM F 2170



No Vapor Retarder or Inadequate Level of Protection


100.0

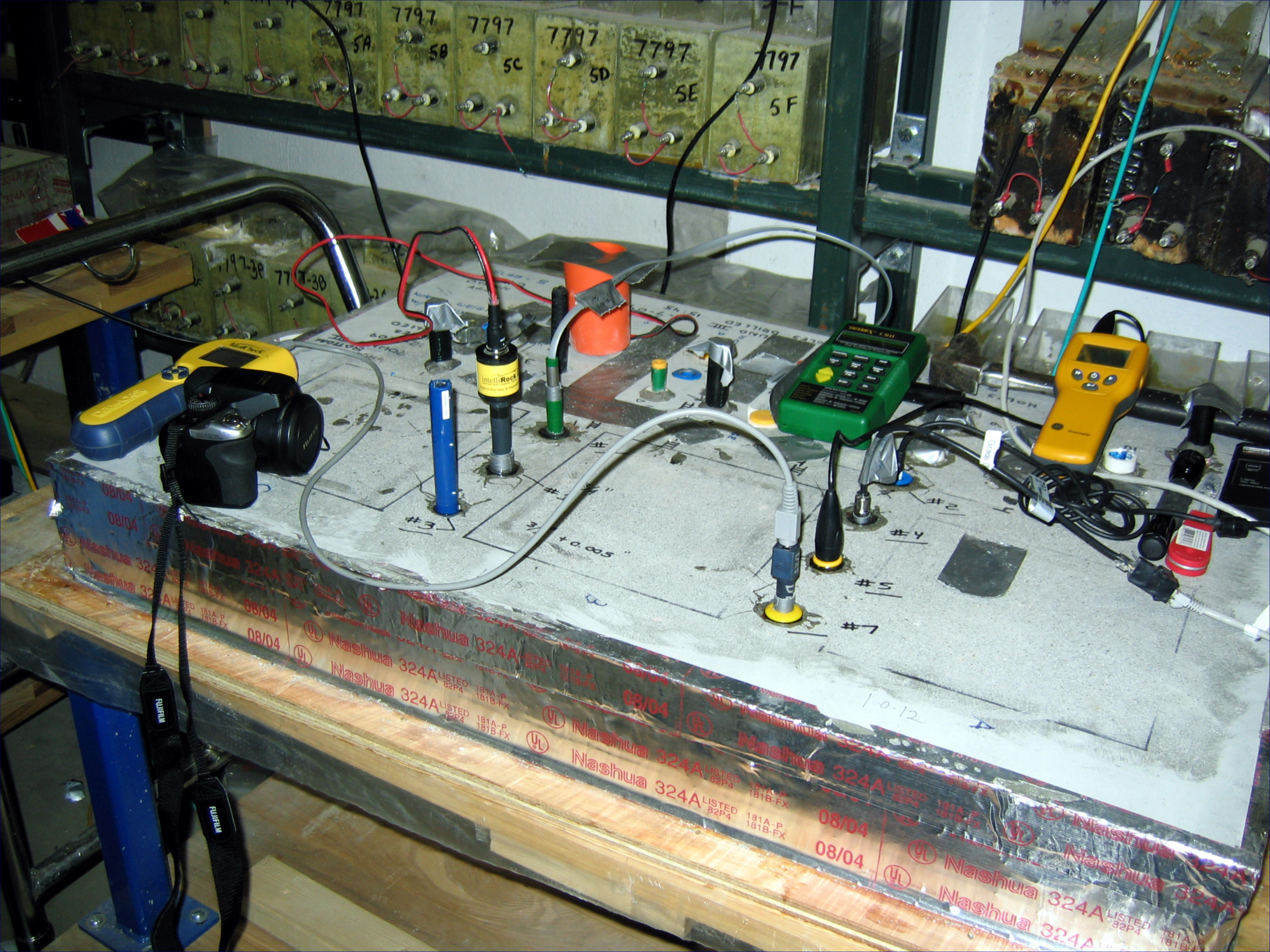
In-Situ Concrete RH Equipment Study

Test Series III

Location: W.R. Grace Labs – Cambridge, Massachusetts

Test Objectives

To determine what factor or factors are contributing to the significant disparity in in-situ concrete internal RH measurements between equipment manufacturers.

