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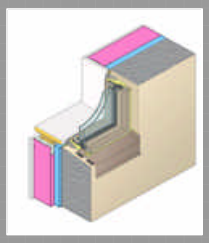
STUDY OF POURED-IN-PLACE CONCRETE WALLS: UPDATE ON CURRENT TRENDS

Sponsors

CMHC SCHL

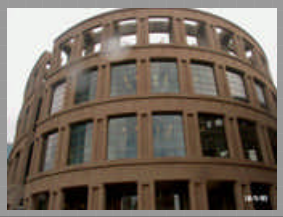
Homeowner Protection Office



Brian Hubbs, P.Eng.
RDH Building Engineering Ltd.

AGENDA

- Introduce the study
  - Most of you have already seen at least 1 presentation at BCBEC, Willis etc..
  - A CD version of the study has been provided
- Review new case studies from recently constructed buildings and discuss based on study recommendations



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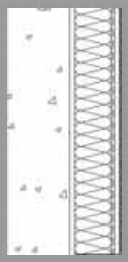
Poured-In-Place Concrete Wall Assemblies



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Study Case Studies 1-4

- Eight buildings were reviewed to provide background information and bias for the study.
- Building age ranged between, 5, 13 and 23 years old and 4 towers under construction. Height ranging from 8 to 40 stories
- Some evidence of water infiltration was observed on all buildings. Older buildings had evidence of previous water infiltration and some mold was observed on the exterior of the interior gypsum board. Signs of water infiltration were related to the following conditions:
  - Cold and control joints
  - Tie holes
  - Honeycombed area of concrete
  - Window, louver and roof interface details
  - Cracks through the concrete
  - Concrete interface with adjacent rainscreen wall assemblies

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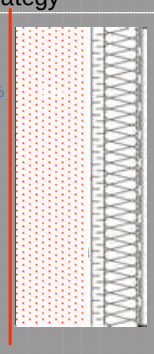
Rain Penetration Control Strategy

- For uncracked wall area rain penetration control relies on:
  - Water shedding at the surface of the concrete
  - Concrete absorbing moisture and subsequent drying to the exterior
- Redundancy is achieved
- What happens at cold joints and cracks?



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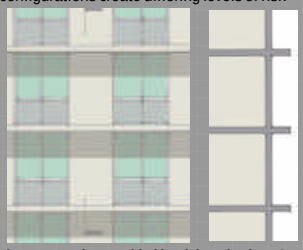
Building Form and Pour Configurations

- Alternate arrangements of overhangs and poured-in-place concrete wall configurations create differing levels of risk



LOWEST RISK

Good overhang protection provided by slab projection. Concrete wall is in compression due to vertical loads and no vertical cold joints used

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Building Form and Pour Configurations

MORE RISK

Good overhang protection provided by slab projection. Use of upstand wall under window creates vertical cold and uncompressed infill concrete element (no significant vertical loads)

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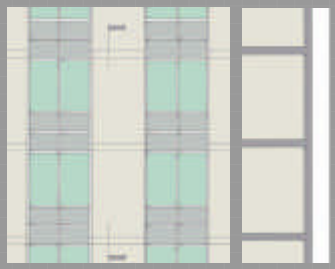
Building Form and Pour Configurations



MORE RISK

No overhang protection. Only exposed concrete occurs between windows and is in compression. No vertical control joints used

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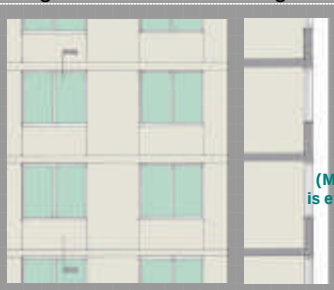
Building Form and Pour Configurations



MOST RISK
(Monolithic pour is even higher risk)

No overhang protection. Use of upstand wall under window creates vertical cold and uncompressed concrete element

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Key Points – Poured-In-Place Concrete Walls

