Building Under the Weather

A STUDY OF BUILT RESPONSES TO RAIN

By PAUL ROBERT FARRELL
Certificate, Boston Architectural Center, 1970

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Signature of Author ....
Department of Architecture

Certified by ....
Shun Kanda
Associate Professor of Architecture

Accepted by .
Imre Halasz, Chairman
Department Committee for
Graduate Students

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ABSTRACT

Rain is an event which can have a positive influence on design. Architecture can take advantage of rain as a connection to nature, an opportunity for richness of architectural response, and a means to add liveliness to the environment.

Understanding of the way rain forms in the atmosphere, and its effect as the primary shaper of the landscape, give an appreciation for rain as a natural force. Its associations with water give it meaning beyond the already strong associations people have for rain itself.

Historic precedents, and the response of contemporary architecture to the problems and possibilities of rain, show changes in values as they are built into the environment.

Two issues are investigated in considering the effect of rain on design. One is ecological responsibility toward the processes of nature. The second is that architecture reinforce the associations between people and buildings, and express our relationship to nature, through symbolism, reference, and opportunity for use. Four processes are proposed to guide designers in considering rain as a positive force. Delay of water's path through the environment is an ecologically sound practice. Gravity is an opportunity to add liveliness to water's movement. The time cycle of rain is concerned with the absence as well as presence of rain. Transformation of the environment by rain adds interest to the environment. An overview of all elements of building concerned with rain attempts to apply these concerns and principles to make rain a positive force in daily life in and around buildings.

Thesis Supervisor: Shun Kanda
Title: Associate Professor of Architecture

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INTRODUCTION

Weather and the changing seasons are the greatest variety we experience. The unpredictability of the weather enlivens the world. It seems that acknowledgement of these ephemeral changes could be built into places, so both the quality of experience of the weather, and the quality of the places themselves could be made stronger.

Rain is especially suited to an investigation of the relationship between built places and the weather. It is unpredictable, has a physical manifestation as water, which extends its effects, and it has an influence on most of the exterior elements of architecture.

The process of water supply for domestic use, agriculture and industry are so mechanized that we assume they are completely under man's control. The connection between the water we use and the rain which is its source has become lost to everyday understanding. In more primitive cultures rain still has a place in myth and religion that recognizes its importance to life. There is a movement now to look for a new (or old) set of values that have more to do with a life integrated with nature, instead of the dominant value system based on the subjugation of nature by man. Rain is one of the most important of natures processes, though often overlooked in favor of more romantic and striking aspects. Since it rains everywhere, city or country, rain is a direct link to nature. Design to accommodate rain can illustrate and deepen our values in regard to the importance of nature to man. The places we build can re-inforce the presence of rain, make it more apparent and in-teresting, as well as protecting us from its more unpleasant aspects. One of the reasons for the unpopularity of rain is the indifference of designers and clients to those who must walk aroung outside in it. In other countries the comfort of the pedestrian on rainy days is accommodated in public and private construction.

In the Northeast, where this study is written, rain falls on an average of one day in three or four. Any per-ceptual or design adjustment that makes rain more inter-esting and enjoyable will necessarily improve at least one out of every four days.

Designing for the ephemeral changes in the atmosphere, such as weather and the seasons, requires an openness to the experience of the environment at a modest and subtle scale, often missed in the concern for the major architectural is-sues. This openness is apparent in a reminiscence about the author Colette:

> "The Earthly Paradise is here: it is not lost for her; others merely fail to see it, indeed shut themselves out from it. From the still silent house, by and by will emerge a husband weighed down by the cares of state, a bookish foster-son a friend obsessed by the recapture of a lost lover, another whose mind is on the obtaining

of a given professional position. Either selfishly, or unselfishly, their concern is with the world of men: to all of them, the newspapers, the mail are a life-line to what matters. Not to Colette. She is completely unconscious of political events, wholly devoid of any ambition. What matters to her is the rapidly changing color of the sky, the increasing roar of the incoming sea, the polish of a pebble which she has now picked up, and venturing farther, the prompt dartings of a shrimp which feels that the tide will soon liberate it from its narrow pool... And when her small daughter, long ago, suddenly stopped in her jumping, having become conscious of the perfume of the flowering troenes, Colette's hands went out in an instinctive hushing gesture: something important had happened, and she drank in this graceful picture of awareness...."

1. Rain, Weather, and Landscape

Rain transforms the environment. The world looks and sounds different; smells are more intense, and the atmosphere is made physical, tangible. Outside space that ordinarily seems open and free is suddenly filled by the presence of rain, and inside space is now open by comparison. Surfaces shine and reflect, water runs and splashes, and noises are muffled by the sound of rainfall. The sky is dark, low and seems to give the world a ceiling and sense of enclosure. Rain cools the atmosphere as water is evaporated into the drier air. Reflections mirror the sky or trees, and bright objects appear brighter in the prevailing gloom. Activities must be adjusted to the weather, and people outside hurry, concentrating on their path. Their moods also may change, in ways dependent on the season and the type of rain.

It seems valuable to consider the ways designers can manipulate or cooperate with such dramatic alteration of the world. As a first step in understanding the relationship of rain and the designed environment, it will be helpful to establish an attitude about rain which sees it as a positive and necessary force of nature, providing variety and vitality to daily life.

Rain in different seasons and intensities provokes various responses. The Japanese have separate names for misty rain, icy rain of winter, rain which comes down like fine threads, the sudden rain. We refer to spring showers, downpours, torrents, drizzle, misty rain, cold rain, storms and hurricanes, thunderstorms. The Atlantic Coast has its famed nor'easter, the south its daily summer showers.

In spring, warming of the atmosphere by the sun causes instability aloft, resulting in brief spring showers, without the long periods of overcast associated with winter rains. After the storms and cold rain of winter, these brief showers release the smell of damp earth and are signals that the earth is coming back to life. The refreshing showers are welcome, clearing the dirtiness and dinginess of winter.

In summer, rains are often in the form of thunderstorms. Downpours are likely, with large amounts of water falling. Summer thunderstorms are dramatic and powerful demonstrations of nature's strength.

Winter rainstorms are long lasting, one to two days of steady rain, depressing, quieting, and generally miserable times to be outside. Ice storms are likely in January and February, as rain falls into colder air near the surface, which cools it so that it freezes on contact with the ground.

Rain intensifies life in buildings. Shelter obviously becomes more important, especially in storms, which can make the sense of inhabiting a safe place more reassuring and thus increase the affection for places that have protected us. "When the shelter is sure, the storm is good." Gaston Bachelard quotes Henri Bosco in Malacroix:

> "The house was fighting gallantly. At first it gave voice to its complaints; the most awful gusts were attacking it from every side at once, with evident hatred and such howls of rage that, at times, I trembled with fear. But it stood firm. From the very beginning of the storm, snarling winds had been taking the roof to task, trying to pull it off, to break its back, tear it into shreds, suck it off. But it only hunched over further and clung to the old rafters. Then other winds, rushing along close to the ground, charged against the wall. Everything swayed under the shock of this blow, but the flexible house stood up to the beast. No doubt it was holding firmly to the soil of the island by means of the unbreakable roots from which its thin walls of mud coated reeds and planks drew their supernatural strength. Though the shutters and doors were insulted, though huge threats were proferred, and there was a loud bugling in the chimney, it was of no avail. The already human being in whom I had sought shelter for my body yielded nothing to the storm. The house clung close to me, like a she-wolf, and at times, I could smell her odor penetrating maternally to my very heart. That night she was really my mother. She was all I had to keep and sustain me. We were alone." [1]

With uninviting weather outside, edges take on more significance, as people seek to get close to that which limits freedom. Windows and porches are the limits of territory we control, and they put us in close association with the enveloping rain. What happens beyond this edge can provide graphic evidence of the effects of rain, as it splashes on pools and puddles; beads and streaks on the window glass; or falls from the eaves. Steady rain can engender a sense of melancholy and contemplation, distancing us from everyday activity and concerns. It seems to slow down life.

> "Montpelier. Six hours of rain here have cloistered us in the hotel. We huddle together like chilly animals, we try to create something homelike.....I pause, not knowing what melancholy words to cover this white page with....The wall opposite, the gray wall that I see through the window, streams with water, and the rain pipe sobs. I wish for the hot tea, the golden loaf, my lamp and its milky shade....and the barking of my dogs, left behind in Paris, the friendly tinkling of the familiar door bell." [2]

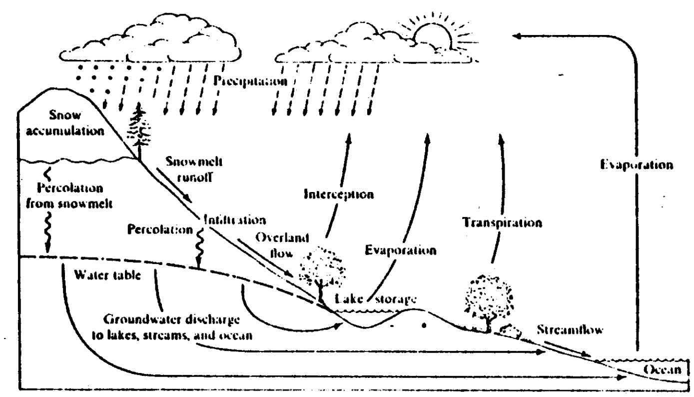
Movement outside becomes more hurried, focused on one's path across the inundated earth with its unexpected puddles. People huddle under umbrellas, or dash about, not paying attention to the visual environment, as the senses of touch, sound, and smell becomes more vivid. Reaching one's destination is a relief, and the shelter offered by porches and wide overhangs gives space for this relief, for relaxing after having braved the storm.

And after a rain, all is changed again. The world glistens, looks clean, fresh, colors are intensifies. Puddles reflect the bright sky. We are survivors of a natural force. The rain has been an event, a special occasion, which announces the presence and pervasiveness of nature in the man-made world we think we control.

Weather

Rain is a manifestation of nature, one element in the chain of interconnected processes which make life possible. The designed environment could be a means for expressing the connection between rain as a process of nature, and ourselves who are dependent on it. Buildings and landscaping must take into account rain as a problem, but they could also incorporate response to rain as an opportunity to demonstrate our respect for, and cooperation with nature. Towards this end, it seems appropriate to establish the place of rain in the natural system known as the hydrologic cycle.

The hydrologic cycle is a continuous loop of water changing its form; evaporated from the sea, carried through the atmosphere as water vapor, and formed into clouds which bring rain. When rain falls, most of it is soaked into the ground, some is evaporated back to the atmosphere, and some is taken by trees, to be gradually sent up through the tree and evaporated from the leaves. Water on the ground either runs into the soil to recharge the ground water supplies, or stays on the surface in streams and rivers. Eventually the running water reaches the sea again, to be incorporated into another loop of the cycle.



Clouds are the visible evidence of the airy segment of the hydrologic cycle, distributing water above the earth, and delivering precipitation when conditions are right. They are formed when moist air is forced upward, condensing the water vapor in the air into miniscule water droplets or ice particles. These gather on even smaller particles of soil, pollution smoke or ocean salt suspended in the atmosphere. If the cloud is still forced upward after formation of the cloud droplets, further condensation occurs and precipitation forms. The purity of rain water is the result of the relatively large amount of pure water vapor a small particle can attract.

Cumulus are individual clouds formed by upward motion of of moist air into domes. They are sometimes generated when some warmer spot on the ground, such as a pond, heats a small volume of warm air which begins to rise. As it rises it condenses water vapor into cloud droplets and the heat released by condensation helps it to rise faster. Cumulus appear singly, or in unconnected crowds, usually with level bottoms and billowing tops. When they reach heights which force enough condensation, rain is produced, and they are referred to as cumulonimbus, the cause of summer thunder showers.

Stratus clouds are arranged in flat layers, and often appear as a gray uniform sheet. They are larger in extent than cumulus, the product of lifting on a much larger scale. If raining, they are nimbostratus. Massed cumulus clouds in a layer are called cumulostratus, likely to bring precipitation as they are the product of mass lifting into an unstable environment aloft, which will pull up warm moist air into the clouds.

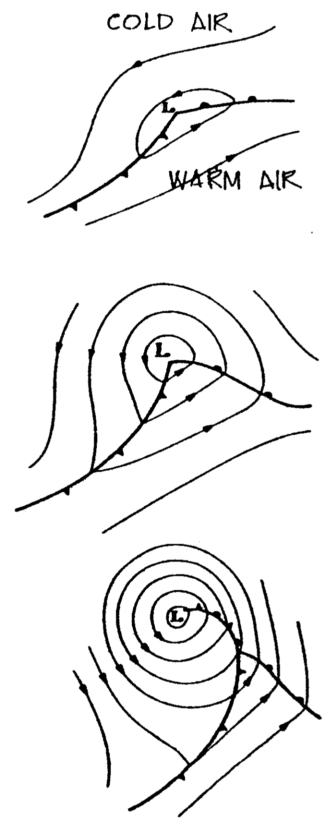
Cirrus clouds are mostly ice crystals, in wispy patterns at high altitudes and seldom have precipitation associated.

Most clouds don't produce rain, but if certain conditions change the cloud's environment, precipitation occurs. They may be forced up into higher, colder air which makes condensation into rain easier, or the air temperature may change suddenly to cause condensation. Precipitation usually begins as snow, because of the high altitude of most clouds, then melts to fall as rain.

Three scales of processes can bring rain to the middle latitudes with which we in the northeast are concerned. One is that of individual clouds such as cumulonimbus, which are formed occasionally in local conditions, and may cause brief showers and thunderstorms. The next scale involves daily cycles such as sea breezes or mountain and valley winds, with attendant precipitation. The third, and most effective rain generator is a pattern of continuous large storms called cyclones and anticyclones, which pass over an area every 3 to 4 days. They are part of the earth's attempt to even conditions between the excess solar heat at the equator and the cold polar regions which radiate more heat to space than they collect. Equalizing these differences is a chain of events which set the general climatic patterns of the world.