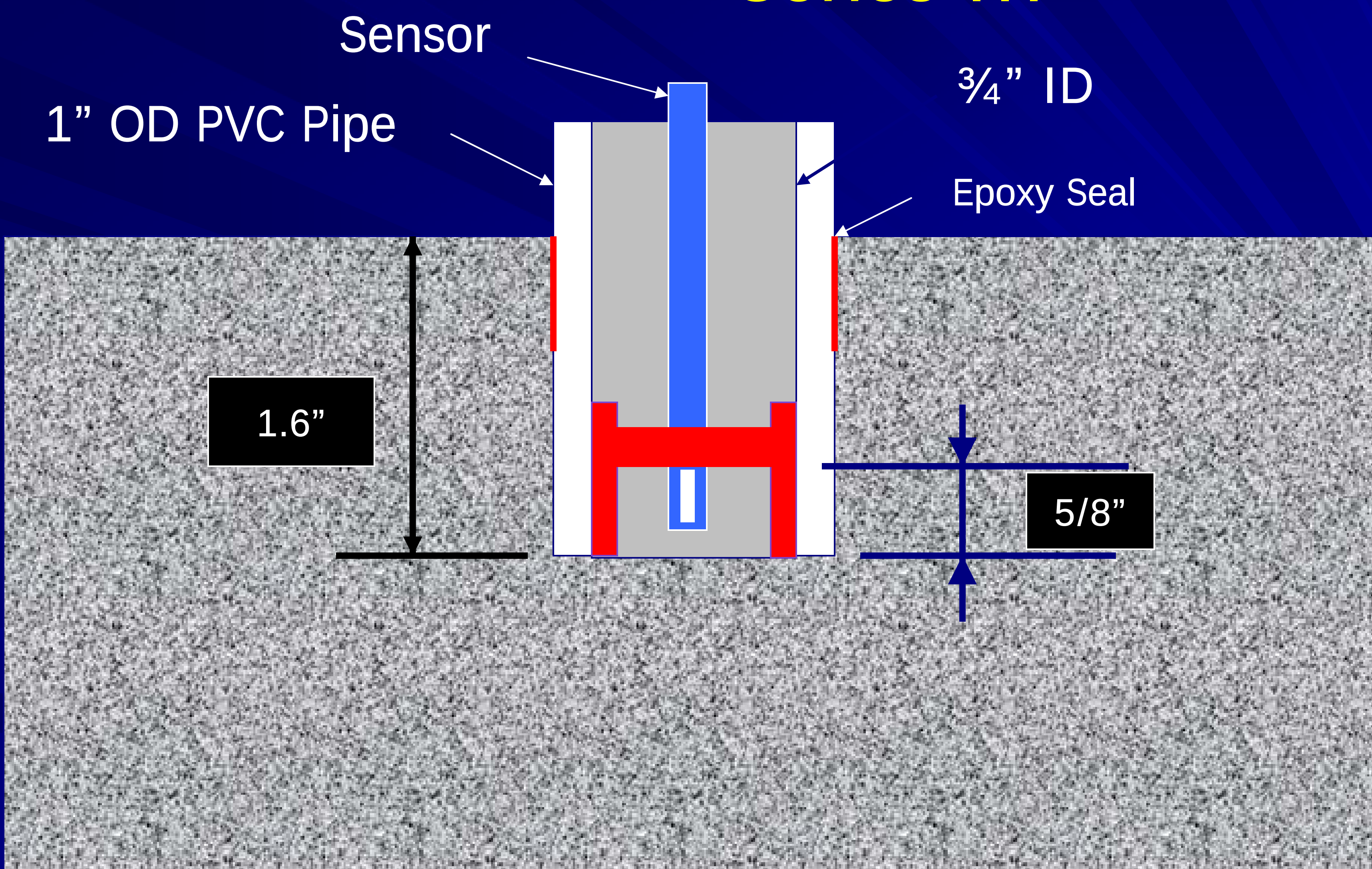

7797
5A
5B
5C
5D
5E
5F
intelliRock
#3
#2
#4
#5
#7
+0.005"
Nashua 324A
LISTED
08/04
FUJIFILM