- The risky part of a concrete wall assembly from a rain penetration perspective are locations of cracks and joints
- Manage rain penetration at joints and cracks
  - Minimize number and size of cracks
  - Encourage them to occur at predictable locations – control joints
  - Provide two lines of defense at all interfaces and joints (redundancy)
  - Building form and pour configurations that limit exposure conditions
- Due to the lesser certainty in predicting the location of cracks and the variable damming characteristics of waterstop materials there will always be greater risk of water penetration associated with poured-in-place concrete walls than with most rainscreen wall assemblies
- Water penetration issues are likely to be localized problems
- Thermal issues are important too (Energy and Condensation)

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Three New Case Studies

- Constructed within the last four years
- High-rise construction
- Reported water infiltration, condensation and/or mold
- Cast in place concrete with exterior acrylic coating
- Within 5 year new home warranty period

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Case Study 1

- No reported water infiltration
- 20% of respondents reported condensation issues
- 20% of respondents reported mold/mildew issues

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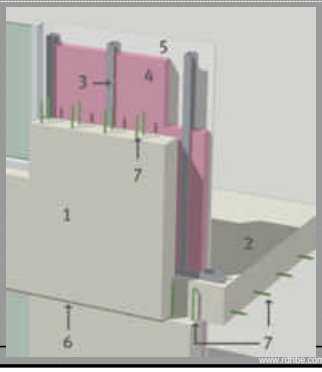
Case Study 1 – As Built

- Typical exterior wall

1. Concrete wall
2. Concrete slab
3. Steel stud framing
4. Fibreglass batt
5. Gypsum wall board & VB
6. Control joint
7. Steel reinforcing



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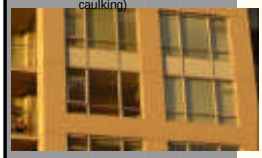
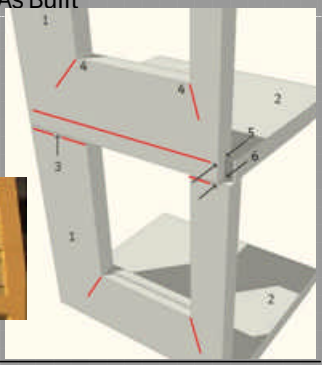
Case Study 1 – As Built

- Concrete detailing

1. Concrete wall
2. Concrete slab
3. Reveal (control joint – no caulking)
4. Typical crack locations
5. Reduced thickness
6. Construction joint (no caulking)





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Case Study 1 - Walls

- Deficiencies - Cracking

u Window sill
s Window corner

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Case Study 1 - Walls

- Deficiencies - Cracking

u Slab joint
s Saddle interface

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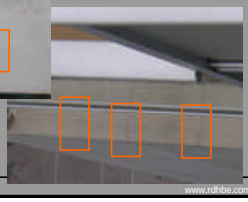
Case Study 1 - Walls

- Deficiencies - Cracking

s Parapet walls
v



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Case Study 1 - Walls

- Deficiencies - Cracking

s Miscellaneous

Crushed Duct s
Inadequate Louver

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Good Practice - Coatings

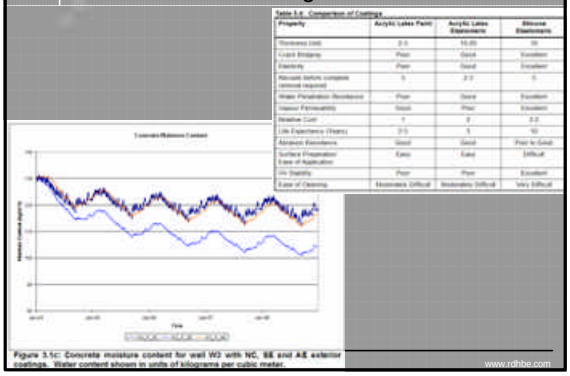

Figure 3.1c: Concrete moisture content for wall W3 with NC, BE and AE exterior coatings. Water content shown in units of kilograms per cubic meter.

