NOTES FROM TIME SAVER DETAILS FOR EXTERIOR WALL DESIGN BY FRED NASHED AIA

I. General Issues

A. Understand the 'forces of nature'

1. **Major forces**
   a. Wind
   b. Water
   c. Heat
2. **Other forces**
   a. Earthquake
   b. Fire
   c. Galvanic action
   d. Noise
   f. Unwanted living things

B. Understand structural issues

1. **Deflection**
2. **Cladding / structure joints**
3. **Distribution of forces around openings**

C. Be aware of cost / cost overruns:

caveat: 'detailing a wall without being thoroughly familiar with the rationale behind its construction is an invitation to failure.'

II. Forces of Nature

A. Wind - Nashed thinks this the an important component to detailing designs for envelopes with today's materials and methods of building

1. **Air infiltration creates:**
   a. Comfort problems (drafts)
   b. Air conditioning problems (unanticipated makeup air)
   c. Envelope failure problems
      i. Condensed water vapor within
      ii. Air barrier collapse
2. **Air pressure on buildings is caused by**
   a. Wind pressure
   b. Stack effect
   c. Mechanically created pressure
3. **Wind pressure - can push in or pull out on the envelope**
   a. Building codes define the design criteria for wind pressure for buildings up to 60 feet high - engineers and testing are needed to set criteria for wind pressure for buildings higher than that.
   b. Building configuration affects wind pressure
   c. Projecting elements of a building - like soffits cannot be treated as finish - they are structure and subject to wind forces
4. **Stack pressure - usually pushes in on the envelope**
   a. Warm air vents out the top of a building as cold air enters at the bottom
      i. Creates pressure making it hard to open outside doors at the ground floor
      ii. Creates whistling around doors to elevator shafts and mechanical shafts
   b. Fans in the HVAC system can be designed to compensate for this pressure
   c. Buildings may lose more conditioned air in the process of compensating, though.
5. **Mechanical pressure - to set up neutral pressure at entrances, then may be pushing out on envelope above entrance level**
   a. HVAC systems designed to compensate for stack pressure create more pressure on the envelope
   b. The best design is when the HVAC systems pressurize only the stacks themselves instead of the whole building.
      i. Stacks in these cases can be
      - elevator shafts
      - mechanical / plumbing / electric shafts
      - stairs
      ii. This kind of design also helps in cases of fire, because the shafts are less likely to fill with smoke.

6. **Protection against wind forces**
   a. Create an air barrier in the building envelope
      i. A continuous seal in the wall and, depending on its design, the roof, too
      ii. It resists wind pressure, but it is still mostly permeable to air
      iii. It can be a self conscious one, like 'building wrap' - 'Tyvek' is a proprietary building wrap
      iv. It can be another component of the assembly doing other kinds of work
      - the vapor retarder
      - the wall finish, like gypsum wall board
   b. It should be toward the inside of the wall assembly
   c. The key to the air barrier is to make it continuous and to give it structural support it against the wind forces, which can be substantial
   d. What does this concept mean about designing your wall / envelope details?
      i. Pick you place for the barrier
      ii. Pick the materials that you will be using for the barrier
      iii. Be sure your barrier is continuous by having a full set of details which confirm its continuity in the envelope and its structural support