Test Series III

Universal Hole Liner – Universal Sleeve

Universal Hole Liner – Universal Sleeve / Volume Test

Series III



Universal Hole Liner Test

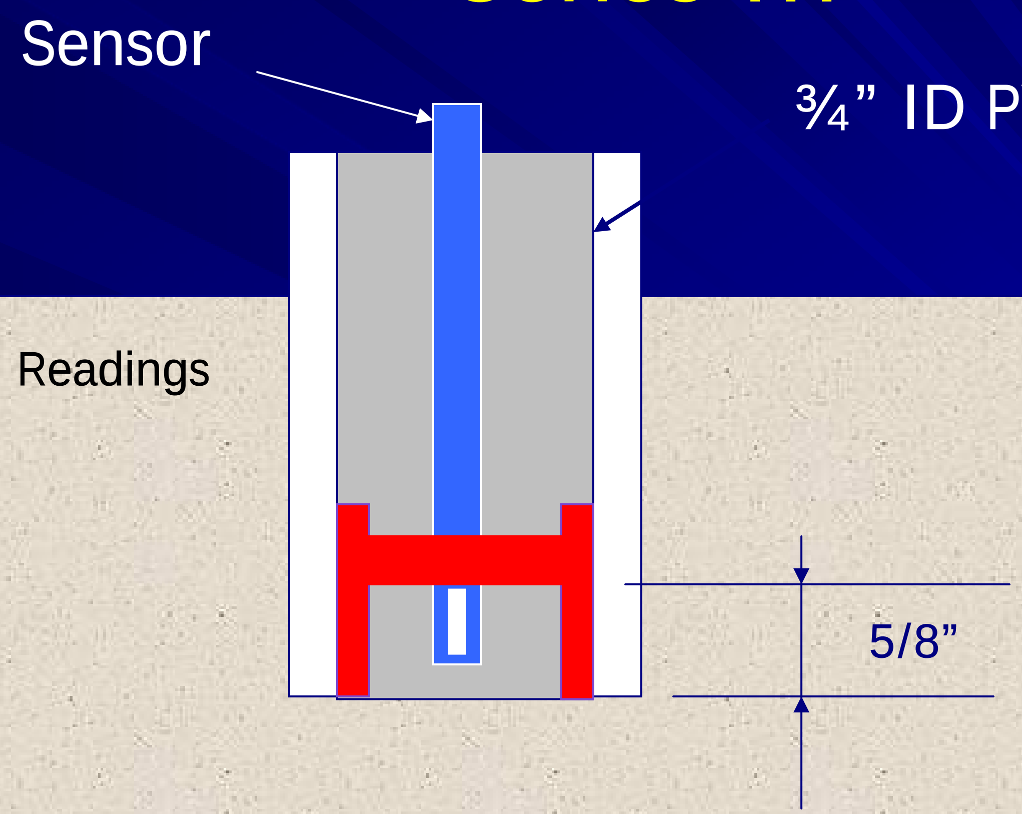
Equipment Calibration

SGH RH Probe Test Chamber
Potasium Sulfate – Approx. 98% RH

Test Results

Universal Hole Liner – Universal Position / Volume Test

Series III

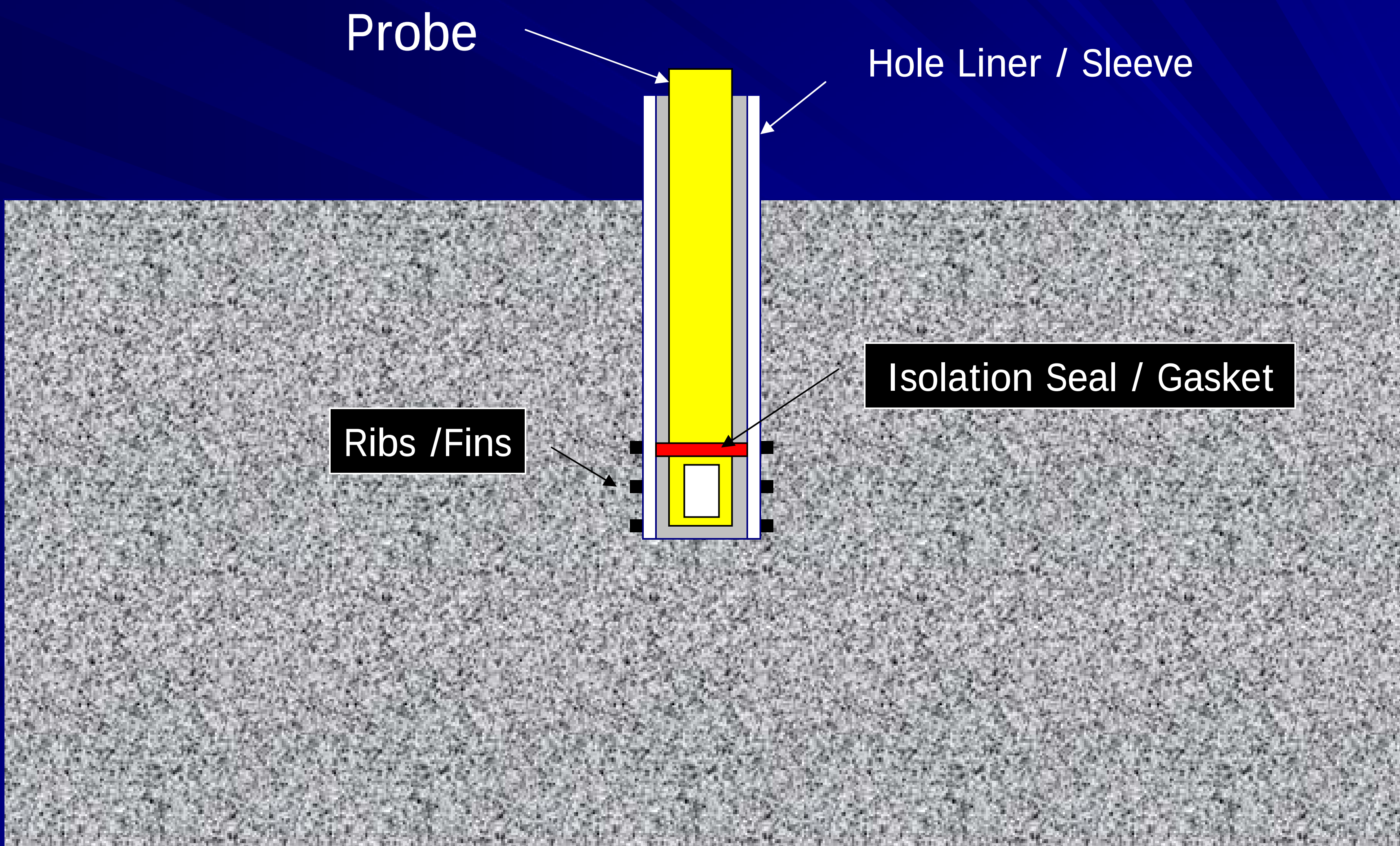


72 Hour Edited Readings

1. 85 %
2. 72 % *
3. 83 %
4. 84 %
5. 82 %
6. 83 %
7. 82 %

* Test directly over coarse aggregate particle

Concept Drawing

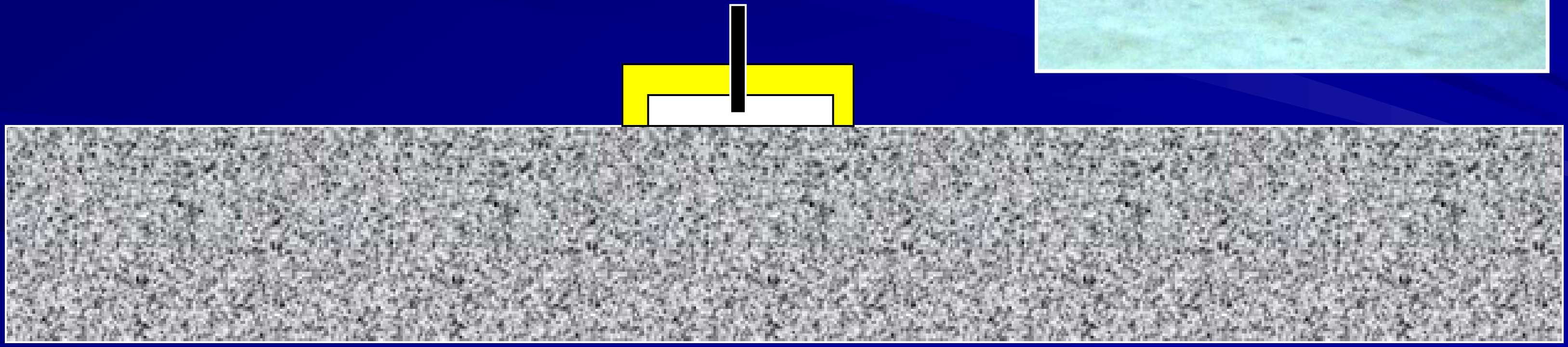


MVER and RH Complementary

- **MVER = moisture near the slab surface**
- **%RH = Moisture level within the slab**

Surface Relative Humidity Test (Hood Method)