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Case Study 1 - Walls

- Exploratory openings

- Cracks in concrete and evidence of past water ingress
- Very little damage to wall assembly at this time

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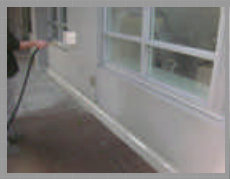
Case Study 1 – Crack Testing - Walls

- 2 cracks were tested for water infiltration by wetting the crack from the exterior without depressurization of the unit.
- One of the tested cracks allowed water infiltration to the interior after 30 seconds.



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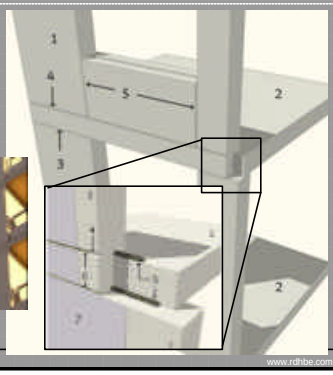
Case Study 1 – Good Practice

1. Concrete wall
2. Concrete slab
3. Control joint at u/s slab (Waterstop + exterior caulking)
4. Control joint t/o slab (Waterstop + exterior caulking)
5. Control joints below window corners (Waterstop + exterior caulking)



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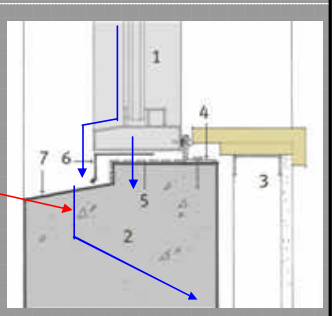
Case Study 1 - Windows & Doors

- Sill detail



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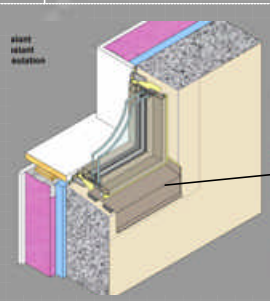
Windows & Doors – Good Practice



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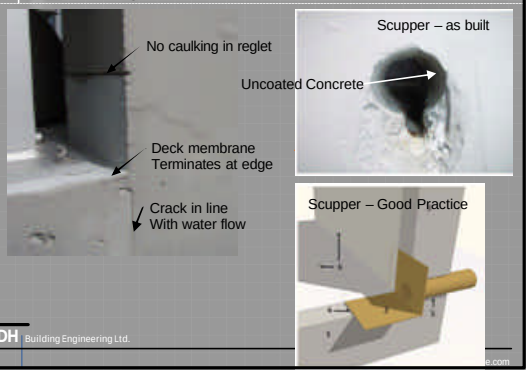
Case Study 1 – Balconies and Decks



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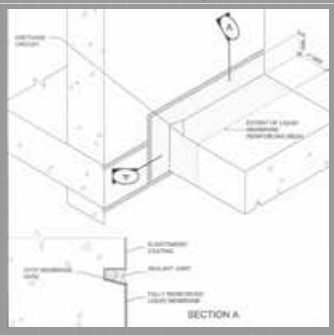
Good Practice - Balcony Details



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Case Study 1 – Waterproofing

- Landscape wall
- Cracking in exposed parapet or curb allows path for water behind waterproof membrane on both sides

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Water Feature

- Design deficiencies
- Membrane termination deficiencies

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Case Study 2

- Numerous reports of water infiltration, condensation and mold/mildew issues

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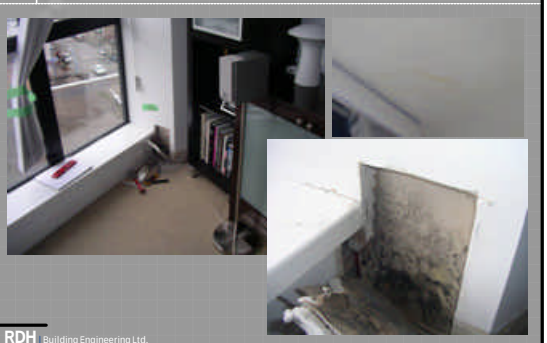
Case Study 2 – Typical Deterioration and Fungal growth