B. Water

1. **We usually can't do anything in customary practice about major water events like tidal waves and floods**
2. **We can, and do things about precipitation, humidity, and ground water. Definitions:**
   a. Precipitation: liquid or solid (ice, snow) water driven by wind
   b. Humidity: gaseous water which is part of air
   c. Ground water: liquid water flowing through soil
3. **Forces that move water into envelopes:**
   a. Outside, above ground
      i. Wind force
      ii. Gravity
      iii. Kinetic energy
      iv. Surface tension
      v. Capillary action
   b. Outside, below ground: hydrostatic pressure
   c. Outside and inside, above and below ground: vapor migration
4. **General comments on designing the configuration of buildings and joints in their cladding which resist forces carrying water above ground into buildings:**
   a. Gravity: the old axiom that 'water flows downhill'
      i. At the largest scale, make sure the site around you building is graded to carry water away from it
      ii. At the scale of joints in your envelope assembly, make sure components are shaped to direct water from the inside of your assembly to the outside and make sure there are 'weeps' in you components to allow the water to flow out.
   b. Kinetic energy:
      i. Precipitation is drawn by the force of gravity and receives energy from wind, so it starts moving.
      ii. The precipitation keeps this energy and will keep moving until something stops it. So moving water will flow uphill until it hits something that, working with gravity, stops it from doing so.
      iii. Make sure there are 'dams' in your envelope assemblies that are tall enough to stop water from continuing to move.
   c. Surface Tension
      i. Water has a tendency to 'stick' to other materials.
      ii. Flowing water will adhere to a wall assembly and move along horizontally and slightly uphill.
      iii. Create 'drips' in the outside of your envelope assemblies which are at least 1/2 inch high and 1 inch wide to let the assembly, with gravity, overcome the forces that permit water to adhere to the assembly materials and start falling away from it.
      iv. Create joint designs which become wider from outside to in and which have weeps in them to let gravity help the water flow out of the assembly.
   d. Capillary action
      i. As water is flowing, it soaks into materials porous to it, and it penetrates cracks.
      ii. The water will try to find an equilibrium across a component in an assembly, going from where there is a higher density of water to where there is a lower density
      iii. Create joint designs which become wider from outside to in and which have weeps in them to let gravity help the water flow out of the assembly.
      iv. Create internal drainage systems in your envelope assemblies which direct water from their inside to the outside.
5. **General comments on designing the selection of building materials and the configuration of buildings and their envelopes which resist hydrostatic pressure moving water into buildings:**
   a. In normal conditions, the soil on which your building stands has water lying in it.
   b. At some point, the soil is completely saturated with water. This point is the water table of the soil
   c. The water table moves up and down in the soil over the seasons depending on the amount of precipitation
   d. Any part of a building which is below the water table is literally under water
   e. Use materials in those portions of buildings which are as watertight as possible

f. Generally it is difficult to make building envelopes completely watertight
   i. Create external drainage systems around your below ground envelope which artificially lower the water table near the envelope
   ii. Create internal drainage systems within your building which collect water leaking into it and carry it away from the portions of your building you want to remain dry.

6. General comments on designing the selection of building materials and the configuration of building envelopes to resist and accommodate water vapor moving into the envelope

a. Water in a gaseous state is in the air, coming from a variety of sources:
   i. Liquid water evaporating off bodies of water or out of the soil
   ii. Gaseous water coming out of living things (like us and plants)
   ii. Gaseous water introduced into conditioned air by HVAC systems

b. The amount of gaseous water that exists in air depends on the temperature of the air; the warmer the air, the more gaseous water there will be

c. Water vapor does not have an adverse affect on most building materials in envelope assemblies, liquid water does have an adverse affect on many.
   i. One purpose of a building envelope is to contain air inside which is a different temperature from the air outside
   ii. In temperate climates, we use HVAC systems to make the air temperature on the inside of the building is usually warmer than that on the outside
   iii. In subtropical and tropical climates the reverse is true
   iv. Usually, there is some point in the building assembly where the air temperature drops to a point where the gaseous water turns into a liquid
   iv. Put a continuous vapor retarder on the warm side of the envelope assembly to minimize the migration of warm air with more gaseous water into the envelope assembly where it will turn into liquid water
   v. Create a drainage system on the colder side of the vapor retarder within the envelope assembly which will carry the liquid water that will accumulate to the outside of the assembly

7. Protection against water: is of prime importance in designing building envelope assemblies

a. We select cladding materials which are not adversely affected by water

b. We configure the cladding and the rest of the envelope assembly keep water being drawn by gravity; carried by kinetic energy, surface tension, and capillary action; and condensing from gas to liquid from coming into contact with the portions of the envelope which will be adversely affected by liquid water

c. We add other materials to the envelope to take more precautions to protect against water. These are:
   i. Sealants
   ii. Sealers
   iii. Dampproofing
   iv. Waterproofing
   v. Vapor retarders

8. Protecting against water with sealants

a. General:
   i. Joints in the cladding of the building envelope are filled with sealants to prevent as much water as possible from entering the portions of the envelope which are meant to remain dry.
   ii. Sealants are special materials which stick to most building materials, hold themselves together, and can change shape over time.
   iii. They are applied in a liquid form and cure into a flexible solid.
   iv. They are resistant to the effects of sunlight, rain, acid rain, and freezing and thawing.
   v. They degrade over time faster than other building materials.
   vi. The ones getting greater exposure to sunlight, rain, acid rain, and freezing and thawing degrade faster than those that have less exposure.
   vii. They need to be applied by qualified trades to joints which have been properly designed by architects
   viii. When everything goes right, the ones with the greatest exposure last for 10 to 15 years; then they have to be replaced.
   ix. There are different qualities of sealants designed by their manufacturers for different conditions of exposure.
   x. Sealants are expensive, so the right sealant should be selected for the right degree of exposure and building material to which it will be applied.