ASTM F 2420



SUMMARY

To Avoid Flooring Failures

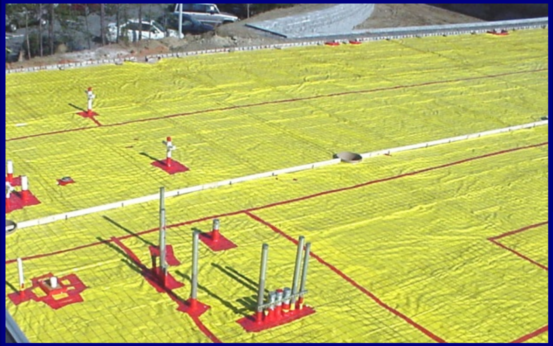
Start From The Ground Up

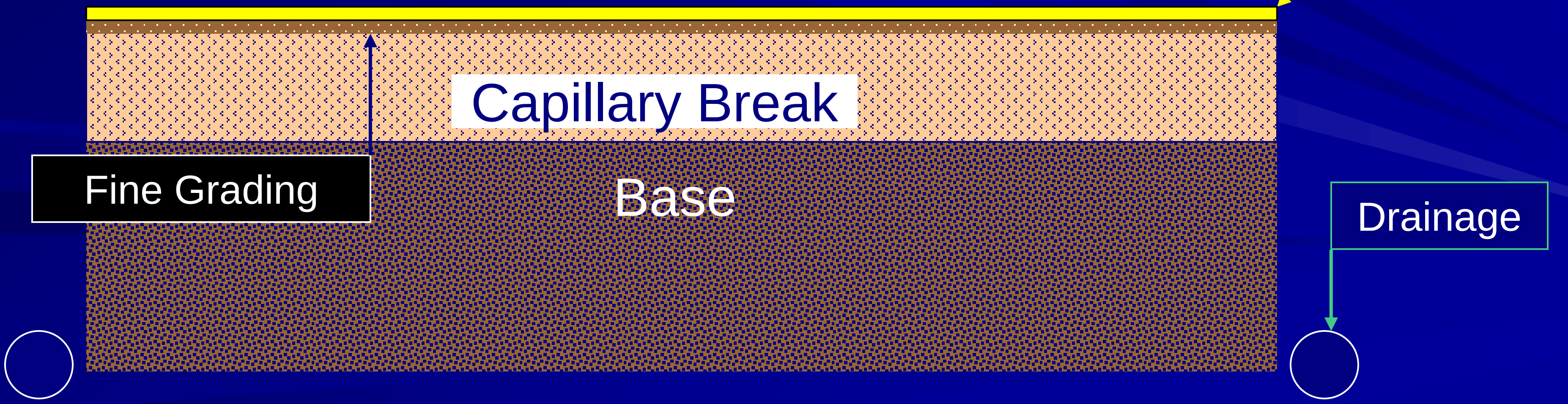
Clear Project Specifications are the Starting Point

Common Sense Helps

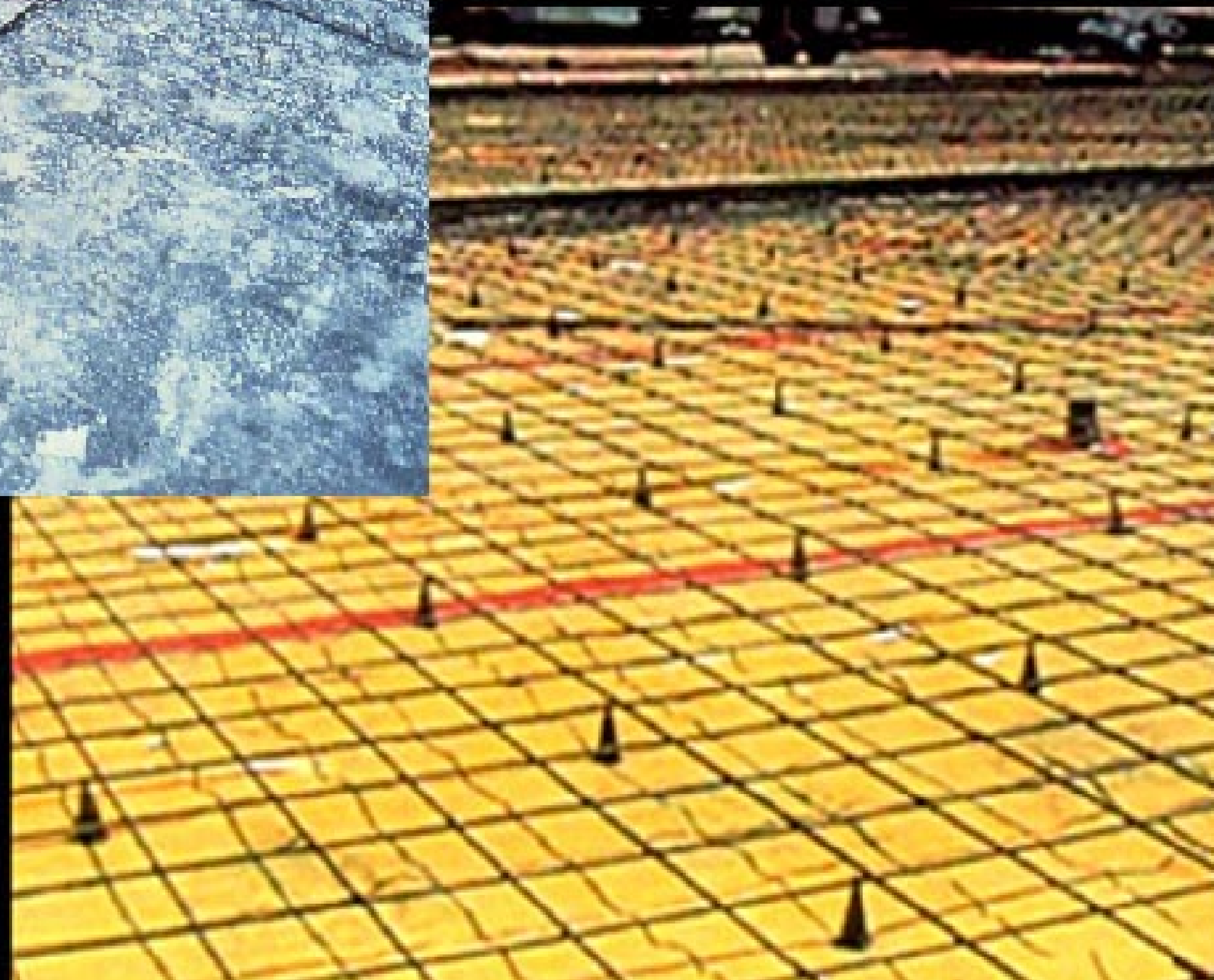
Steps … to Avoid Flooring Failures:

1. Geotechnical & Design Considerations





Take the ground out of play!