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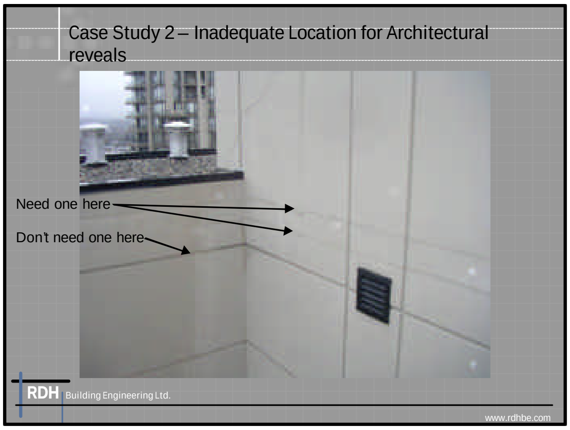
Case Study 2 – Inadequate Location for Architectural reveals
Need one here
Don't need one here
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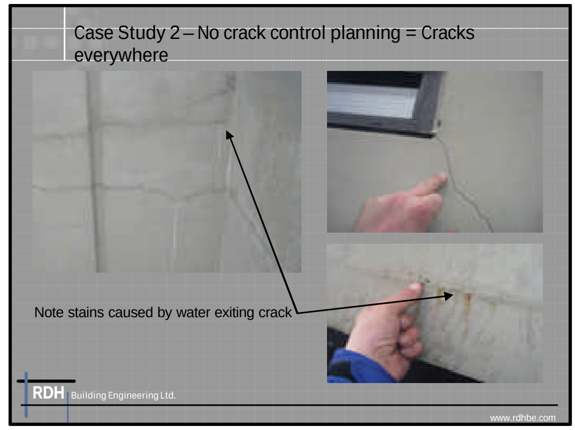
Case Study 2 – No crack control planning = Cracks everywhere
Note stains caused by water exiting crack
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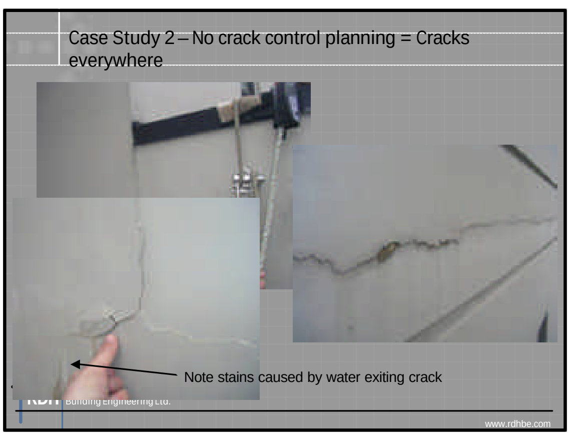
Case Study 2 – No crack control planning = Cracks everywhere
Note stains caused by water exiting crack
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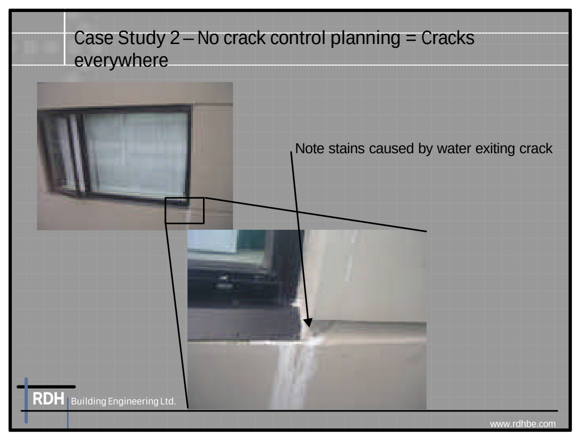
Case Study 2 – No crack control planning = Cracks everywhere
Note stains caused by water exiting crack
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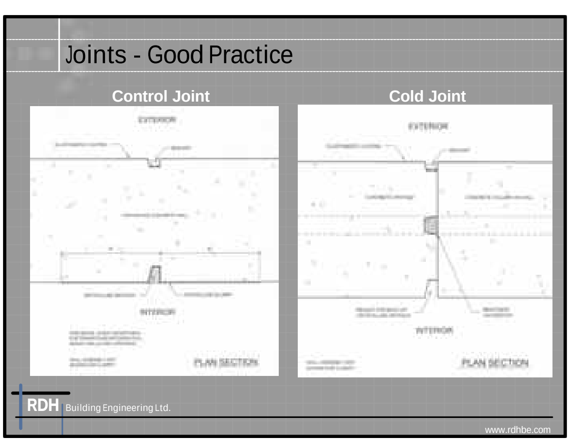
Joints - Good Practice
Control Joint
Cold Joint
EXTERIOR
INTERIOR
PLAN SECTION
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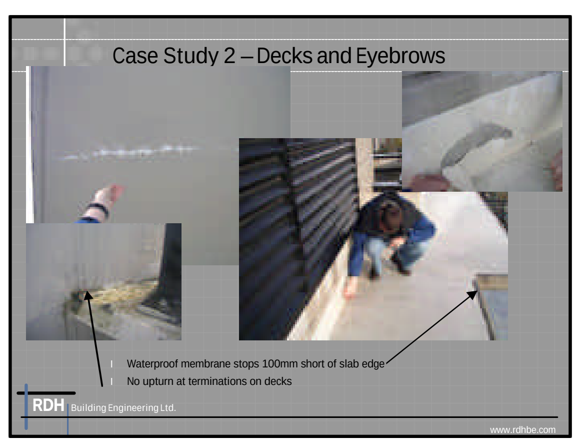
Case Study 2 – Decks and Eyebrows
Waterproof membrane stops 100mm short of slab edge
No upturn at terminations on decks
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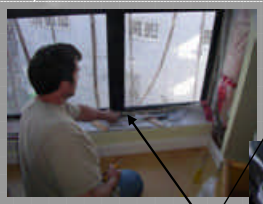
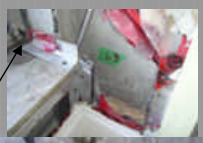
Case Study 2 – Water Testing