Heated moist air at the Equator rises, and in doing so condenses to form tropical rainstorms. The hot, dry air rises and flows north in the upper atmosphere, to descend at about the 30th latitude, causing most of the deserts on the earth. The air then returns across the water as the trade winds, picking up moisture as it approaches the Equator to start the cycle again. This north-south ring of circulation is modified by the rotation of the earth, which causes the winds to travel in a northeast - southwest direction. This warm air must be transferred still farther north across the middle latitudes (30° to 60°) to reach and mix with arctic air in order to even out temperatures. Steady flows such as the trade winds are not as efficient in this zone, because the increasing curvature of the earth varies the amount of solar heat falling on the surface, making conditions less stable. The exchange of heat and cold takes place as masses of warm air from the south and cool northern air slide past each other, often clearly recognizable as warm front or cold fronts. Temperatures across the front differ sharply but the temperatures within the warm or cold air masses are fairly homogeneous.

A general front between cold polar air and warm tropical air, continuous around the northern hemisphere, is always being modified as pockets of cold air hundreds or thousands of miles across advance to push warm air before them (a cold front) or warmer air pushes northward into the cold air mass (a warm front). These fronts cause much of the rain we experience, as cold advancing air pushes the lighter, warm moist air up, causing condensation and rain, or as advancing warm air rides up over the cold air it is pushing before it. An area of low pressure develops when the warm air pushes into the cold front, and winds develop in a counterclockwise direction around the low. The warm air following the low pressure area pivots around the low into the colder air, and the cold air on the other side of the low pushes down, so the circulation is like two opposite hands on a clock. The cold air moves faster and eventually overtakes the warm front to neutralize it. These cyclones last from one day to a week but usually have a duration of 3 to 4 days.



So we see that rain has its own cycles, 3 to 4 days at the scale of the large weather front, and one day at the smaller scale. But it is not a regular pattern predictable as is the rising of the sun or the changing of the seasons. It is idiosyncratic, dependent on what happened just before, modified by what is happening a thousand miles away. Rain never becomes part of the routine, but is always out of the ordinary, unexpected.

Geomorphology

Rain is the chief agent of change in the natural landscape, providing moisture to weather rock into soil, raindrops to loosen and move the soil, and running water which transports and deposits soil and rock particles. These particles cut still further into the rock in their path. Geomorphology is the study of these processes.

> "Constantly working on the water are two main driving forces: (1) solar energy, which causes evaporation from land and sea surfaces and through the action of winds moves water vapor great distances, and (2) the attraction of gravity, which causes water to flow downhill.
>
> As long as energy-laden sunlight continues to arrive on the planet earth, the hydrologic cycle will provide running water, which as a continuous agent of erosion, produces change in the interface zone of land, oceans, and air." [3]

Weathered soil is distributed by running water, which initially flows down slope in a sheet across the surface of the ground, then forms itself into small rivulets to travel around obstructions. These small channels, at first parallel to one another, gradually merge into several larger channels favored by small topographic differences, with enough power provided by the accumulated water to cut themselves deeper, and extend themselves up and down slope. As the banks of these channels erode, more rivulets are captured, and the channels widen into valleys, then merge again into larger valleys to form stream or river basins. Other land forms are created where the streams are slowed, either as they enter the sea or at obstructions in their path. The slower water can no longer carry the eroded soil that is suspended in its flow, and drops it as sand bars, flood plains or deltas.

Streams gradually cut their valleys to shallower slopes, and cut upslope until they meet the edge of another valley system. Valleys require water for erosion and this ridge where they meet defines their edges, because neither gets enough water from the meeting point to cut further. So stream drainage patterns emerge and gradually all land belongs to one or another drainage basin, defined by its limiting ridges.

Vegetation slows erosion of valleys by helping them hold steeper slopes. Plants are essential to nature's general tendency to reduce extremes: trees slow down the velocity of raindrops, reducing their force, and leaf litter and underbrush slow the water's path downslope. Water is held on the surface, and given time to soak in, emerging farther downstream, and much later, as springs. Thus, nature reduces as much as possible the threat of floods.

The cutting of stream valleys is the most important and visible determinant of landforms as they appear in the landscape. Forces at the continental scale are necessary to provide the potential for stream formation. The earth's crust is composed of enormous shifting plates of stone, floating on the molten interior core. These <u>tectonic plates</u> are continually sliding against and over each other, causing enormous shears and cracks at and near their edges, which we see as mountain ranges. Other parts of these vast slabs are compressed by the weight of glaciers, or warped by the weight of layers of ocean sediments. Mountains, sloped plains and the broken surface of rock layers give direction and structure to the drainage patterns of the land, either compelling water to run off directly downslope, or modifying the path of runoff to correspond to faults in uplifted and exposed rock. In addition to setting drainage patterns, these larger earth forms modify climate to allow more or less rainfall in certain areas.

The natural processes at work in modifying the natural landscape also attempt to modify man's works. If we understand the processes we can cooperate with nature instead of fighting an expensive battle for control of the landscape.

Water

To understand rain, it will be helpful to understand the processes and symbolism of water at scales that relate to rain as a water source.

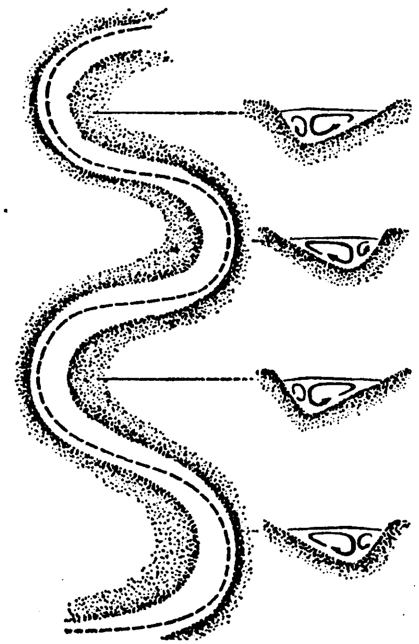
Water is a contradictory force, at times a powerful ally, at others a destructive enemy. It is nature at its most elusive; totally changable in form, but unfailingly obeying its own rules. Taking any shape in which we can constrain it, it never surrenders its essence: freedom from shape. Unlike earth, which may be molded and formed, water works to free itself, to obey gravity, to move and escape.

> "Wherever water occurs it tends to take on a spherical form. It envelops the whole sphere of the earth, enclosing every object in a thin film.

Falling as a drop, water oscillates about the form of a sphere; or as dew fallen on a clear and starry night it transforms an inconspicuous field into a starry heaven of sparkling drops. We see moving water always seeking a lower level, following the pull of gravity. In the first instance it is earthly laws which cause it to flow, draw it away from its spherical form and make it follow a more or less linear and determined course. Yet water continually strives to return to its spherical form. It finds many ways of maintaining a rhythmical balance between the spherical form natural to it and the pull of earthly gravity. A sphere is a totality, a whole, and water will always attempt to form an organic whole by joining what is divided and uniting it in circulation. It is not possible to speak of the beginning or end of a circulatory system; everything is inwardly connected and reciprocally related. Water is essentially the element of circulatory systems. The cycle through the solid, liquid and gaseous phases may be counted among the best known circulatory processes of water. Rising from oceans, lakes and rivers, it circulates with the air in the great atmospheric currents round the earth. Where it enters cooler zones, for instance when rising to pass over a mountain range, it contracts into clouds and falls back to earth as dew, rain snow or hail."

Theodore Schwenk
<u>Sensitive Chaos</u>

The meandering course of streams and rivers is an example of the compromise between the imperative toward spherical form and the pull of gravity.

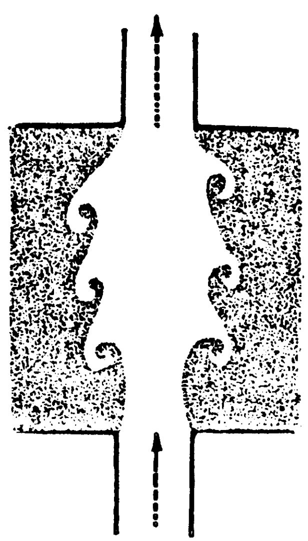


> "Looking at a naturally flowing stream we notice the winding course it takes through the valley. It never flows straight ahead. Its endeavor to complete the circle is here only partially successful, as it cannot flow back uphill to its starting point." [4]

Water is revolving within the downhill flow, as edges are slowed by friction, and the center moves more quickly. The interface between the two induces a spiral motion in the flow, and this spiral movement causes the stream to force itself from bank to bank, and generates the bends in its course.

The vortex is an extension of the spiral movement of water, occuring when two differing properties of a liquid, such as fast and slow, or warm and cold, come together. The form of this merging is a series of spirals.

> "At the surfaces of contact there is always a tendency for one layer to roll in upon the other. The water acts as a sense organ which perceives the differentiation and then in a rhythmical process causes them to even out and merge..." [5]



Whirlpools are extensions of the processes of vortices. Falling sheets of water also tend to curl in at the edges, and streams of water soon separate into drops.

The same spiraling principle that operates in cyclones to even out temperature differences is thus also at work in many of the scales of water movement, from ocean currents to the mixing of different streams of liquid, and falling water.

The meanings and associations that we have with rain are partly dependent on our associations with water.

> "Some of the power of water, in myth and ritual, surely lies in its ability to keep its identity, so that the water in a tiny stream is related in our minds to the water of rivers and rains and the sea, through all the world."[6]

Water is associated with the sea, indifferent to man, vast and eternal. The sea gives to water a quality of being infinite.

At the most intimate and individual scale, water draws us to its edges, to streams and ponds and beaches; and we wish to be closely associated with it. Thus, water suggests both intimacy and infinity.

> "Its symbolic content is rich to the point of paradox: on the one hand, water, as the source of life is a symbol of fertility; on the other hand, water the cleansing agent, is a symbol of chastity and purity. On one hand water the source of life becomes a symbol of life; on the other hand, water becomes a symbol of death and then of rebirth. On the one hand flowing water has from man's early history symbolized the passage of time; on the other hand water in the sea suggests timelessness. On the one hand water is the symbol of immediacy, of contact, even of sexuality; on the other, of limitless distance."[7]

Water can provide the setting for reverie, when its' flows, ripples, or splashes take one's mind away from everyday life, and into daydreams or deeper thoughts, or just a mental release and relaxation. The soft noise of falling water gives a natural background of gently varying sound, masking city noises. Water of great power, such as waterfalls or the edge of the sea bring on feelings of awe and excitement.

An understanding of rain provides many possible avenues which can be developed to add richness and meaning to the built environment.

It changes the moods and attitudes of people; connects them with nature, and exposes them to a powerful substance, water, which has strong associations itself. It integrates many of the processes of nature by revealing the occurrence of spiraling forms, and adds vitality and liveliness to the atmosphere.

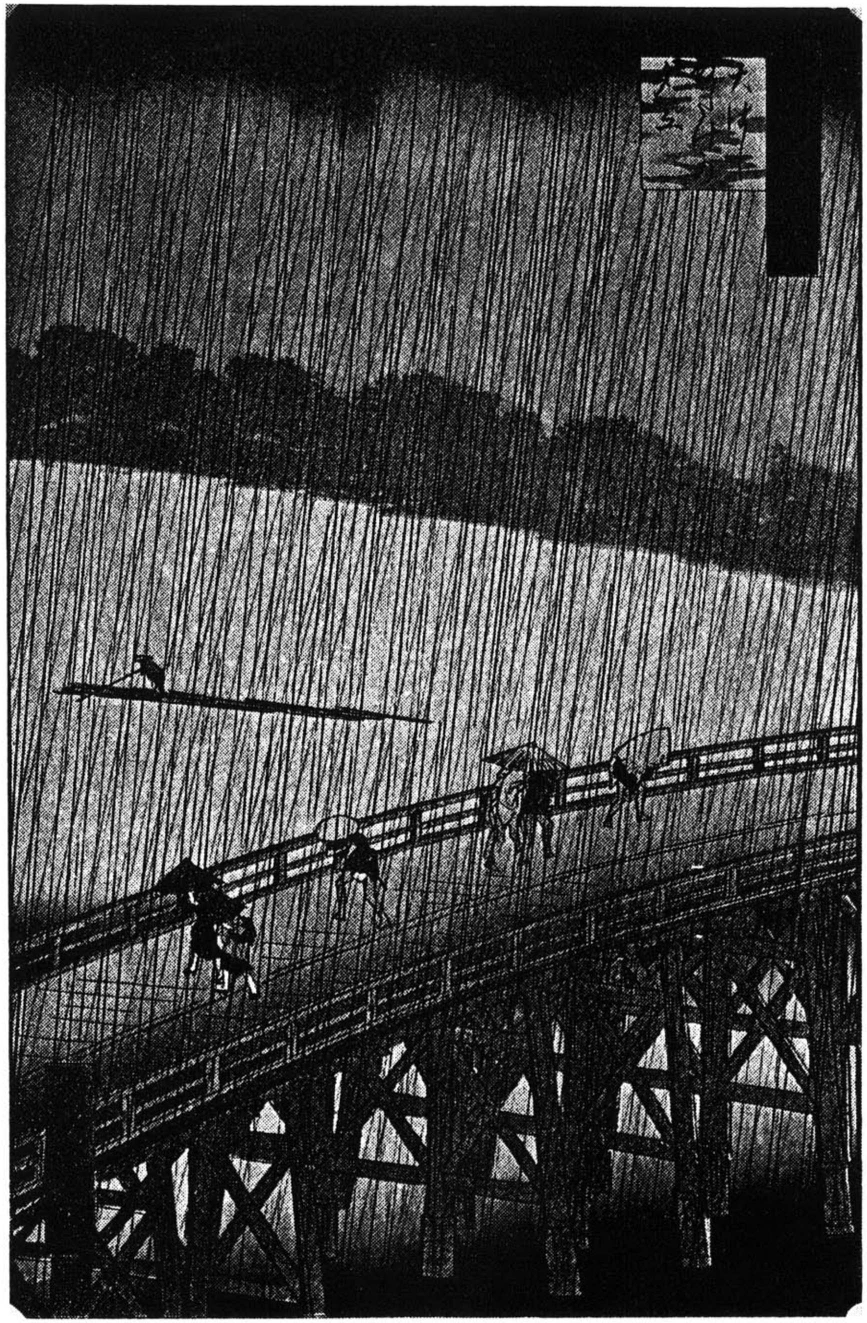
With this background understanding of rain as a phenomenon in itself, this study will focus on rain as it affects (and is affected by) buildings and the man-made landscape.