b. Kinds of joints to design with sealants: There are three choices:
   i. Single stage joints:
   - a single bead of sealant and backer rod in exposed (outside) of the joint in the cladding of the envelope assembly
   - when everything is applied perfectly, the sealant will keep water from entering the joint for the life of the sealant

ii. Two stage joints
- a bead of sealant with a backer rod in the exposed (outside) joint in the cladding at of the envelope assembly and another bead of sealant with a backer rod at the inside limit of the cladding joint.
- the outside sealant keeps most of the water from penetrating the joint
- the inside sealant keeps any water that may penetrate the outside sealant
- the outside sealant has to be interrupted with weep holes to permit water entering the cladding joint to flow out of the cladding joint
- the inside bead of sealant is less exposed to the general environment and does not degrade as quickly as the outside joint.

iii. Rain screen joints
- a refinement of the two stage joint
- both sealants are applied deep into the cladding joint
- the cladding joint and outside sealant is configured to have weep holes and drainage channels to let water accumulating in the joint to drain out.
- the cladding joint is also configured to create an air pocket, called a pressure equalization chamber, so when wind blows against the building, air fills the pocket and is stopped by the inside sealant joint. The air pressure in the pocket becomes higher than the air pressure outside the joint, and more air carrying precipitation (water) is prevented from entering the joint.

iv. For two stage or rain screen joint designs, the inside bead of sealant can be applied from the inside or the outside of the joint. In either case, the joint has to be designed so the inside bead of sealant can be replaced later.

c. Joint widths in cladding and sealants

i. Cladding joints are needed because:
- cladding increases and decreases in size as it is subjected to changes in temperature and humidity.
- the building structure to which the cladding is anchored moves from the forces which include wind, changes in temperature, seismic activity, and changes in the live load
- there is a limit to the amount of movement which the cladding can accommodate without cracking
- the cladding is subdivided into panel sizes which are small enough to keep the cladding from cracking

ii. The kind of cladding material and the size of the panel of the cladding determines the required size of the cladding joints.

iii. Architects consult technical literature and seek the advice of engineers to determine the right size of cladding panel and the right locations for joints between panels.

iv. Once the locations of the joints are determined, the size of the joint can be determined by the amount of movement that has to be accommodated.

v. The depth of the bead of sealant needed to be applied to the joint is usually one half of the width of the joint, but no less than 1/4 inch.

vi. The sealant depth is assured by inserting a backer rod (made of a material to which the sealant does not adhere into the joint.

vii. The applicator fills the joint with sealant and tools it to get it to adhere to the cladding material and to give it a shape which lets it flex without tearing after it has cured.

viii. The architect needs to design the cladding joint to have flat sections to accept the backer rod and the appropriate depth of sealant.

9. Protecting against water with sealers

a. Sealers are chemical formulations applied in liquid form which soak into a building material to get it to resist being soaked by water.

b. Sealers can be good to preserve the appearance and integrity of a material which ages as a result of being saturated by water.

c. They have to be applied periodically and relatively frequently.

d. If the sealer is going to be used on cladding which is part of an envelope assembly, the cladding material after soaking has to be five times more porous to water vapor than the vapor retarder which is used deeper into the assembly or water vapor passing through the vapor retarder and into the assembly with condense in liquid form at the cladding which is saturated by the sealer.

10. Protecting against water with dampproofing

a. Dampproofing is used on above ground walls, and it has the capacity to shed liquid water.

b. It is usually applied to a material which is porous to water which is part of the envelope assembly, but is not exposed to view.

c. It can be a liquid which is brushed or sprayed onto the material.

d. It can also be a membrane material like house wrap or asphalt impregnated felt which is applied with fasteners.

e. Like sealers, dampproofing has to be five times more porous to water vapor than the vapor retarder used deeper in the assembly or water vapor passing through the vapor retarder and into the assembly in liquid form at the dampproofing.