- Water leakage at window interface and crack in concrete

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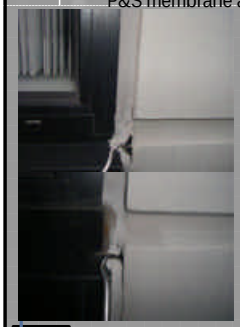
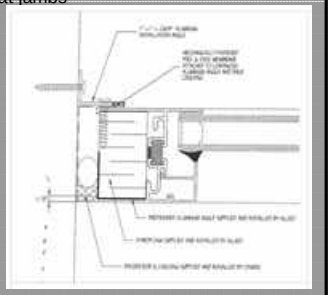
Case Study 2- Delamination of sealant and P&S membrane at jambs





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Case Study 3

- Several reports of water infiltration and condensation

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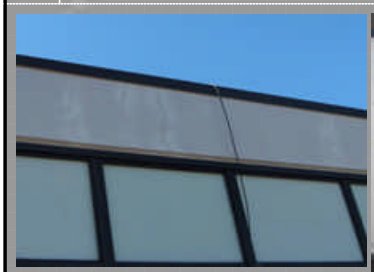
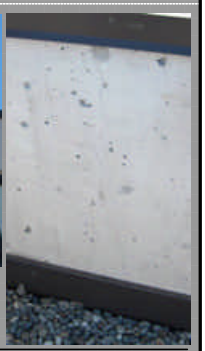
Case Study 3 – Lack of Control Joints





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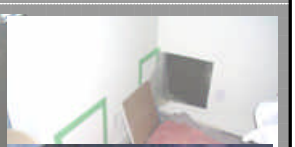
Case Study 3 – Cracked concrete leak