2. Rain and Architecture in the Past

Perhaps the most valuable source for the images of physical form that will be suggested in this thesis was the process of establishing a collection of references from the past about rain and water. Materials and methods required a careful and forthright response to the rain, which often led to delightful treatment of rain elements. Weather was always a direct concern of people who had limited means for modifying it. It seems important to bring weather back into the consciousness of people today, so that its variety and vitality add to our lives.

Technology has made it possible for us to ignore rain as a force in shaping buildings, and in the process we have lost the richness that comes from recognizing more subtle possibilities for weather adjustment. One way back to the appreciation of weather might be to exaggerate our response to rain, to make gestures which associate people with the idiosyncracies and charms of the weather. A guide to this exaggeration can come from the highly developed responses to rain necessary in the past.

This chapter records references that were especially evocative. They are not presented in any particular order, but are offered to help set a tone of appreciation for the possibilities for rain on built places.

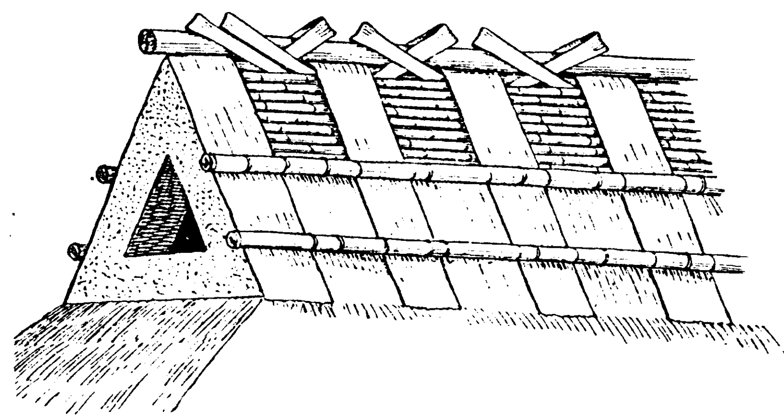


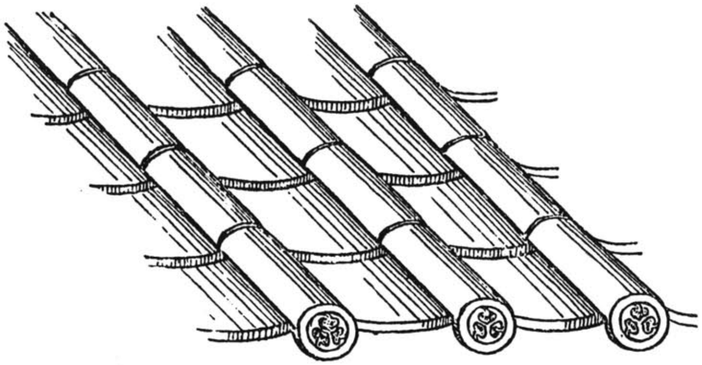
60. *Squall at Ōhashi*, from *"One Hundred Views of Famous Places in Edo"* ◆ ōban ◆ published by Uwoei ◆ 1858 ◆

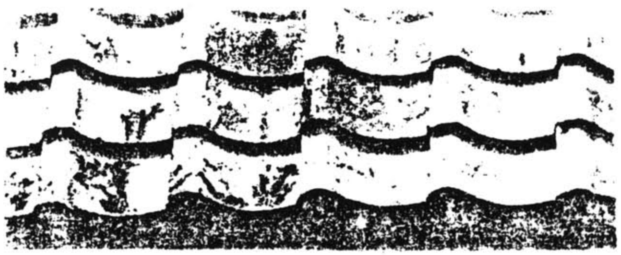
The nineteenth century Japanese printmaker Hiroshige was known as the artist of rain, for his ability to record on paper the quality of the environment during rain: the density of the atmosphere crosshatched with streaks of rain, lowering clouds and fading light, and the attitudes of people caught outside, shoulders bowed, under umbrellas, running for cover or huddled in shelters watching the storm. Throughout his work is an interest in the ephemeral sense of changing seasons. This inclusion of the weather in the enjoyment of daily life is also manifest in Japanese architecture and gardening. Materials are used in their natural state, or without elaborate finishes, so that they are affected by rain; wood darkening when wet, or stone glistening and holding water in recesses in the surface. At Ise Temple is a sand mound which is under the care of one priest, who carefully forms the mound each morning, and then leaves it to record the changes during the day as rain falls on it, or leaves are blown across, or birds walk on it.

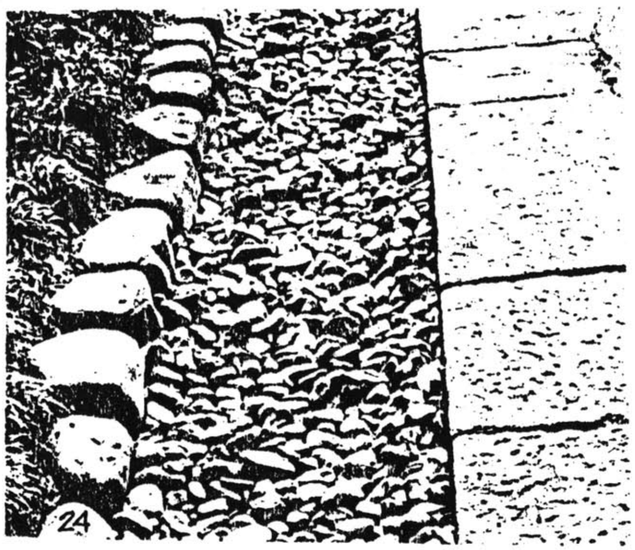
In traditional Japanese building, graceful forms acknowledge the rainy climate - roofs are dominant, giving a sense of shelter, while the walls are light screens protected by verandahs, and the building is lifted off the ground on posts.

Roof materials are thatch, tile or wood shingle, invariably topped by some sort of decorative ridge. In thatch roofs, the ridge is often of wood or tile, or thatch at a steeper angle, referred to as a ridge-roof by Edward S. Morse,





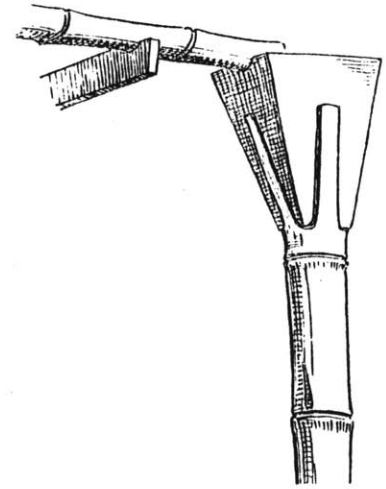




whose book *Japanese Homes and Their Surroundings*, first published in 1886, is one of the best documentations of traditional domestic architecture. Gable ends were often open for ventilation and to let out the smoke of the cooking fire. Thatch roofs were uniformly steep, between 10 in 12 and 12 in 12 pitch, and straight, in contrast to tile roofs which often copied the Chinese models with upswept eaves. Tile roofs were usually formed with separate ridge and valley tiles, deeply profiled to reflect their function as water channels and give visual importance to the roof. Some tiles incorporate both ridge and valley in one, with a profile like parallel waves, as on the garden wall at Ryo-anji Temple. Walls were often protected by their own roofs, extending the domestic scale to the gardens and street edges. Special eave tiles end the roof in round caps, thickening the eave.

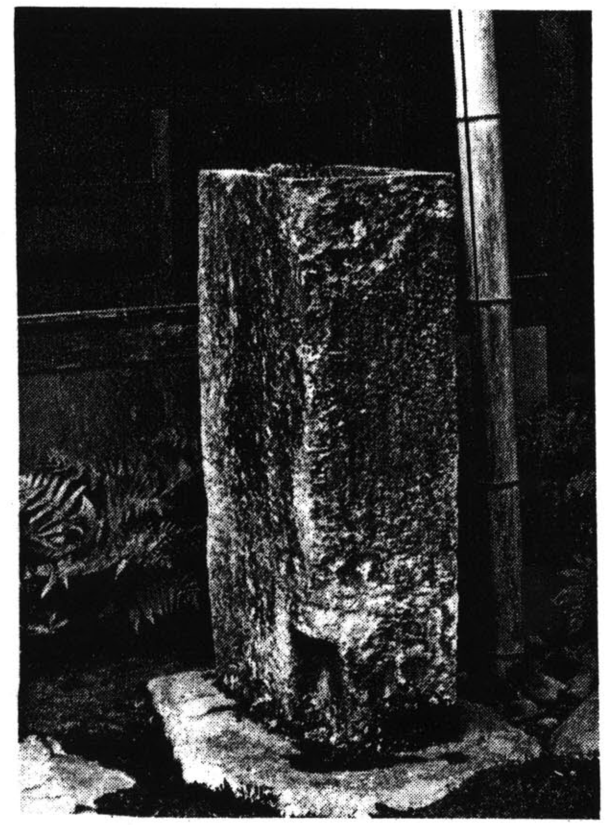
In thatch roofs, the eave is thick and irregular, and rain penetrates partway into the reeds, so it is difficult to position a gutter to catch runoff. Water is allowed to drip off the edge and fall to the ground onto a path of gravel,(often bordered by rectangular stones) that follows the eaves. At the Imperial Palace in Kyoto, this path is a strip of stone gutter, sharp against the field of raked gravel in which it *is* set.

Where gutters were used, bamboo was split lengthwise, and the internal partitions knocked out to form channels. Brackets were either wood slats nailed to the rafters, with notches to hold the gutter, or steel straps nailed to the rafters, or driven into rafter ends. Often the bamboo gutters extended beyond the roof, to drop rain water in a stream far from the walls. Examples are seen in which two hip roofs of different heights each have a gutter, one bypassing the other, or the higher one emptying into the lower. When gutters were connected to conductors carrying the water to the ground, the wood box of the conductor was notched to support the gutter. Occasionally the conductor was attached to the building. but more often a freestanding vertical bamboo pole with the partitions knocked out was sunk into a dry well filled with stones.



> "The upper end of this bamboo is cut away in such a manner as to leave four long spurs; between these spurs a square and tapering tunnel of thin wood is forced, - the elasticity of the bamboo holding the tunnel in place."

<u>Japanese Homes and Their Surroundings</u>



The dry well into which the conductor empties is often similar to the chodzu-bachi, an arrangement of stone reservoir and pebbles that accomodates hand washing. This consists of one boulder with a bowl shaped carved out to hold water, and at the foot of this stone, several buried stones or tiles enclosing a pit of small rocks or gravel which allow the used water to run into the ground. In one case, the gutter drops water into the reservoir stone, from which it overflows onto the small stones. In another, the bamboo downspout is sunk into the pebbles of the chodzu-bachi itself.

Japanese gardens have ponds if possible, on which seasonal change is registered; rippling under the wind, reflecting sky and clouds, and showing the concentric patterns of raindrops expanding across the surface of the pond. In the Imperial Garden at Katsura Palace, a stone lantern called "night rain lantern" lights the surface of a pond, making rain visible at night from the verandah. When no water is available, a dry cascade is often built, using stones and gravel or moss to suggest the movement of water. A vertical stone with a rough but fairly flat surface is flanked by two boulders, which contain the "waterfall" of the vertical surface, while rocks under this represent splashing water, and gravel or moss make the pond.

The overhang of the verandah makes it possible to leave the inner screens open during interesting weather, so rain or snow or wind rustling the leaves can be enjoyed while going about household activities. Small rustic pavilions in the garden, either on posts or having two walls forming a corner, provide shelter for sitting in the midst of the garden, to enjoy the weather more directly.

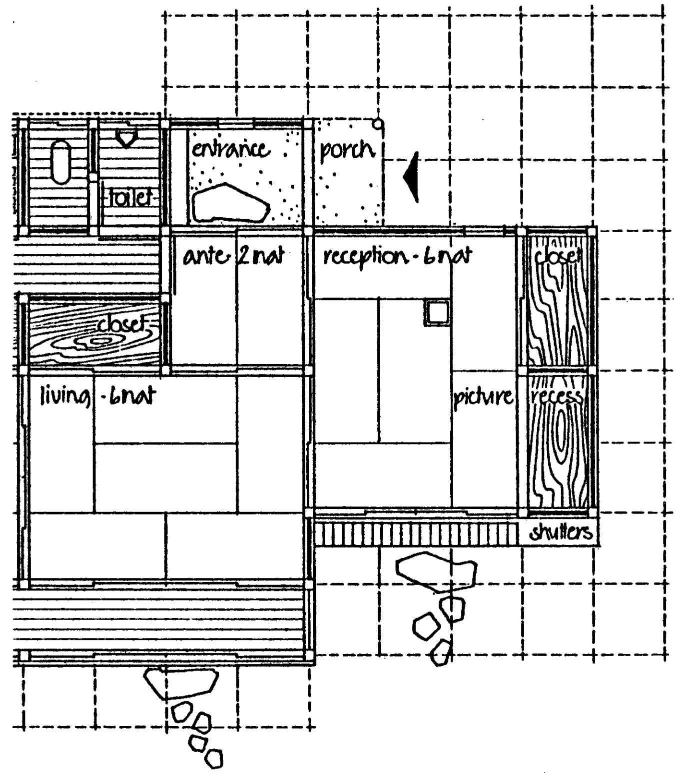
Entering a traditional Japanese house on a rainy day involves a distinct progression from wet to dry. First the visitor comes under the roof at an entry where the verandah deck has been omitted. Still on the ground, but under cover there is room to fold umbrellas and remove rainwear, then step up onto a stone in front of the platform of the house. Here one leaves the geta - high platform rain shoes - and then steps up barefoot onto the dry mats of the home, to see through large protected openings into the garden and the rainy world just escaped.