11. Protecting against water with waterproofing

a. General: The force of gravity on standing water exerts pressure on an envelope assembly which lies in that water. This water is usually found in the below ground portions of the envelope, the foundations.
   i. Therefore, waterproof materials are generally used for the building envelope below ground to create a barrier resisting the pressure of the water.
   ii. Waterproofing is usually used with a drainage system outside the envelope assembly which reduces the pressure of water in the ground.

b. Concrete is a good barrier to water if it is thick enough and if it is placed well.
   i. Concrete usually gets cracks resulting from its shrinking during its curing process
   ii. Concrete also gets cracks at the joints between each pour of the material

c. Because concrete - or another foundation material, like masonry and mortar - may have cracks, a membrane is usually applied to the water side of the assembly to fill them.
   i. Waterproof membrane materials can be:
   - a special fluid applied by brushing or spraying;
   - a special sheet which is adhered;
   - a panel made of betonite clay and paper which is mechanically fastened.
   ii. Many of the membrane materials can be punctured by backfill materials, so the membrane has to be protected with a board which is resistant to puncturing by backfill.

b. Drainage systems are important to use with waterproof envelopes, because the envelopes may have small failures or may not have been perfectly applied. The drainage takes water coming close to the foundation away from it faster than the water flows through the undisturbed ground, reducing the water pressure and decreasing the effect of water pressure on any small failures or imperfections.
   i. The drainage system usually has a medium like coarse gravel or a specially manufactured panel which is more porous than undisturbed ground.
   ii. The porous medium needs to be separated from undisturbed ground with a filter medium, because moving water carries lighter pieces of the undisturbed ground - 'silt of fines' - with it as it flows. The filter medium stops traps the silt.
   iii. A drain pipe is at the bottom of the porous medium to carry the water away from the building. The outlet of the pipe has to extend to either the surface of the ground which is below the pipe or to an approved connection to a municipal storm water drainage system.
   iv. The drain pipe has to be located at least 6 inches below the floor level of the inside of the building and at least 4 inches above the bottom of the footing of the foundation to minimize the possibility of moving water undermining the undisturbed ground on which the footing is placed.

12. Protecting against water with vapor retarders

a. Water vapor (the gaseous state of water) migrates into a building envelope as part of the air in which the envelope is bathed. Warmer air has a greater capacity for gaseous water than colder air. When warm air with gaseous water is cooled in an envelope to a point where some of the gaseous water condenses into liquid, the liquid water may settle in a portion of the envelope which cannot tolerate liquid water.

b. A vapor retarder, a material that limits the passage of air, is put into building envelopes on the warm side of the assembly to prevent much of the warm air with water vapor from penetrating deeper into the assembly.

c. Some warm air with greater amounts of water vapor than the cooler air in the assembly is going to pass through the vapor retarder. The vapor will condense into liquid, and the assembly has to be designed to capture this liquid and direct it out of the assembly or to get to a portion of the assembly where it will evaporate again.

d. When designing assemblies, it is important to determine what materials in the assembly might act as vapor retarders but which are not put in the assembly for that purpose.
   i. As a result of experiments and observations we have found that the water vapor is going to condense on the surface of the warmer side of the first material that is next most impermeable to water vapor than the intended vapor retarder material.
   ii. It is at this point in the assembly where the materials in the assembly should not degrade from being wet.
   iii. If there is a material in that part of the assembly which cannot tolerate water and which is needed, that material has to be enclosed in its own vapor retarder.

e. Envelope assemblies should have both a vapor retarder and an air barrier
   i. Both the vapor retarder and the air barrier should be continuous in the building envelope.
   ii. Take special care in designing envelope details to look at areas above finish ceilings, at the joint between roof and walls, and at wall penetrations such as windows and doors to be sure the two membranes are present and continuous.