Emphasis on

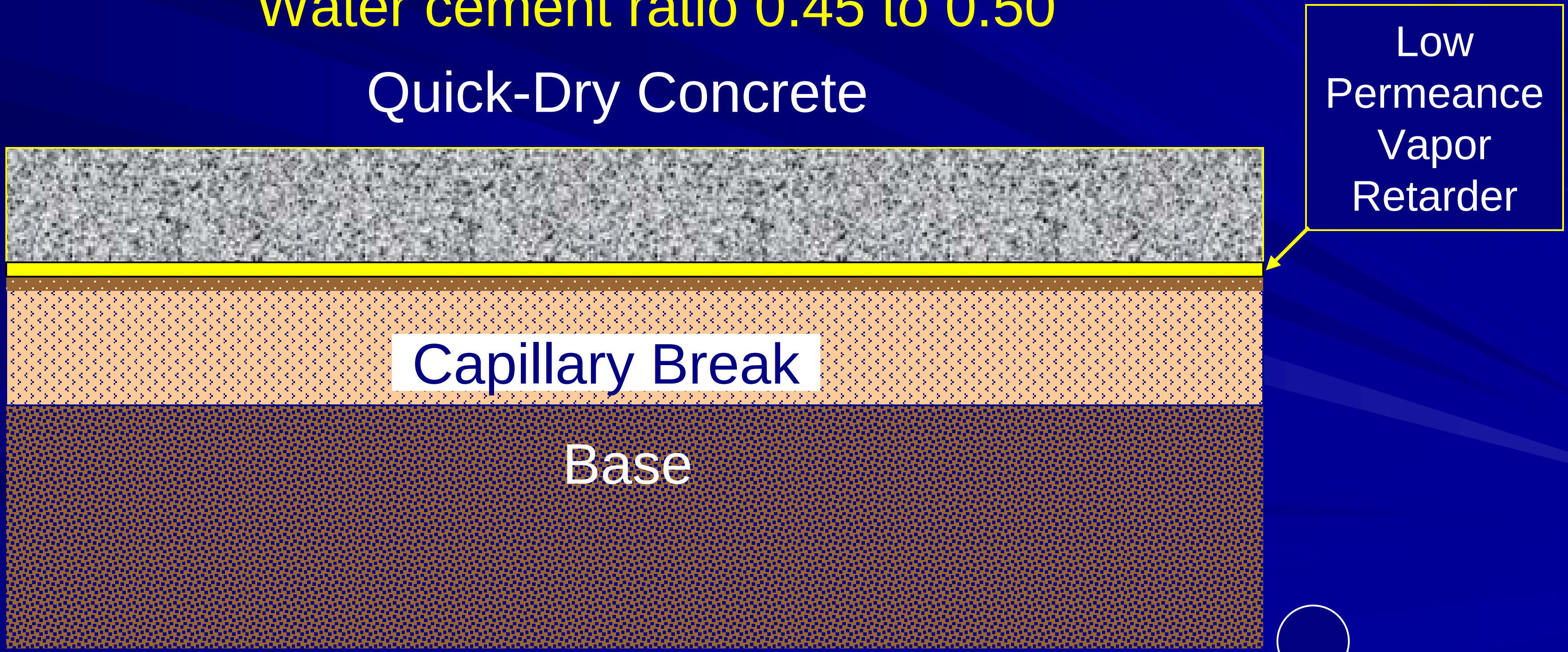
Low Permeance

Steps … to Avoid Flooring Failures:

2. Concrete Considerations

Water cement ratio 0.45 to 0.50

Quick-Dry Concrete



Quick-Dry (self-desiccating) Concrete

Advantages:

- Provides concrete that will reach an acceptable dryness in 30 days
- Places and finishes similar to conventional concrete


Central
1635
CENTRAL
635


SOMERO
LASERSCREED
IN LEVELING
CENTRAL

Quick-Dry (self-desiccating) Concrete

Advantages:

- Provides concrete that will reach an acceptable dryness in 30 days
- Places and finishes similar to conventional concrete
- Reduces drying shrinkage and curling

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- Overcomes slab re-wetting issues