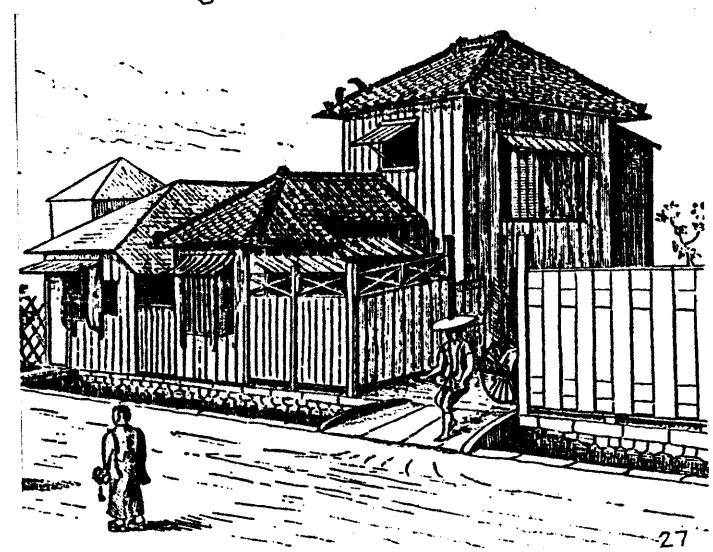
The culture of Japan attempted to accept and merge with the processes of nature, and therefore welcomed weathering and the change of materials through time. Wood surfaces were often unfinished so they were darkened and stained by rain, and moss, lichen and grasses were encouraged on thatch and shingle roofs. Nail heads rusted and streaked walls and fences.

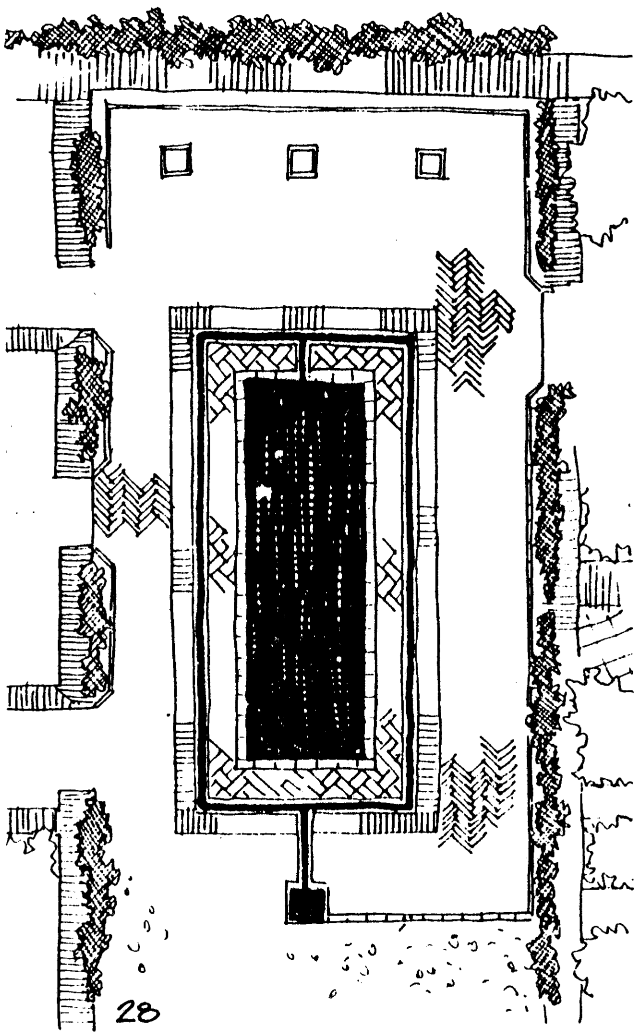
The transient changes in the environment caused by rain were incorporated by providing surfaces such as pitted stones, that capture small pools of water, or smooth pebbles that shine wetly during and after a rain.

Water channels paralleled the streets, carrying away rainwater and kitchen waste in cities and towns. In some small villages these stone lined ditches were used to supply domestic water. Stone or wood bridges cross them at the entry to each house, increasing the sense of inward focus of the houses.

In Persia water was also channeled through the streets, though on a grander scale which also set the social organization of the city. From horizontal wells dug at the base of the nearby mountains, the city of Isfahan was supplied with water. The Royal Palaces were built nearest the mountains,







and water flowed through the Royal Gardens first, when it was purest. Then each social class was housed in descending order, each receiving less pure water than the one before it. The channels form four parallel courses along the main street as they pass through the commercial heart of the city, separating pedestrians and cars, and providing water for the lines of trees alongside them. The water washes debris off the street and cools the air. Finally the water is used for irrigation of crops below the city. The Khaju Bridge at Isfahan crosses a river whose flow fluctuates greatly between dry and rainy seasons. Built in the 17th century, it is designed so that even in the low flow of summer, one of the channels under the bridge is deep enough to capture all the water flowing in the river, and concentrate it to provide the sound of running water even in the driest times. Steps between the water passages allow people to sit beside the cascading streams.[8]

The Moors, who imposed their culture from Africa and Asia on Spain in the 7th to 14th century, left palaces remarkable for the great effects obtained from the sparing use of water. Narrow rills direct water through paved plazas, where it ripples and murmurs as it runs quickly through the shallow, steep passages. The channels are laid out to provide as much length as possible, often doubling back on themselves.

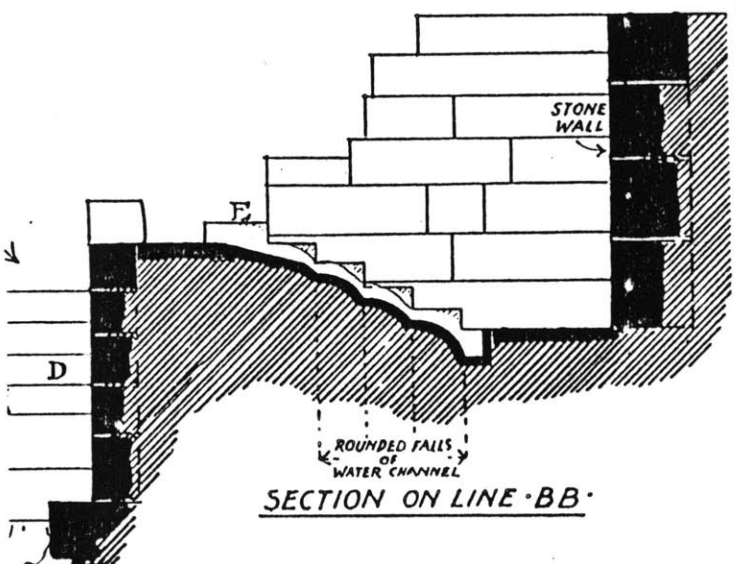
In shallow pools it overflows across wide curbs to spread its surface area. Glossy tiles in and around the pools increase the apparent size of the pools. Jets in the fountains are designed to look as if they have been shaped by the water forcing through them, so that even when not spraying, they are reminiscent of the jetting of water.

At the Generalife, summer palace of the Moorish kings at Granada, a stairway leads from the hillside above to the gardens below. Standing at the top of the several flights of stairs, the view down shows a fountain at each landing, so that water accompanies the trip down, in larger steps, while the balustrade along the sides is carved to carry a stream of water down under the hand of the visitor.

In the court of the Oranges, at the Mosque of Cordoba, the Moors used stone paving and orange trees to continue the

geometry of the regular columns of the mosque into the open. The entire square is criss-crossed with narrow, paved ditches connecting small basins from which the orange trees grow. Water is directed to each row of trees separately by means of small wooden dams which slide into grooves in the side of the channels. One man can move up the main channel, sending water to each cross axis in turn.

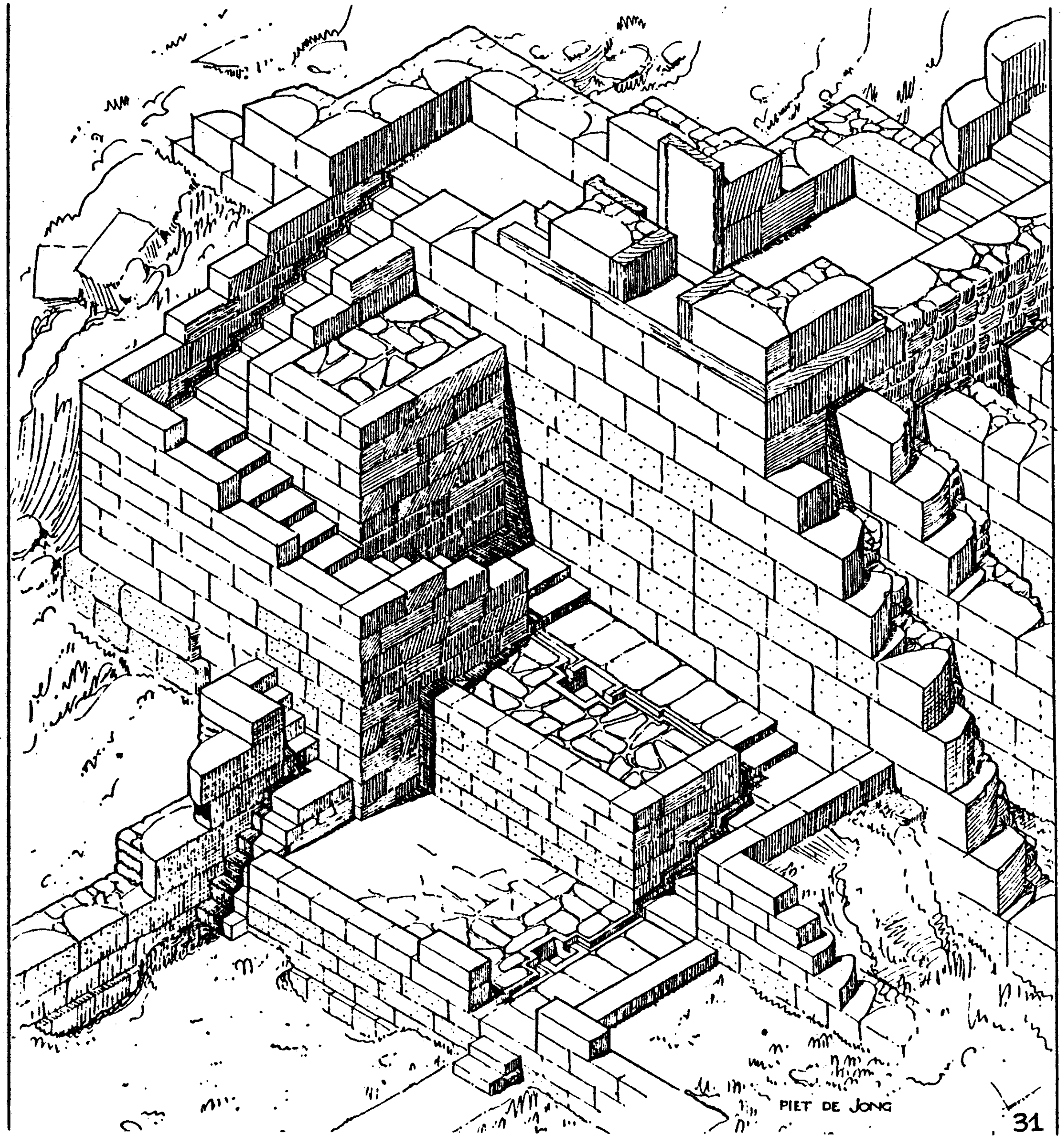
The Palace of Minos, on the island of Knossos, Greece, revealed to archaeologists a remarkable piece of rainwater engineering. Along a stone stair on the northeast bastion a channel had been cut to follow one side of the stair through several flights and changes in direction. The stairs and landings all sloped slightly to the channel so it could carry away rainwater. The bottom of the channel, if sloping with the stair steepness, would have accelerated the water so that it would splash out at the landings where the water had to change direction. So the Minoans cut the bottom into a series of convex parabolic falls, each one corresponding to a step, which allowed smooth flow without building up speed.



SECTION ON LINE ·BB·

> "For enabling the current to pass round these abrupt angles in its course without splashing over the pavement beyond, the retardation of its velocity by the curving course of the channel was a most efficacious method. The curves themselves almost exactly agree with the natural parabolas that the water falling down a slope of such an angle would execute, and the additional friction due to the increased length of its course neces-

Northeast Bastion
Palace of Minos, Knossos
Greece

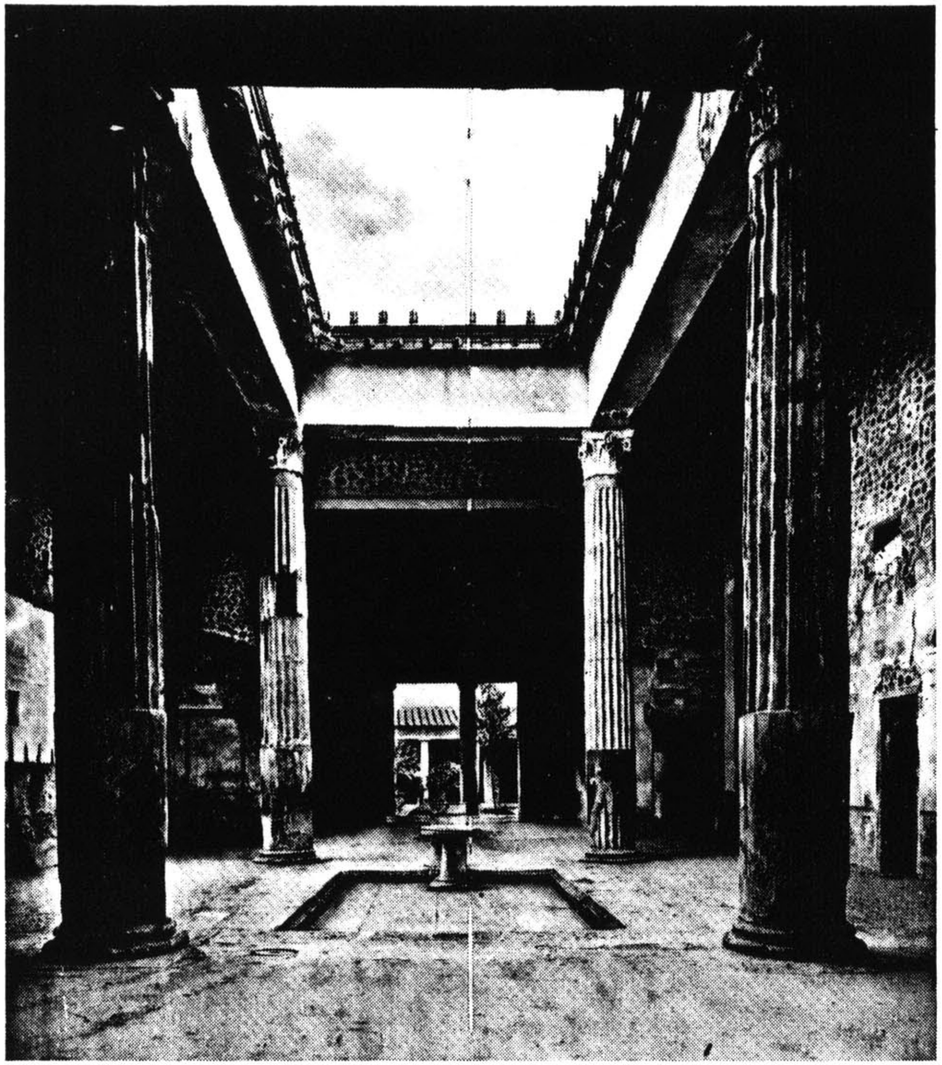


sarily diminish the speed. It has been calculated that the water reached the bottom of the flight with about half the impetus that it would have attained had it poured down the slope in a straight line instead of a series of leaps. The current thus reached the critical point - namely the sharp turn at the foot of the flight - with such diminished force as to enable it to pursue its changed direction without shooting over its border."