13. **What can go wrong with designing to resist the forces of water**
    a. Generally, everything can go wrong frequently in the design and construction using these means.
    b. Typical problems with interface between control joints, expansion joints, shelf angles, and window frames in cladding design and solutions
        i. Inadequate detail design
        ii. Check details for thoroughness of coverage of all envelope applications
    c. Typical problems with sealants and solutions:
        i. They can be improperly installed
        ii. They can be installed at times when ambient temperatures are at the extreme highs or lows
        iii. Be aggressive in observation of installations during construction, note unacceptable work in the project meeting notes
        iv. Choose to use two stage sealant design whenever possible, educating your client on the cost benefits of two stage over one stage designs if needed.
    e. Typical problems with sealers and solutions
        i. Discoloration
        ii. Incompatibility with sealants
        iii. Do tests either before installation to be sure of desired results
    f. Typical problems with dampproofing and solutions
        i. Dampproofing is not porous enough to water vapor
        ii. Dampproofing used in below ground applications
        iii. Check material specifications for porosity and compare to that of the vapor retarder
        iv. Check material labelling on site for proper application
    g. Typical problems with vapor retarders and solutions
        i. Lack of continuity of the vapor retarder
        ii. Penetrations in the vapor retarder
        iii. Unintended vapor retarders in the assembly
        iii. Check documents for completeness of coverage of details
        iv. Do aggressive field inspection and make note of unacceptable conditions in the project meeting notes
        v. Calculate permeability to water of the components in the envelope assembly.

C. Heat and Cold

1. **Introduction**
    a. The amount of insulation designed for the wall or roof of an envelope is a function of the entire design of the envelope and the design of the HVAC system.
    b. Architects and engineers should determine the amount by:
        i. The architect making a preliminary design of the wall and roof
        ii. The engineer analyzing the entire design of each to determine how much heat will pass through it and how much heat will be gained from sunlight passing through glass in the windows and skylites.
        iii. The engineer determining the size of the HVAC system required for the design
        iv. The architect and engineer determining if the size of the energy demand required to run the HVAC systems is as good or better than generally accepted norms or legal requirements
        v. The architect modifying the design of the envelope to decrease the energy demand on the HVAC system.
    c. The goal of the process is to balance the first cost of the building envelope with the life cycle cost and energy demand of the HVAC system.
2. **Heat Transfer**
    a. Building envelopes are designed to counteract the natural flow of differences in heat energy from higher states to lower ones.
    b. Heat energy moves through envelopes in three ways:
        i. Convection of air carrying heat
        ii. Conduction of heat through solids or liquids
        iii. Radiation adding heat to solids, liquids, or air.
    c. The design of envelopes reflects our understanding of how energy moves.
3. **Protections / Counteraction of Heat Transfer**
    a. General: the tools available to the architect are:
        i. An insulation material that resists the conduction of heat through it.
        ii. An insulation material that reflects the radiation of heat
        iii. An insulation material that absorbs and the conduction of heat slowly by its great mass.
    b. Industries design and manufacture materials that have a resistance to conducting heat.
        i. These materials are rated with an 'R value,' the higher the value, the less energy is conducted.
        ii. When indicating the insulation in the detail design of an envelope assembly, it is better to state the needed R value than the thickness of insulation. Different manufacturers of a given insulating material often achieve different R values within the same thickness of the material.
    c. Ultimately, the architect should be interested in the R value of the entire envelope assembly, not just that of the insulation within it.
        i. Fine tuning the design can make a big difference.
        ii. An air pocket toward the inside of outside of the envelope has a measurably good affect on the assembly's R value.

iii. Materials which have a relatively higher level of conductivity of heat than others - such as metal or wood - and which bridge all the way across the envelope can have a measurably bad one.