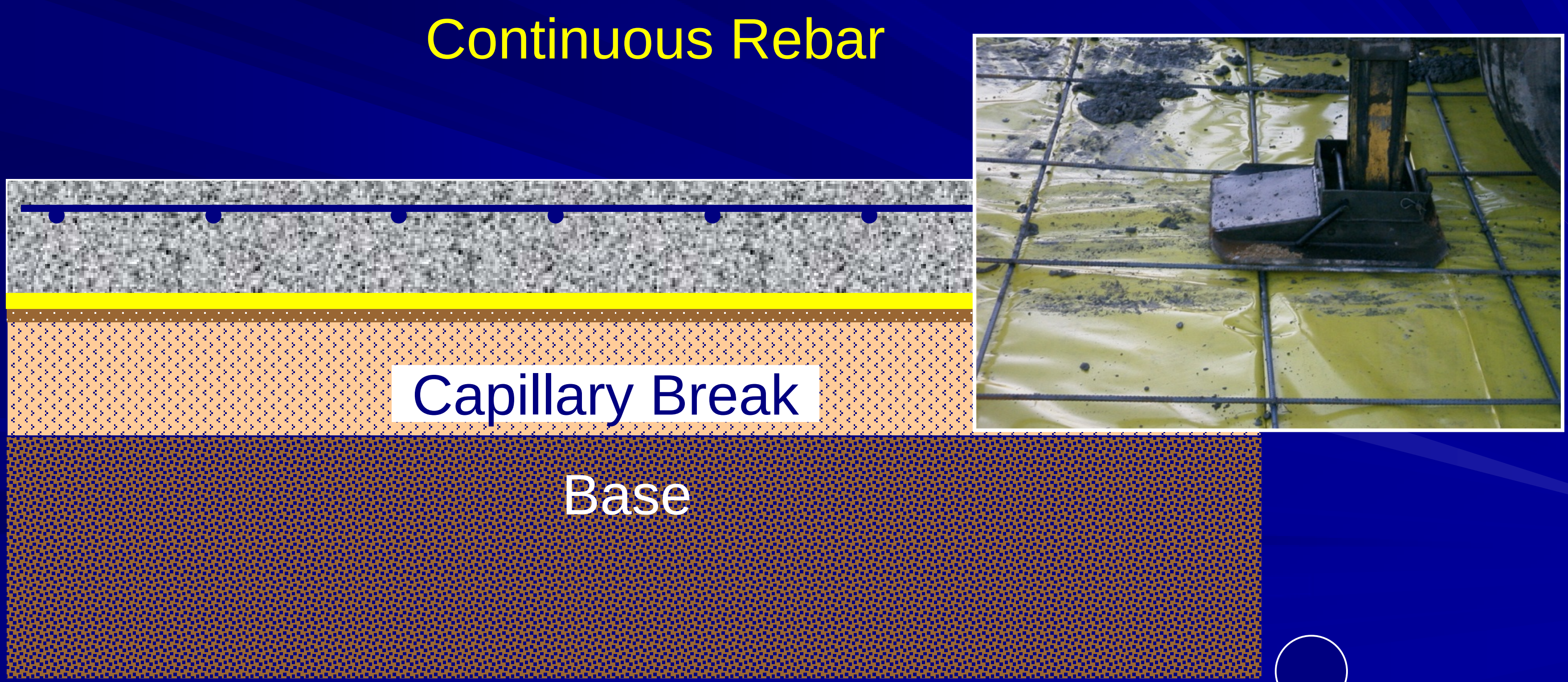
Quick-Dry (self-desiccating) Concrete

Advantages:

- Provides concrete that will reach an acceptable dryness in 30 days
- Places and finishes similar to conventional concrete
- Reduces drying shrinkage and curling
- Overcome slab re-wetting issues
- Cost effective

Steps … to Avoid Flooring Failures:

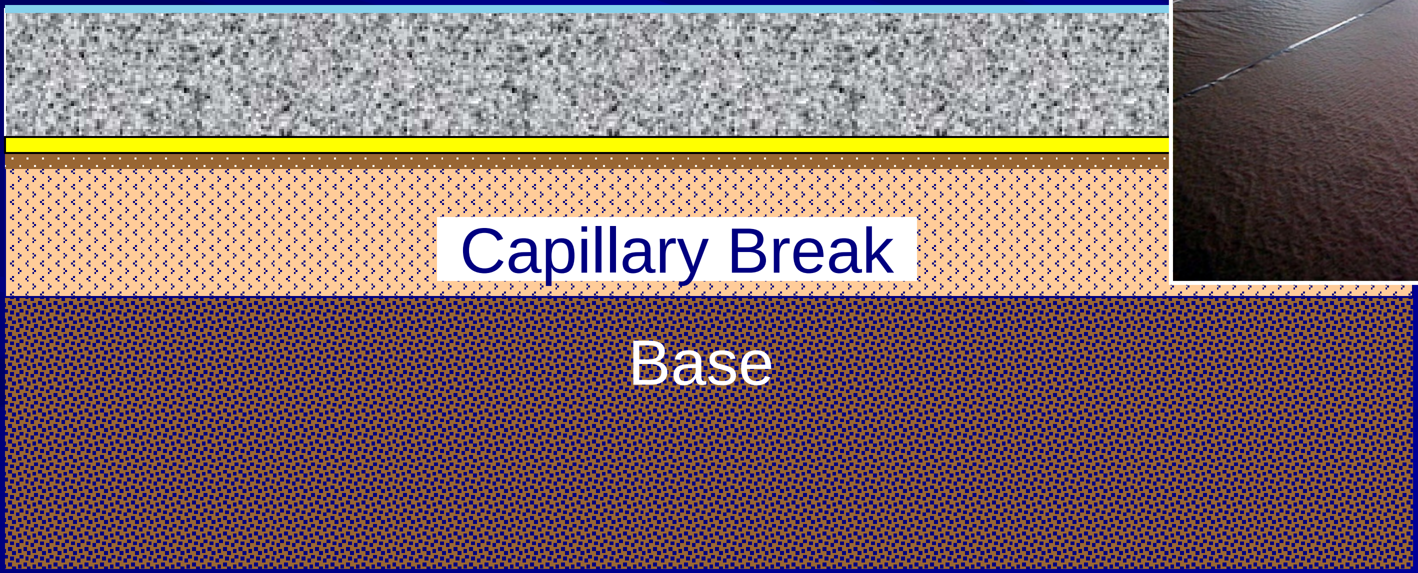
2. Concrete Considerations



Steps … to Avoid Flooring Failures:

2. Concrete Considerations

Moisture Retaining Cover Cure

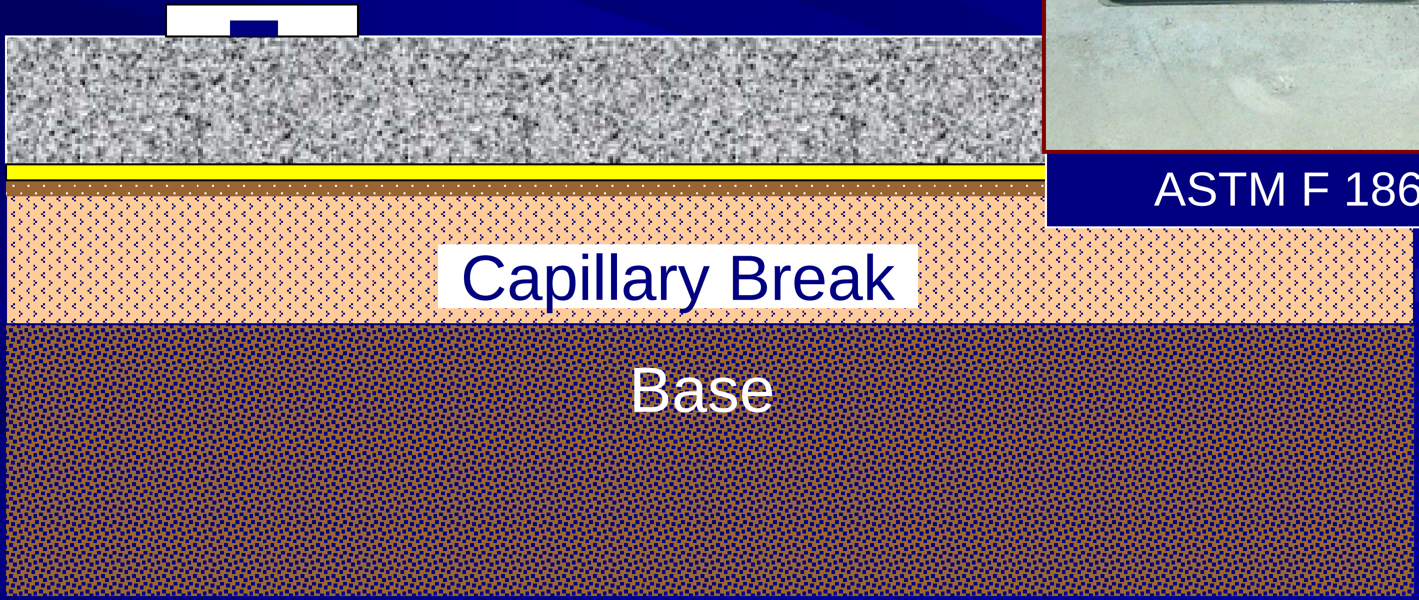


Steps … to Avoid Flooring Failures:

3. Proper Testing

Moisture Vapor Emission Rate Testing (MVER)

ASTM F 1869

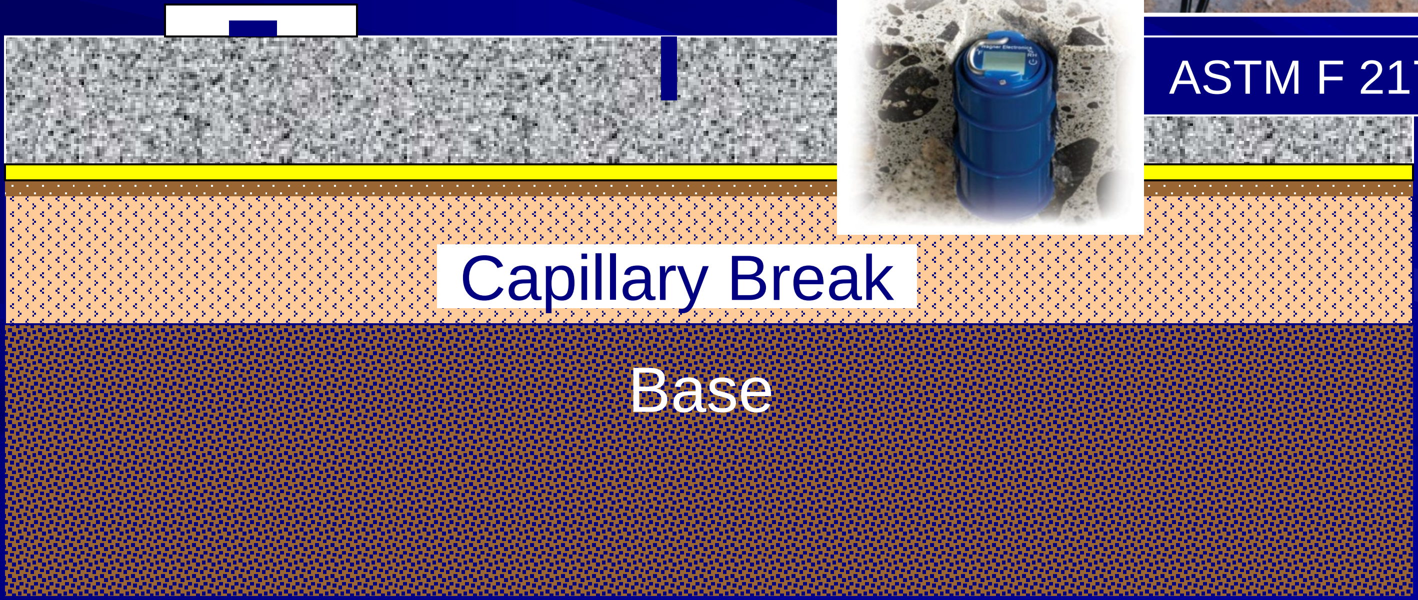


Steps … to Avoid Flooring Failures:

3. Proper Testing

MVER

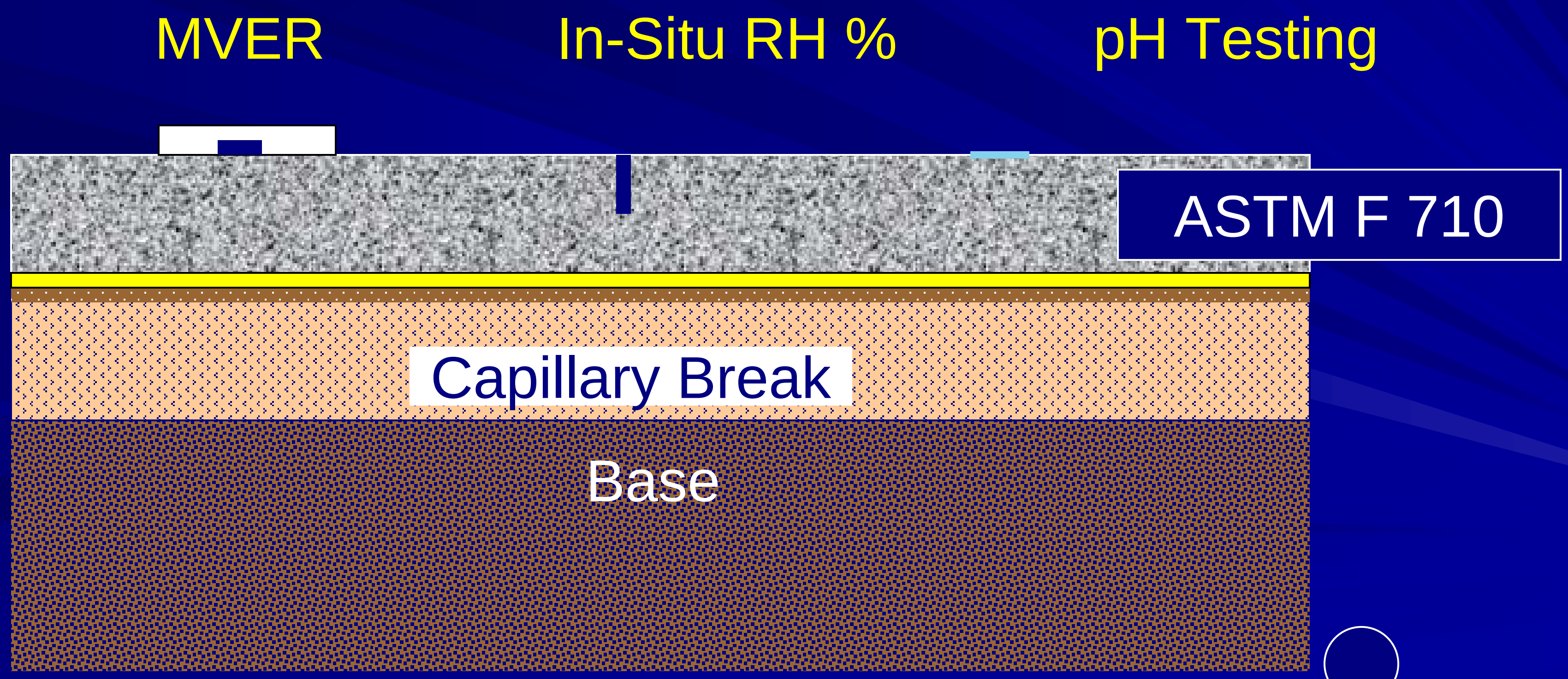
In-Situ RH %



ASTM F 2170

Steps … to Avoid Flooring Failures:

3. Proper Testing



Test both the Moisture Vapor Emission Rate (MVER) & the Internal Relative Humidity of the Concrete

ASTM F 1869

Calcium Chloride Method

ASTM F 2170

In-Situ Humidity Test

Test both the Moisture Vapor Emission Rate (MVER) & the Internal Relative Humidity of the Concrete

ASTM F 1869

ASTM F 2170

Calcium Chloride MVER Testing Alone Does Not Provide Sufficient Information to Reliably Determine the Moisture-Related Suitability of a Concrete Sub-Floor.

But Remember !

Without Adequate, Low-Permeance Moisture Protection, Directly Beneath the Slab, Acceptable Pre-installation Moisture Test Results Do Not Insure that a Moisture-Related Flooring Problem will not Develop.

The Ground Must be

Taken Completely Out-Of-Play, or…

But Remember !

Moisture Levels within the slab will increase over time

ICRI

INTERNATIONAL
CONCRETE REPAIR
INSTITUTE

Concrete Moisture Testing Technician Certification Program

Why Certification Is Needed ?

Throughout the country there is significant disparity in how portions of the current ASTM moisture and pH testing standards are being interpreted and how the tests are being performed.

What is the ICRI Certification Program Based Upon ?

Four ASTM standard test methods

- Moisture Vapor Emission Rate (MVER) - ASTM F 1869
- Concrete Internal Relative Humidity - ASTM F 2170
- Concrete Surface RH - ASTM F 2420
- Concrete surface pH testing - ASTM F 710

CERTIFICATION

What's included in the Level 1 certification program?

- Training seminar—3 to 4 hours (mandatory)

CERTIFICATION

What's included in the Level 1 certification program?

- Written examination

CERTIFICATION

What's included in the Level 1 certification program?

- Performance Examination

    4 ASTM Test Methods

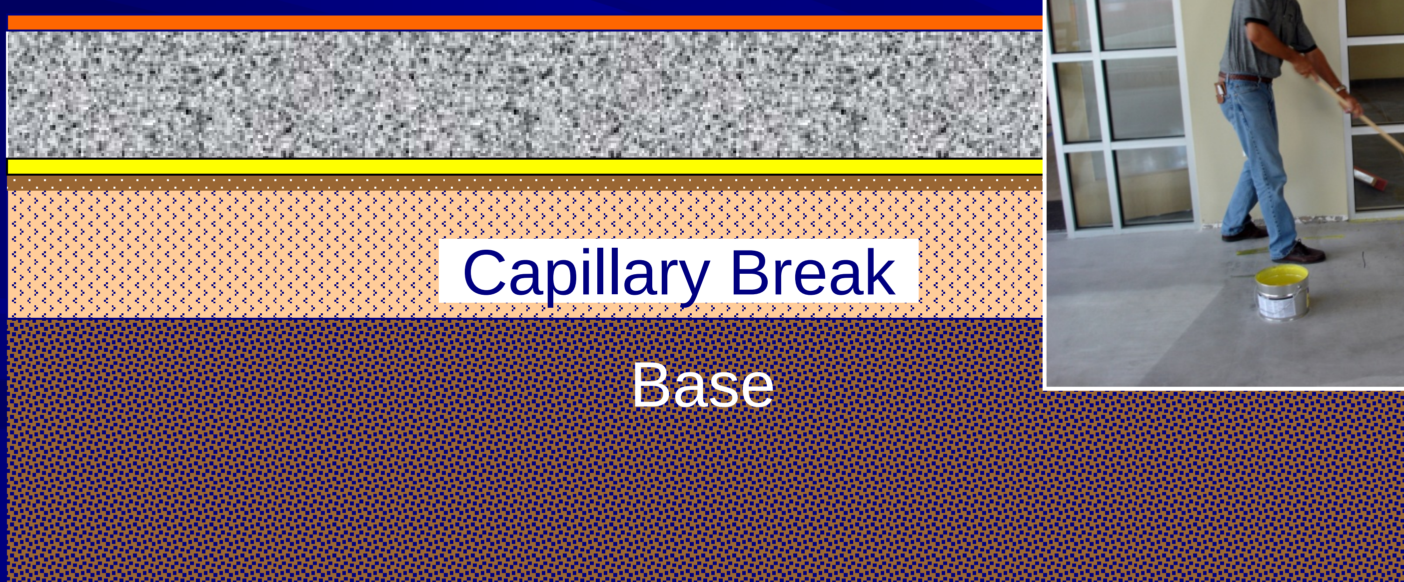
- F 1869 CaCl MVER
- F 2170 Concrete in-situ RH
- F 2420 Concrete Surface RH
- F 710 pH

Steps … to Avoid Flooring Failures:

4. Accelerated Drying

Steps … to Avoid Flooring Failures:

5. Moisture & pH Suppression System



It All Adds up to:

Success

Thank You For Attending!

For Further Information go to:

www.FloorWorks3.com

MOISTURE TESTING

Presentation for:

AMERICAN SPORTS BUILDERS ASSOCIATION

Build it Right

Presented by: Peter Craig FICRI

Concrete Constructives