Arthur Evans
The Palace of Minos, Knossos Vol. III

In the middle of the channels, as they pass across the landing, is a structure which causes the water to go through a double bend designed to slow the water as it passes over a deeper rectangle, so that sediment settles out of the slowed water into this basin. After passing down several flights and landings in this manner, the rainwater is collected in a cistern, presumably for use in washing linens or other processes requiring mineral-free water.

In the excavations at Pomeii, homes were discovered with a central open court, or compluvium,open to the sky, with the roofs of the surrounding rooms sloping toward it. The roof was held by four or six columns at the edges of a shallow basin, called the impluvium, where rain from the roof was gathered for storage in cisterns. The roofs drained through gutter spouts at about one foot on center around the edge of the roof opening. During a rain, twenty or thirty streams of water jetted into the pool, in addition to rain falling through the opening above.



Pompeii's streets are well known for the stepping stones which allowed carts to pass between, while pedestrians walked on the raised stones, keeping themselves out of the rainwater running in the streets.

European squares and urban spaces were developed with concern for drainage and the opportunities presented by water, paving and large numbers of people.

> "St. Mark's Piazza, in Venice, derives its character of vast outdoor drawing room in part from the horizontality of its floor. But if the pavement were really horizontal it would be a shallow, mossy lake. Instead, the linear paving pattern, apparently only decorative, establishes the horizontal plane strongly enough so that the darker pavement between the lines can slope unobtrusively to the drains"
>
> "In the Piazza of St. Peter's in Rome, Bernini emphasized the non-horizontality of the pavement, with undulations which suggest the swell of the sea, complement the curve of his colonnade, and give thousands a chance to see over the heads of the people on the slopes around them to the Pope himself."
>
> \- Charles Moore
> Water and Architecture

At the Piazza Navona in Rome, the drains in the relatively flat pavement were stopped on Sundays, and the fountain overflowed to flood the square. Carriages rolled through the water up to their hubs, and people gathered around this new lake to watch and wade.

The entire plaza of the Campo in Siena, Italy is a huge drainage basin, with white paving strips radiating from the lowest area of the square, an ornate drainage orifice.

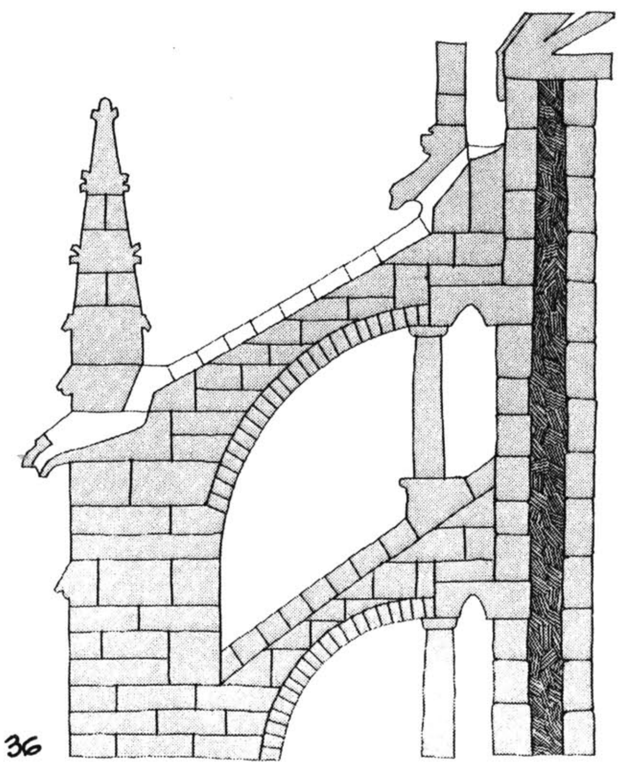
Bernini's Trevi Fountain, built in Rome in the seventeenth century, was conceived as a symbolic demonstration of the then newly discovered principles of rain and water movement over the earth. Oceanus, at the top, distributes water to the Tritons and sea nymphs, who disperse it across the land to sustain life, after which it flows back to the sea, represented by the pool below.

The fountain is carved into a natural seeming rock cliff, appearing to have been formed by the action of water. There is no optimum amount of water necessary for it to flow properly, as any amount, from trickle to cascade, works with the natural forms and seems to fit.

Charles Moore analyzed the increasing understanding of the effects of rain in medieval cathedral building. He compares the early Cathedral of Abbaye-aux-Dames in Caen to later works in which the master builders had an opportunity to study the effects of rain over time on enormous stone facades. The Cathedral was built of white Caen stone, with thin mouldings, and no overhangs where sloped surfaces met vertical walls. Soot and dirt were deposited on the slopes, and washed down the vertical slopes by rain. The shallow trim and decoration also collected dirt, but did not project far enough to be washed by rain, so the whole facade become streaked and gray.

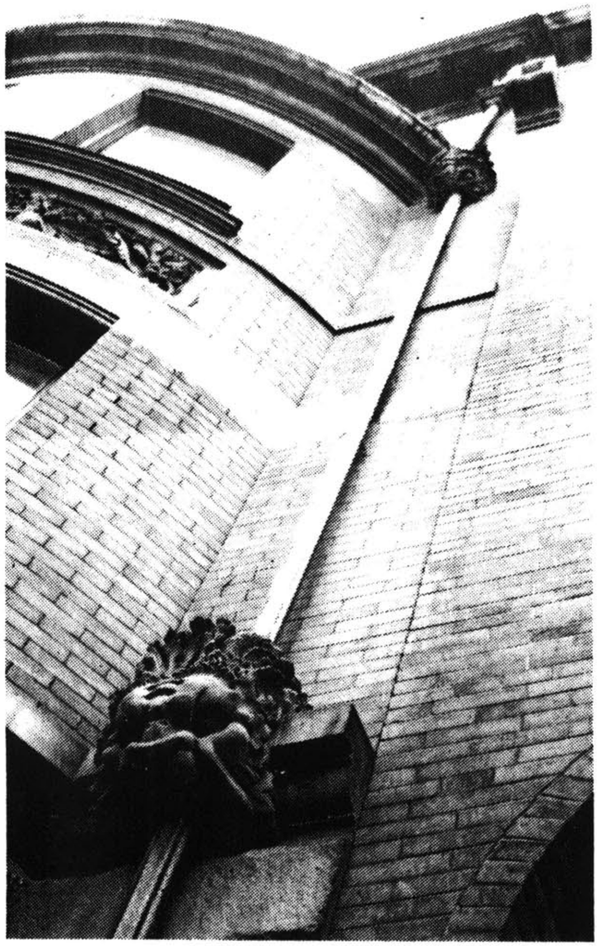
The builders of the Cathedral at Chartres, in the thirteenth century, benefitted from observations of the effects of rain on the older facades.

> "On the butresses at Chartres, the sloping surface projects beyond the vertical surface. This provides a neatly articulated joint between the sloping face, which will catch more dirt, and the vertical face, which will remain lighter. It also throws the accumulated rainwater clear of the vertical face, so that the wall does not streak. Then, as final touch, a thin shadow line just below the overhang, therefore out of the way of the water, restores the precision that the heavy shadow produced by the overhang might have lost.
>
> In the cornice now, the play of light and water are made to emphasize each other. The top molding, just under the parapet, is washed by the water and lit by the sun, so it makes a light line, not against the sky where it would be lost, but against the dark roof and walls above. It throws the water free of all the rest of the cornice except for the bosses, which project to where they can be washed white by the rain, the better to contrast with the shadows they cast. Just under the light top line is a deeply undercut moulding, dark from the dirt that lodges there, untouched by the rain, and dark from the shadow. Thin projections, almost vertical and therefore least affected by the weather, restore precision to the cornice. Over the window, bosses under a projecting molding thrust forward far enough to catch the rain, and are large enough so that their shadows are important." [9]



Runoff from the roof over the nave construction is caught at the nave wall in a large channel, which diverts it to the opening in the buttresses. It is then carried along the top of the buttress to the outer pier, through which it passes, emerging in a carved stone projection. These gargoyles might be grotesque monsters spitting on the town, or animals, or even comments by the sculptors, such as the figuresat Freiburg Cathedral, in which a human gargoyle "aims his backside in the direction of the Prelate's Palace - the sculptors protest, so local folklore asserts, against some greivance."[10] In another gargoyle at Freiburg, a beautiful girl cheerfully urinates from one of the towers. Most gargoyles were in the form of monsters, part bird and part dragon, said to ward off evil spirits. A forerunner was the lion's head spout often used in Egypt, in which the projecting head threw water clear of the walls, with the outstretched tongue channeling the run-off in a narrow stream.

In more recent times, the development of Boston's Back Bay neighborhood, built in the last half of the 19th century, used any opportunity to add expression and individuality to the facades. Rain conducting elements were developed as a decorative system, from pinnacle to downspout. The rain systems are distinguished by their use of copper, which has weathered to a soft green, standing out against the slate and brick of the buildings. Many townhouses have turrets crowned with copper needles, or serrated copper ridges. Gutters are used as horizontal mouldings at the top of the cornice, often in half round or ogee shape. They are sometimes



integrated into the stonework; water from the gutter passing into a projecting stone which in turn channels it to the downspout. A few of these stones are carved into the form of monstrous heads, which spit water into a downspout held in their mouths. It is more common for the gutter to empty into a leaderhead, a large, ornate receptacle atop the leader, or downspout. Leaderheads in the Back Bay are often embossed with dates or initials, or floral patterns. The leaderheads provide a larger dimension in the linear sequence from gutter to downspout, giving the system more presence on the facade.

Downspouts often are woven through projecting stone courses, thus integrating the two, and testifying to the consideration given the rain conductors in the facade's planning. The stone courses may be notched for the downspout to pass, or the pipe may go through a hole in the stone. On larger buildings, the downspout becomes a large box shape at the moulding. The back of the box is fabricated to the shape of the projection, while the front may have some other profile.

Brackets that fasten the downspout are also opportunities for decoration, large patterned sheets of copper fastened to the wall with heavy bolts. The brackets are like punctuation along the length of the pipe.

3. Rain on Contemporary Architecture

After gathering images and details from the past, I explored the attitudes toward rain that were built into more recent architecture. It seems, unfortunately, that most of the history of building which is our immediate legacy has not recognized rain as an opportunity for enriching the environment, but treated it as a nuisance to be eliminated behind the scenes.

In a broad sense, architecture may be seen as the built solution to three categories of tasks: climate, use program, and construction method. A fourth task, providing a meaningful environment, is dependent on the expression of the solutions to some of these tasks, selected by the architect for personal or cultural reasons. The solutions which are selected for presentation as the image of the building are an exposure of the architect's concerns and those of his society. For example the climatic problem, in effect the problem of man's interface with nature, is revealed as an important and meaningful issue in Japanese traditional building by the clear expression and visual prominence given to rain shedding and conducting elements.

The "Heroic" period of the Modern Movement, during the early part of the century, vehemently rejected ornament and style. Buildings were stripped down, to become ammunition

Frank Lloyd Wright to Philip Johnson:

"Are you still putting up little buildings and leaving them out in the rain?"

Quoted by Selden Rodman
Conversations with Artists

in arguments against the elaboration of earlier architecture. In the process, almost all expression, including climatic protection, was eliminated from visibility. The buildings expressed the frame, space enclosure, and some programatic differences. The work of Mie Van der Rohe and others continued this reductionism as the International Style. This aesthetic was adopted by the artists of commercial real estate, for whom the attraction of reductionism was more financial than polemical. Day to day and seasonal variations in weather and climate are not intentionally reflected in the buildings. If they are, it is because of a failure of detailing, which allows rain to stain the concrete, or rust to grow on the steel. About rain, sun, and snow they are dumb, making no adjustment or accommodation.

Today, architects are beginning to look beyond the International Style to an architecture that includes and expresses more of the tasks of architecture in a manner comprehensible to people. Herman Hertzburger wrote "It is not the outward form wrapped around the object that matters to us, but form in the sense of inbuilt capacity and potential vehicle of significance."[11] The argument of this thesis is that awareness of rain is one of the issues which will allow buildings to offer this "inbuilt capacity" for people to use and enjoy the built environment, and that consideration of rain can help us make buildings which are "vehicles of significance", embodying our cultural attitudes towards our place in nature.

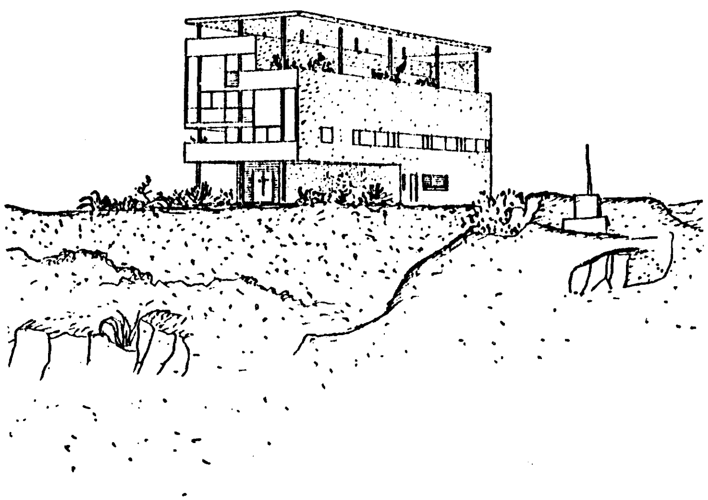
This chapter focuses on four architects whose work illus-- trates a progression towards designs that include more of the problems and possibilities of rain on buildings.