4. **Products Available to Protect or Counteract Heat Transfer**
   a. Fiberglass batt insulation
      i. Comes unfaced, paper faced, foil faced
      ii. Available in different thicknesses
      iii. Not meant to be used in wet conditions
      iv. Most commonly used insulating material
   b. Fiberglass or mineral wool semi rigid board insulation
      i. Material held together by a binder
      ii. Plain or foil faced
      iii. Different thicknesses
      iv. Not very flammable - denser versions used to resist spread of fire
      v. Supports loads without compressing very much
      vi. Frequently used in roof assemblies
   c. Polystyrene, polyisocyanurate, phenolic foam and high density fiberglass insulation
      i. The 'plastic' based closed cell materials may be used in wet locations; however highly flammable - must be separated from rest of assembly with gypsum board or another fire resistive material if used inside the building
      ii. Other materials not meant for wet locations.
      iii. Comes in boards
      iv. Some plastic materials come formed in shapes that can be fit into concrete blocks's hollow cells.
      v. Some materials are integrated into metal panels as an integrated sandwich panel system.
   d. Expanded mineral perlite or vermiculite as well as shredded cellulose (paper / wood product) loose fill insulation
      i. Perlite and vermiculite can tolerate wet conditions
      ii. Cellulose cannot tolerate wet
      iii. Inherent heat transfer resistance is good, but it is difficult to be sure the material has been placed with continuity.
      iv. Because of problems placing material, it is less effective, in practical terms than other insulation materials.
   e. Thin metal reflective foil insulation
      i. Resists radiant transfer of energy
      ii. Most commonly used with resistive insulation products
   f. Masonry, concrete, earth, adobe or other capacity insulation:
      i absorbs and releases heat energy slowly
      ii works well in dry climates with hot days and cold nights
      iii design idea for envelope is to absorb heat slowly during the day and then release it at night
      iv. Do not use other insulation materials with capacity insulation since they resist transfer of heat and it is meant to transfer heat, but slowly.
5. **What can go wrong with designing for protection or counteraction of heat transfer**
   a. Generally, little goes wrong.
   b. Insulation materials not meant to get wet can become so if the assembly is not designed to account for water vapor
   c. Foil insulation is very impermeable to water vapor and putting it in the wrong place in the envelope can result in an unintended vapor retarder.
   d. Thermal bridging can take place in an envelope design - guard against it by finding the highly conductive elements like:
      i. Metal or wood studs
      ii. Slab edges
      iii. Steel shelf angles and hangers tied back to the structure
      iv. Window frames which are not internally thermally isolated

      and putting a resistive insulation material between the ambient environment and the conditioned one inside the envelope.
   e. Frequently the R value of the entire envelope is assumed to be that of the insulation material only instead of the assembly
      i. Doing so can add to the cost of the envelope not only because of the cost of insulation but also because of the thickness of a portion of the envelope required to house it
      ii. Doing so can lead to the HVAC engineer adding unneeded capacity to the HVAC System, resulting in a higher first cost for it.

D. Earthquakes - Nashed talks about these, but I have not taken notes on it

E. Other Forces of Nature

1. **Nashed mentions several, and features four:**
   a. Fire
   b. Electrolysis
   c. Sound
   d. Infestation by living things
2. **Fire**
   a. Our building codes and insurance underwriters laboratories define requirements for designing envelopes for resistance to fire.
   b. As a general rule:
      i. The closer one building is to another, the more fire resistive the envelope must be
      ii. When buildings get very close together, glass windows need to be protected by fire shutters or fire suppression systems
      iii. Taller buildings need a more fire resistive envelope than shorter ones
      iv. Buildings with larger floor areas need a more fire resistive envelope than ones with smaller floors.
   c. Fire is capable of moving from story to story of a building once it starts.
      i. Fire can migrate in this way through the building envelope
      ii. Building codes require and insurance underwriters recommend the degree of fire resistance needed in a wall from floor to floor for particular kinds of buildings
      iii. The problem area in the wall where this occurs in the space between the edge of the floor slab and the cavity in the wall. Design a fire stop, usually some kind of fire resistive insulation in the enclosure at this spot.
      iv. The problem can also be with all glass window walls, because glass will shatter when subjected to fire and then the fire can move up the face of the building. Check the literature on the window wall to find out what its behavior is in case of fire. If necessary, abandon an all glass wall and substitute a spandrel panel of fire resistive material.
   d. If there are flammable materials in an envelope assembly, they need to be protected from fire.
   e. Building structures may require protection from fire.
      i. For exterior walls, the problem is usually at the joint between the structure and the enclosure assembly
      ii. Frequently the fire protection of the structure may be removed as a result of the installation of the enclosure assembly, because the fire protection on the structure is installed before the enclosure itself.
      iii. Design enclosure assembly details with a notation about the fire protection material and with advice about repairing that material after the enclosure is in place
   f. The best protection against fire for buildings is a fire suppression sprinkler system which goes into operation at the source of a fire, douses it with water, and either puts it out or slows its growth and spread as a result.
3. **Electrolysis - 'Galvanic Action'**
   a. When two different metals are dumped in a solution of water and minerals the molecules of each begin to break up. The product of this reaction is an electric current
   b. Metals are listed in the periodic table of elements, and they are classified as to their 'nobility'
      i. Ones at the top of the table are considered less noble
      ii. Ones at the bottom of the table are considered more noble
      iii. The farther away metals are from each other in the table, the more of a reaction there is between them when they are put in a water / mineral solution
      iv. In this situation less noble metals degrade and electroplate themselves onto the more noble ones.
   c. In construction we use metals like zinc and aluminum because, when they react with air and water (oxidize) to create a compound of oxygen (an oxide), that oxide coating on the metal is tough enough to greatly diminish any more oxidation, preserving the integrity of the component of which they are made.
   d. We use an alloy of iron, steel, because it has great strength, both in compression and tension, in relation to its weight.
      i. The oxides of most steel alloys are not tough enough to stop additional oxidation in the steel
      ii. We have developed coatings for steel, such as a film of zinc, to protect the steel from excessive oxidation
      iii. We have also developed other alloys of steel which oxidize very slowly (stainless steel)
      iv. However, a component made of stainless steel is more expensive than one made of nonstainless steel coated with a film of zinc, so we usually do not make large pieces out of stainless steel.
      v. However, the stainless steel alloy is more noble than the zinc coating the nonstainless steel
      vi. Sometimes, we put stainless steel and zinc coated steel together, though. The zinc touching the stainless steel degrades in a wet environment.
      vii. We solve this problem by putting an electric insulating material between the two metals, like a plastic washer.