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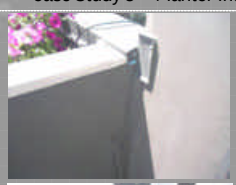
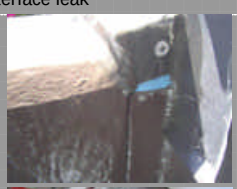
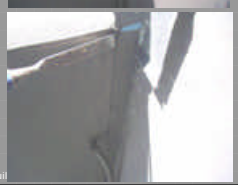
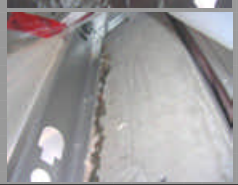
Case Study 3 – Planter interface leak









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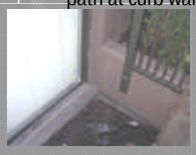
Case Study 3 – Dye test to isolate leakage path at curb wall interface



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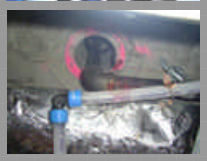
Case Study 3 – Dye test at curb wall interface





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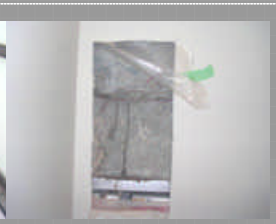
Case Study 3 – Water leakage through crack at wall/slab cold joint

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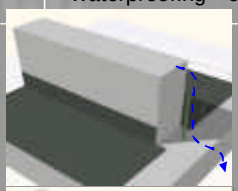
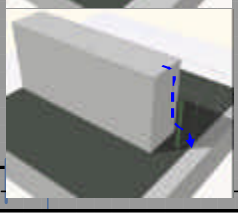
Waterproofing – Case Studies as-built

- Poorest Performance
- Membrane can be maintained and replaced
- Cracks in concrete curb allow water to interior side of waterproof membrane
- Water flows laterally to ends or cracks and enters interior
- Locating leakage paths very difficult

- Better performance
- Water entering at cracks flows to exterior
- Rebar penetration always under water, potential leakage path as bar corrodes
- Membrane can not be repaired, maintained or replaced without curb removal or significant alteration of aesthetics
- Membrane pre-stripping is often damaged at the edge during construction requiring curb removal to make proper transition, this is rarely done creating a weak point at critical location

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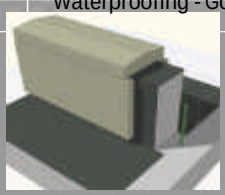
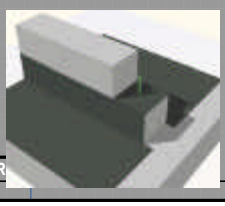
Waterproofing - Good Practice

- Best Performance
- Removable precast protects and allows membrane maintenance and replacement
- Membrane can be installed in one application allowing proper quality control

- Good Compromise
- Water entering at cracks flows to exterior
- Rebar penetration always above water ponding level
- Membrane can be repaired, maintained or replaced without curb removal
- Membrane pre-stripping is coated over at transition when main field membrane is installed

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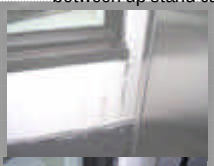
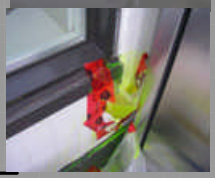
Case Study 3 – Dye test of unsealed crack between up stand curb and wall



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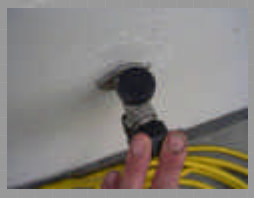
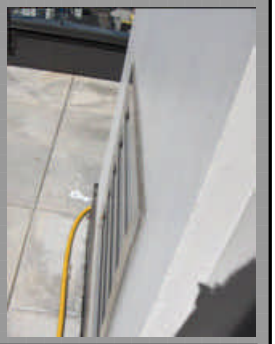
Case Study 3 – Poor interface details





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Case Study 3 – Root damage

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Questions

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