The work of Le Corbusier is studied through time, to trace its development towards an architecture conscious of rain and nature. Malcolm Wells is concerned with the ecological consequences of building; Herman Hertzburger builds in concern for use and gesture in his response to the weather. Finally a project by Lucien Kroll is discussed, as it includes both ecological concerns and provision for use and gesture which connect people to the environment and to each other.

Le Corbusier

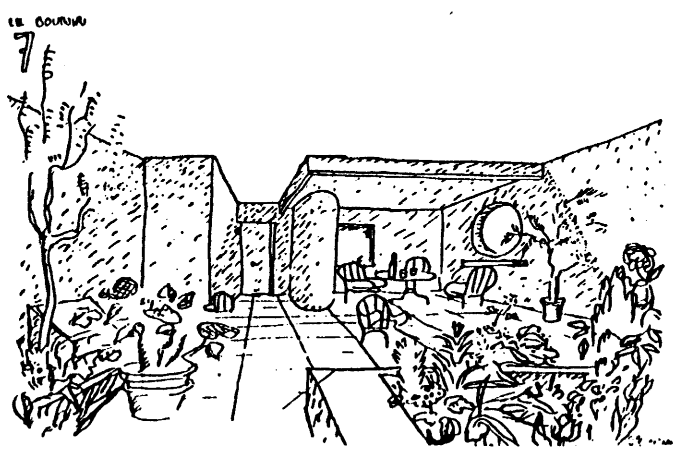
Seeking a harmony between clearly stated oppositions was at the heart of Le Corbusier's architecture. In his early villas, the opposition was between the simple white washed forms and their natural surroundings, as well as between the regulating cube and the free plan within.

Later of his buildings gradually mellowed, included more and more references to other conditions. The brise soliel was devised to mediate and celebrate the confrontation of sun and interior space. Materials became rougher, giving the natural weathering processes a head start, instead of expecting perfect planes to be kept glistening white. This development of Le Corbusier's work may be seen in microcosm in the changes



in treatment of elements related to rain. The early heroic buildings of the twenties and thirties were pristine objects, facades designed to be unaffected by weather, and conducting rain away unobtrusively after its use in watering the roof garden. Their flat roofs are a confrontation with nature, as opposed to a shed roof. Corbu's "five points of a New Architecture" set out his principles for design; the second, and longest, is concerned with roofs and rain:

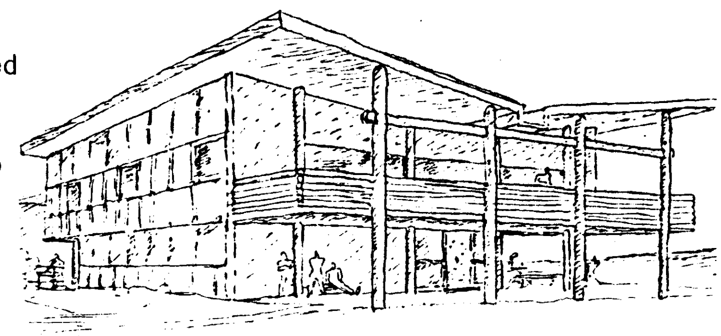
> "2. The roof-gardens: For centuries the traditional rooftop has usually supported the winter with its layer of snow, while the house has been heated by stoves. From the moment central heating is installed, the traditional rooftop is no longer convenient. The roof should no longer be convex, but should be concave. It must cause the rainwater to flow towards the interior and not the exterior.
>
> A truth allowing of no exceptions: cold climates demand the supression of the sloping rooftop and require the construction of concave roof-terraces with water draining towards the interior of the house.
>
> Reinforced concrete is the new means for realizing a homogeneous roof. Reinforced concrete experiences a great deal of expansion and contraction. An intense movement of this sort can cause cracks in the structure. Instead of trying to rapidly drain away the rainwater, one should maintain a constant humidity for the concrete of the roof-terrace and thereby assure a regulated temperature for the concrete. An especially good protection: sand covered by thick cement slabs laid with staggered joints; the joints



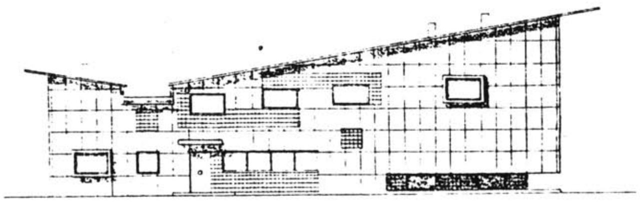
being seeded with grass. The sand and roots permit a slow filtration of the water. The garden terraces become opulent: flowers, shrubbery and trees, grass.

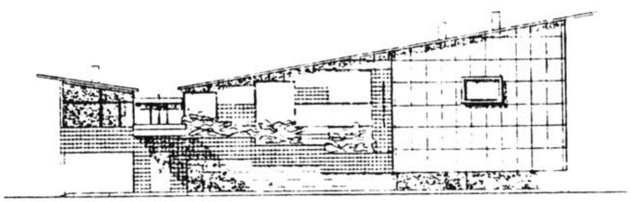
Thus we are led to choose the roof-terrace for technical reasons, economic reasons, reasons of comfort and sentimental reasons."

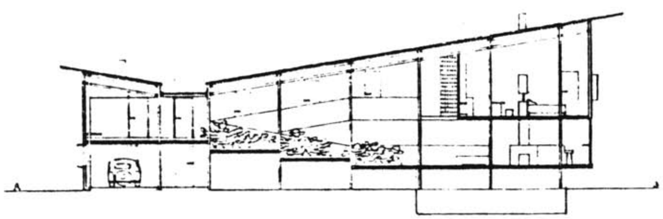
This "truth allowing of no exceptions" shows an intense interest in the problems of the weather, (leaving aside the dubious proposal for unwaterpro fed concrete decks.)



During the 1930's this style was modified, perhaps for cost reasons, to allow housing in which two oppositely sloped roofs drained to a central channel, roofs steep enough that they are clearly not intended for use. The rationale can no longer be that of holding water on the roof for plants, or temperature control of the concrete. The functional reason for this section is unclear, but it was an opportunity to project differences in plan into the section. The first house in which this device appears is the Maison Jaoul of 1937. Two halves of the roof divide the plan into two wings, childrens and parents'. Each has its own roof opening up toward the o outside. This section is indeed a confrontation with the normal method for shedding rain, causing a dramatic problem to be overcome, though it is not yet detailed as such. The rain valley corresponds with the division of the plan, and the vertical circulation, which ramps through the center of the building.



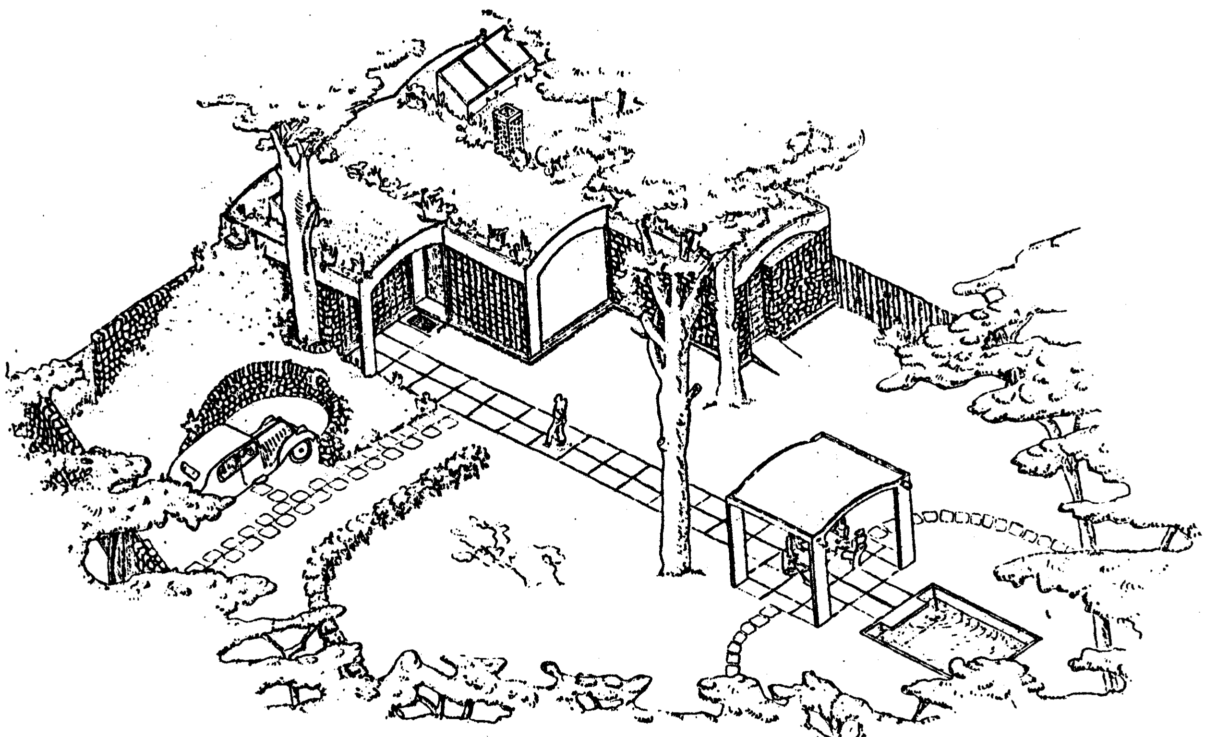




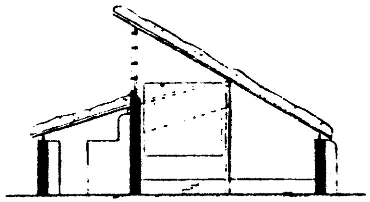
In a house project from 1939, the reverse shed is carried to an extreme, as the slope of the roofs is parallel to the long axis of the building. The low channel between the two roofs is larger than in the previous example, and now corresponds to a short entry corridor. The front door is located under the channel, which is sloped to the back, where the rear entry has been moved aside and the elevation indicates a turned down lip the width of the channel, for drainage. Again in this project, the roofs attack the notion of rain shedding and use the functional solutions to the problem for definition of another level of architectural concern - that of use. The entry is signaled by the low channel, and the movement up into the private rooms is by a ramp that parallels the roof slope above it. This is the forerunner of a proposed series of industrialized houses, in which the rectangular valley sits on unbroken masonry panels, from which the two wings seem to cantilever, propped up by the outside walls. Rain runoff is collected in free-form troughs at each end of the valley, lending an informal touch to the facade. These houses, unbuilt, also introduce the idea of sod on sloped roofs to Le Corbusier's work.

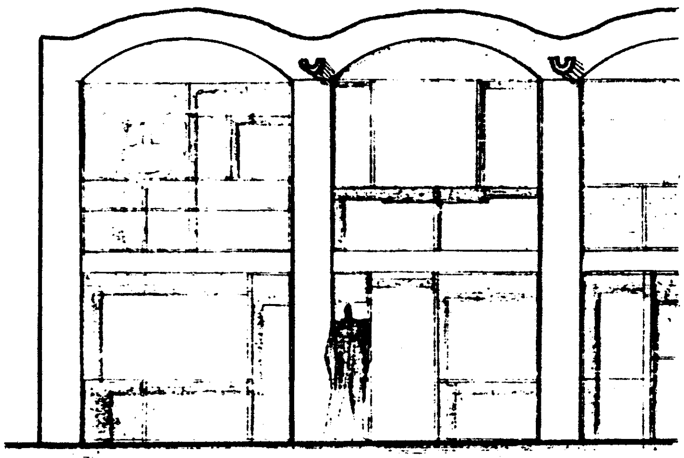
He had first used sod as a roof cover in a weekend house built in 1935, along with vaulted roofs, which were to become an important building element later. Three parallel vaults of different lengths are covered in soil and sod, and a berm against one of the vaults continues the ground up onto the roof. This is an amazing turn from the white villas and airy buterfly roofed houses he had designed and continued to propose for 10 years more.

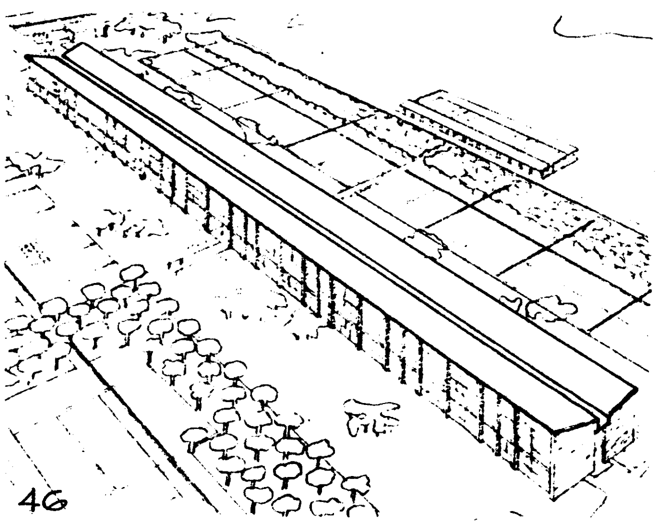
Stephen Gardiner, in his study of the development of Le Corbusier, points out several periods in which Corbu did tiny experiments in another direction than that in which he was working, and these eventually grew to be the next major themes. This little weekend house was an exploration of more natural forms and materials, which found its strength after World War II.