viii. We also mitigate this problem by using the more noble metals only for relatively small things like fasteners instead of larger components. When the mass of the less noble metal is much more than the more noble metal, the amount of current generated is smaller, and there is less degradation.

4. **Sound**
   a. Some building uses need more sound isolation from the outside environment than others. Examples are hospitals or sound recording studios
   b. Some locations have a high amount of ambient sound, like airports, and buildings in such locations need to be isolated from the sound.
   c. We detect sound, mostly with our ears, from vibrating air.
   d. Sound is transmitted either by vibrating air or by a vibrating structure.
   e. You diminish the transmission of sound by:
      i. Sealing the vibrating air away from the air of the space where you want less sound - using sealants.
      ii. Putting insulation materials - usually the same ones you would use for insulating against the transmission of heat - in an envelope assembly which dissipate the energy of the vibrating air and do not pass the air vibrations into the air on the other side of the insulation.
      iii. Putting very massive materials, like stone or steel, that absorb the energy of the vibrating air, but do not vibrate noticeably themselves as a result to pass on the vibrations to air on the other side of the massive material.
5. **Infestation by living things**
   a. Other living things, just going about their business of living, can bother humans or destroy what we've made. Bugs and birds, mostly, but also mice and rats, are part of what is called 'infestation.'
   b. Design the outside of your envelopes so birds don't want to live there.
      i. For places in the envelope under cover, slope surfaces at least 30 degrees to discourage nesting.
      ii. Design weep holes, cavities, and louvers so rats can't get in or don't find a reason to stay - means of protection include screens over hole, porous stuffing in weep holes, pea gravel in big cavities in the envelope.
   b. Nashed suggests, with tongue in cheek, that a well placed umbrella or awning over places used by humans under places in buildings that birds and such find inviting, may be an appropriate solution to the problem of infestation.

III. Conclusion

A. Forces of nature have 'a profound effect on today's thin wall construction.'
B. We design details in recognition of these forces
1. **We put a continuous air barrier, structurally capable of resisting the force of air currents which flow into around our building into its envelope.**
2. **We put a continuous vapor retarder on the warm side of our envelope to minimize migration of water vapor into it.**
3. **We make sure that the other materials we put in our envelope assembly are five times more porous to water vapor than the vapor barrier we put into it.**
4. **We design the panels and joints in the outside of our envelope to resist water being carried by gravity, kinetic energy, surface tension, and hydrostatic pressure into the envelope assembly.**
5. **We use and understand the limitations of recent innovations in building materials like sealants, sealer, dampproofing, and water proofing to enhance the performance of the joints and cladding materials we design.**
6. **We design envelopes with built in drains to carry any water which will accumulate in them to the outside of the envelope.**
7. **We create envelope designs which resist or control the transfer of heat energy through them to minimize the need for HVAC equipment to keep the temperature and relative humidity of the insides of our buildings at a level comfortable for the occupants.**
8. **We build in barriers to the spread of fire through the envelope from one part of the building to the other.**
9. **We choose and detail fastenings within our envelope which minimize the effects of galvanic action on the metals within it.**
10. **When required we add elements which reduce the passage of unwanted sound from the outside of the envelope to the inside.**
11. **We design our envelopes to be less friendly to bugs, birds, and rodents than the natural world outside them.**