The sloping sod roof appears again in housing proposed for youths displaced by the war. Shed roofs meet at an off-







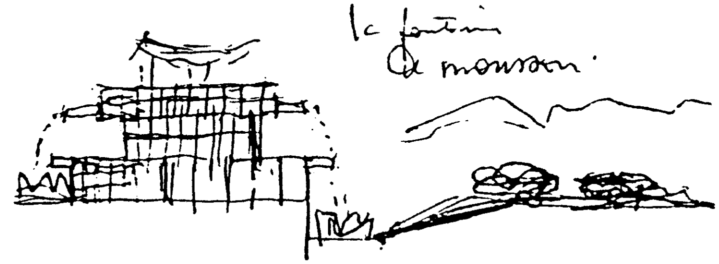
set ridge, one of the few uses of the gable roof section - perhaps because of the modesty of the form, and its association with the general run of housing. It does not appear again until Le Corbusier needed modest buildings below the Chapel at Ronchamp.

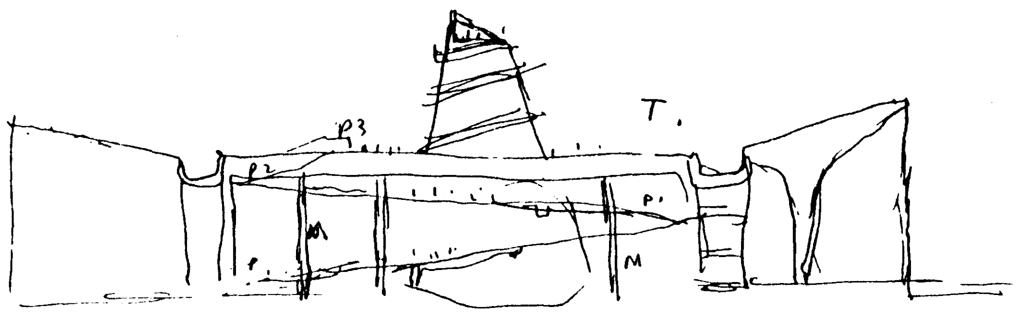
In 1942 vaults were applied to a proposed farmhouse compound in North Africa. For the first time, rainspouts projected from the plane of the wall, draining the valleys of the vaults. The spouts were to become a familiar element from then on. Their source may be the indigenous houses of Africa and the near east, where they threw water far beyond the vulnerable mud walls.

More proposals for refugee housing used the butterfly section, this time in long rows of attached units. The channels marked circulation along the double loaded corridors, and also provided light and ventilation to the hallway. The plans were not sufficiently developed to see the solution to the interesting problem of delivering the runoff from thousands of square feet of roof to the end of the valley - the same place hundreds of people would have to enter.

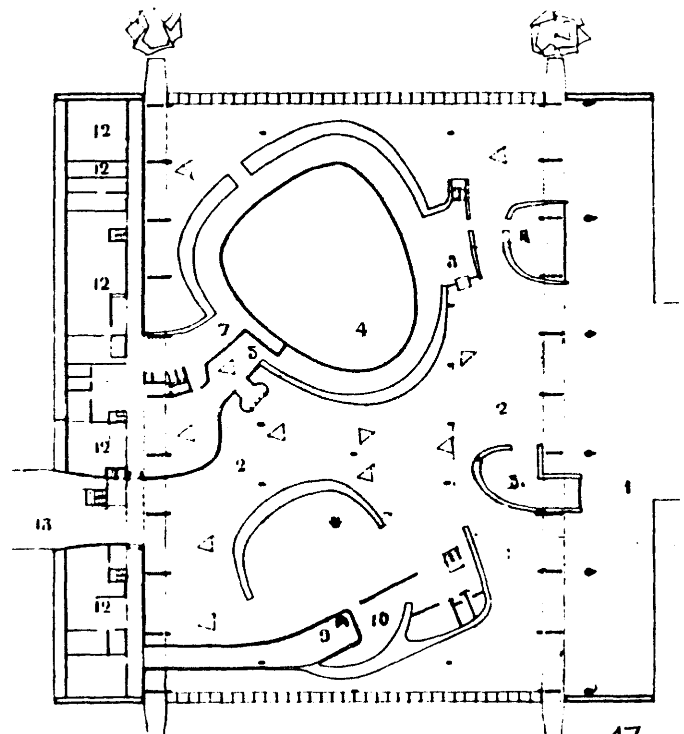
What are the advantages of this section, which cause it's almost universal use in Corbu's houses of the thirties and forties? Perhaps the sense of opening outward was the goal, which would be negated by the low eaves usual to gable roofs. The butterfly roof clearly delineates the architectural elements, using rain shelter as the rationale for identifying the circulation as different from the living space. It is also the beginning of use of the ceiling as an element of direction and interest.

Le Corbusier's most profound opportunity to confront the elements was presented at Chandigarh. On his first site visit he stated that the major issue was finding "an architectural solution to the double problem of rain and sun." Early sketches for the Assumbly Hall and Palace of Justice show dramatic spouts of water pouring from channels through the buildings into rocky basins.



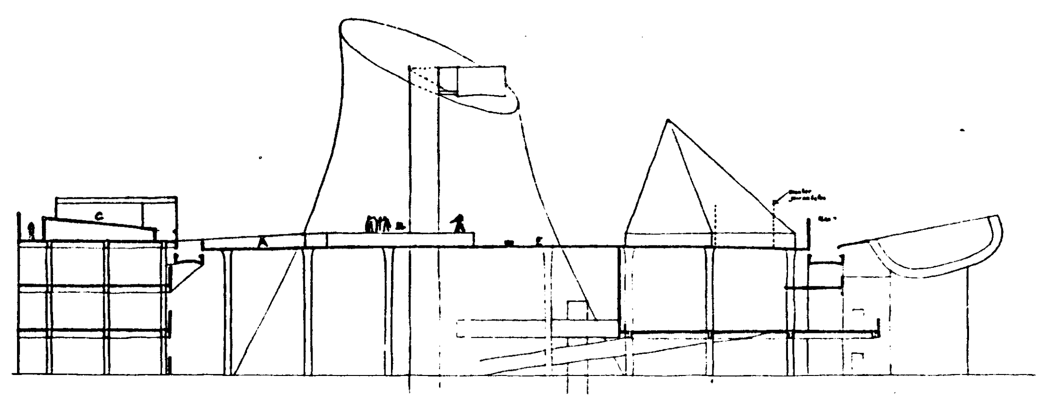


In the first scratchy drawings of the Assembly Hall, enormous sun shades on the front and back of the building tip rain into the channels, which also drain the large central assembly space. The scheme at the next phase of development shows the building strongly divided by the two rain channels into three segments; entry canopy, assembly halls and lobbies, and offices. The entry canopy and the offices, at the opposite ends of the plan, are covered by sunshades. The channels and the piers which support them form the major or-

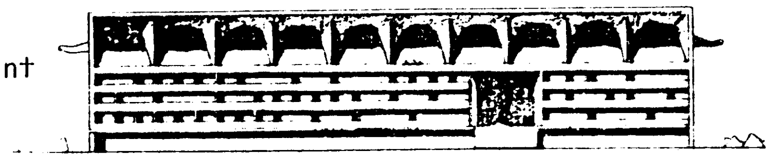


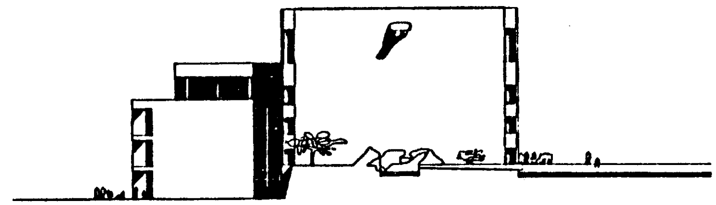
ganizing elements inside the building, dividing the functions of entry, meeting, and bureaucracy. The rain channels end in spouts which project at least 20 feet from the facade, to throw water onto man-made rockpiles.

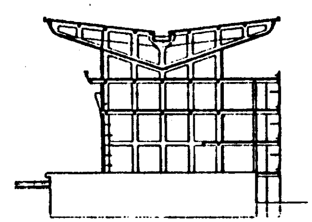
The building as constructed keeps the tripartite separation of functions. The channel between the offices and main assembly space is cantilevered from the office block on a row of large triangular fins, while the channel at the front is held on piers attached to the front of the assembly hall, free of the concrete parasol of the entry. The sunshade no longer drains toward the building, but seems tipped toward it like a pitcher. It drains through two underplayed chutes at each end, leaving the two building channels to be the main drainage elements, as was originally intended. The roof water drops into a giant pool across the front of the building.



The High Court building was executed almost exactly as first sketched. The entire building is sheltered under a giant billowing vaulted parasol roof, which keeps the sun off the roofs of the courts and offices, and drains all runoff to a central channel, running to spouts through the end walls. These spouts are rather anthropomorphic in shape in the early drawings, similar to those proposed on an early scheme for Ronchamp. These were changed to more straightforward, geometric chutes, which dropped water 50 feet or so to a basin which contains concrete prisms of various shapes in a reflecting pool, as at Ronchamp.







The entire roof of the court building is thus clearly separated from the enclosing function of the inhabited space. This separation and clarity of elements was a preoccupation with Le Corbusier, whose buildings were at first compositions opposed to nature, and free plans bounded by conceptual or actual cubes. As his work came to have more of the qualities of nature within them, the distinctions were made between parts of the buildings, either functional divisions, or a clear separation of the function of the building elements, such as sun protection or rain shedding.

> "......where the normal window would let in light and air, Le Corbusier invented a separate form for each function - a "solution-type" for each characteristic. And both were formed by machine materials in contrast with the "natural" concrete to either side; opaque aluminum let in no light, sealed glass

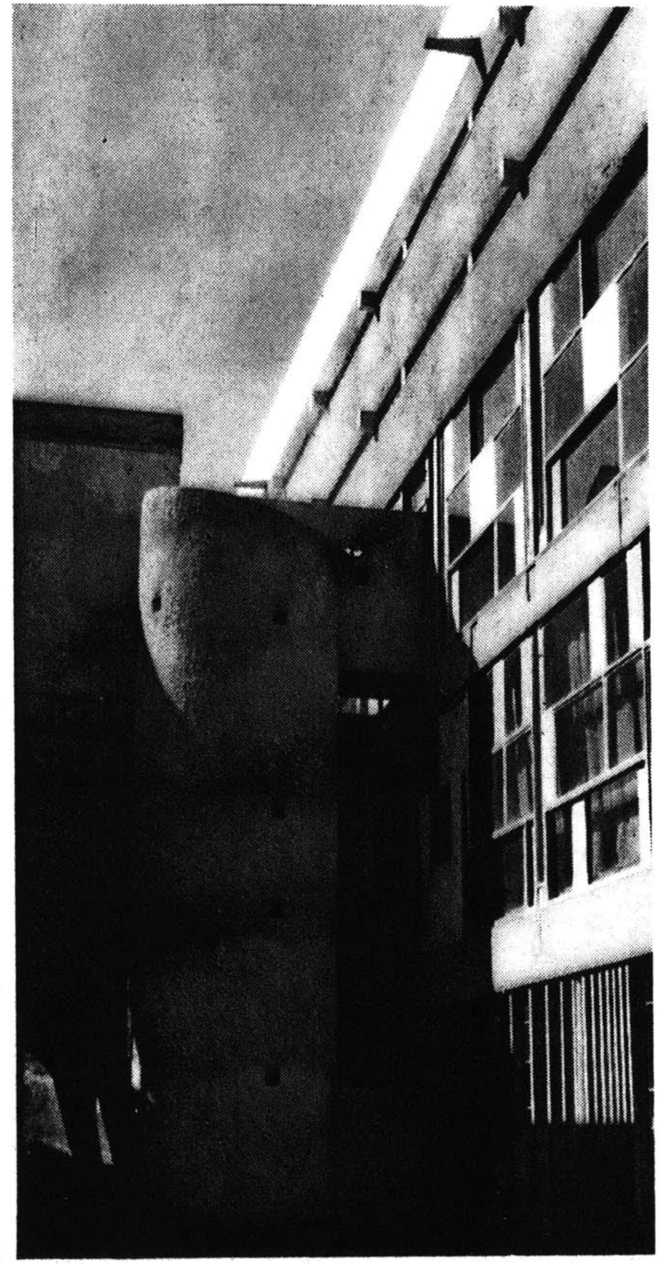
> no air. Such a tendency to individualize had a long history, dating back in his own career to the "separation des pouvoirs" ("separation of powers") of the Dom-Ino system, where much was made of the way the point support, supported slab, and non-supporting wall were manifestly separate elements. It might be christened the "atomic tendency": the need, at all costs, to individuate the elements of architecture according to discrete, indivisible functions. There it was applied to structural parts, here to environmental ones." [12]

The Secretariat at Chandigarh is not a place of governmental ritual, as are the two previously mentioned, but an office building for use in everyday activities. The roof therefore reverts to roof garden, with rain handled unobtrusively after it soaks through the planting beds. Thus he sets up a distinction between regular buildings which do not make much of the drama of confrontation, and the ceremonial buildings, in which sun and rain are treated with ritual care and grand gesture.

The same distinction can be seen between the Chapel at Ronchamp and La Tourette Monastery. La Tourette provides housing and collective spaces for monks who have taken vows of poverty, so the building is seen as an austere place to live in simple beauty. The environmental problems and possibilities of sun and weather are treated carefully but in a straightforward manner. Rain spouts are fairly evenly distributed, and roofs are left to grow as wild roof gardens. The chapel, most ceremonial of the spaces, merely gets a larger chute from one wall. The one charming exception, perhaps irresistable given the possibility, is a spout that runs water off the top of the spiral stair enclosure.(R) At La Tourette, as in much housing of the late forties and fifties, the rain elements seem to be used as punctuation, casting shadows like small sundials on the surface, or providing a minor rhythm on the facade, as at the Pavilion Suisse in Paris.

The design for Ronchamp, although set in its basic image by a sketch only three weeks after Corbu's first site visit, changed significantly during development of the roof design. The first scheme sloped the roof across the axis of the church, dropping roof drainage from a rectangular chute next to a secondary entrance. The chute is reminiscent of the simple box forms used as gutters in the butterfly roofed houses of the thirties and forties. The location of the drainage valley did not reinforce any direction or functional division of the building, and in fact lent greater importance to the smaller entry.

In the final schematic drawings, the low valley of the vast roof runs with the axis of the church, in fact the gargoyle is now exactly on axis and opposite the altar. The high point of the roof rises clearly and directly from the low end, and the church thus has a front and back. The spout shown in these drawings is similar to those shown on preliminary sketches for the Palace of Justice in Chandigarh, under design at the same time. This organic design seems to be in



the act of pouring, like the lip of a Mycenean pitcher.

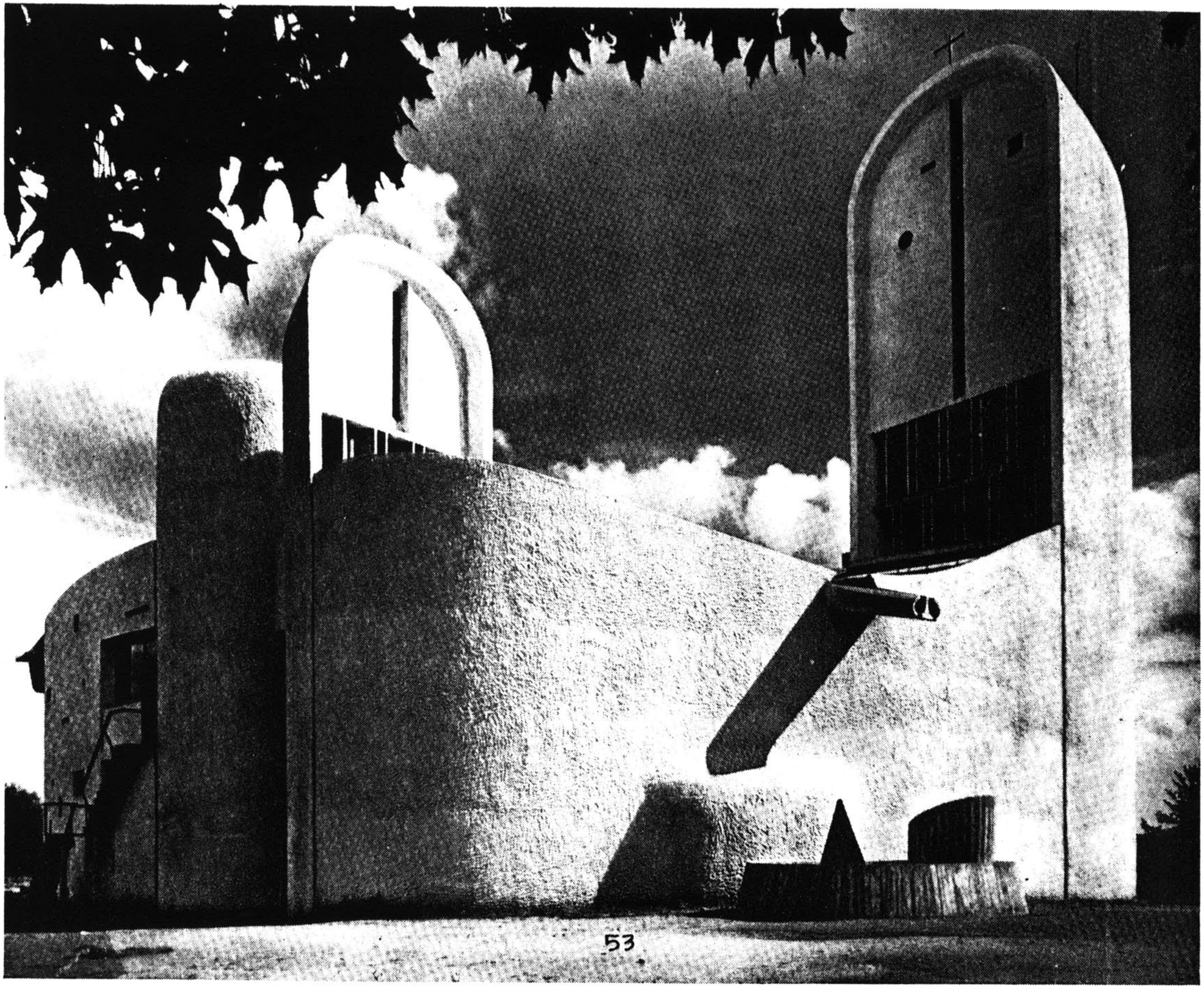
The spout finally built is as beautiful and emigmatic as the rest of the Chapel, and as open to interpretation of the sources of the forms. (Right)

Le Corbusier used the necessity for rain protection as an opportunity to express the functional divisions of the plan in section; to provide punctuation and rhythm on the facade; and to make ritual gestures in buildings of great public importance. With the exception of the roof garden, he was primarily using the potential inherent in having to deal with rain to further visual and formal ends.

Today, two new issues seem important to consider in designing with regard to a natural process such as rain. The first is ecological responsibility for the effects of our construction on the environment. The second is providing connections that include people more directly in built places by offering opportunities for use, and reference to shared attitudes which can give the environment meaning.

Malcolm Wells

Perhaps more than any other well known architect, the work and writings of Malcolm Wells are generated by concern for ecological responsibility. Since the mid-sixties, he has become an advocate of underground architecture as a means to reduce the impact of construction on landscape and natural systems. The values of buried buildings are: 1) rain is allowed to soak into the sod, taking pressure off storm drain-



age systems, recharging the ground-water supply, and preventing erosion; 2) soil provides insulation from heat, cold and sound and 3) buried buildings with plants and trees on top are more beautiful than building decorated by man.

Wells had established a successful conventional practice when be began to realize that the problems of urbanization were caused by "people just like myself," architects who litter the land with buildings, "paving and waterproofing the earth's surface with so much concrete and asphalt that the amount of water denied access to the land exceeds the total U.S. water consumption." '(Quoted in A.I.A. Journal, November 1978)

He then began developing and publicizing the idea of underground architecture as a way to cooperate more with the natural cycle of rainfall, ground water and plant life.

> "The city of Philadelphia, in whose suburbs I live has an area of 135 sq. mi. Its annual rainfall is 45 in. If you convert all these miles, inches, acres, and feet into gallons you get a staggering 122 billion gallons as Philadelphia's share of the nation's rainfall. And do you know how much water her thousands of homes and water-wasting factories consume each year? 125 billion gallons! Just the amount of rain that falls within the city limits.
>
> Impressive, wouldn't you say? It points up one of the reasons why most of us in the United States are in big water trouble; we throw the stuff away by building and landscaping as we do. We could build watergates on our roofs, devices for slowing the rush to the rainspouts, so the

rain would have time to soak in when it reached the ground. We could even use giant sponges. But the best way by far is the natural way: do what nature always did on the land; plant trees and shrubs or grasses in deep, cheap mulch. Such watergates have to be done with care of course, from the initial planning to the final coverup, but they hold great promise. Watergate architecture, or underground architecture, or whatever kind of architecture you care to call it, makes good sense in a lot of ways, and it's been around a long, long, time...."

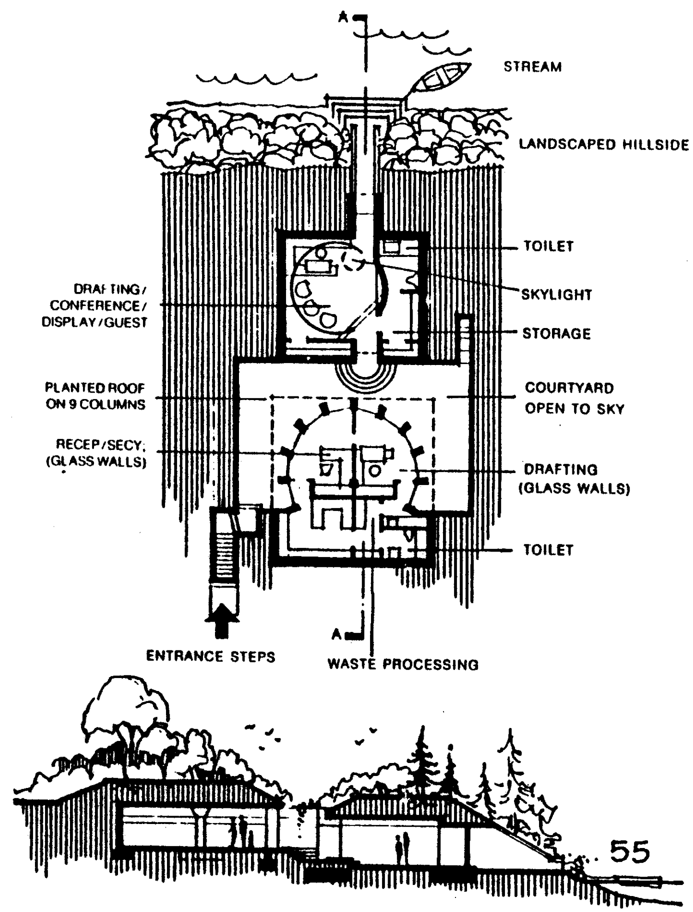
Progressive Architecture
February, 1965

His own office in a suburb of Philadelphia was designed as a prototype of the kind of construction he envisioned -- a place built into the earth, with sunken courtyards and sod roofs on concrete decks. It is also an example of his attitude toward site planning and the landscape. He bought

' ".....a tiny place on a tiny lot, wedged between a freeway and a sewer. When I bought the property (for $700!) all I could see were a few scabs of old asphalt on a patch of barren subsoil." Today the site is grown over like a small jungle. "Now when we tell our clients how to find choice building sites, we always urge them to pick the worst ones....to restore a bit of the trampled earth." '

Wells, as quoted in A.I.A. Journal
November, 1978

By reclaiming this piece of land, Wells has radically changed its response to rain. Through intensive landscaping



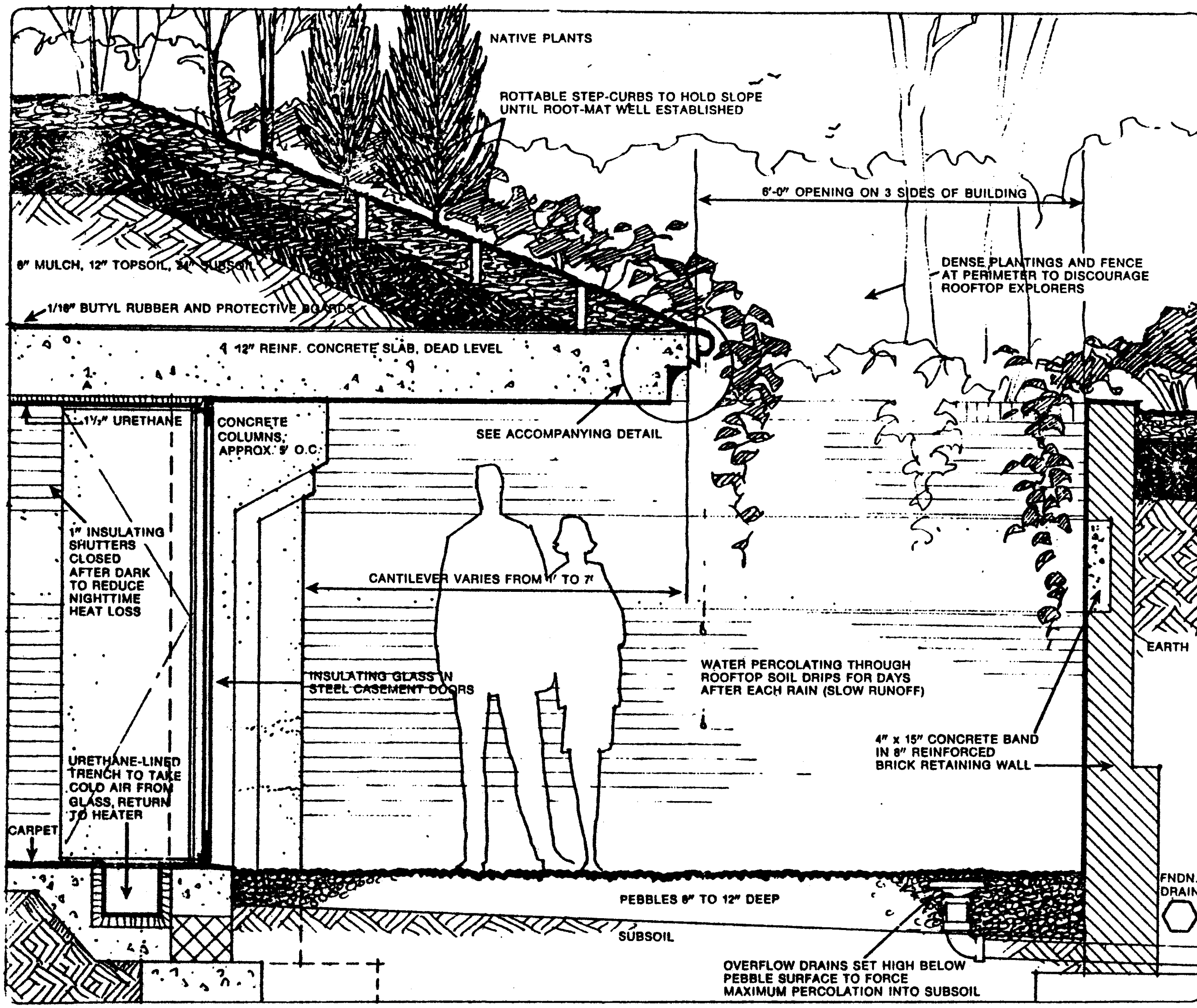
and sod covered roofs, water is held on the site and given time to soak into the ground. Runoff is therefore greatly reduced, and a healthy growth of plants covers the site and provides organic matter to improve the soil.[23] (Right)

His concern for the natural environment has led his to devise a rating system for new construction which measures how well the building emulates a mature forest, his example of ultimate good construction. He has written that "all of nature is beautiful, that only nature is beautiful, that nature is beauty...." This statement underscores a limitation apparent in underground architecture. It is certainly as ecologically concerned as any method of building around, but the second issue of connections between form, use, and meaning is undeveloped. None of the more subtle issues of reference to other images, to function, or to shared values are possible, beyond the implied value of subservience to nature.

Herman Hertzburger

The issue of providing more opportunity for use and meaning through connections between people and built places is addressed by the Dutch architect Herman Hertzburger.

In his Montessori School in Delft, Holland, a gutter channel runs across a terrace filled with planting beds and playing pits, to empty into a nearby canal.

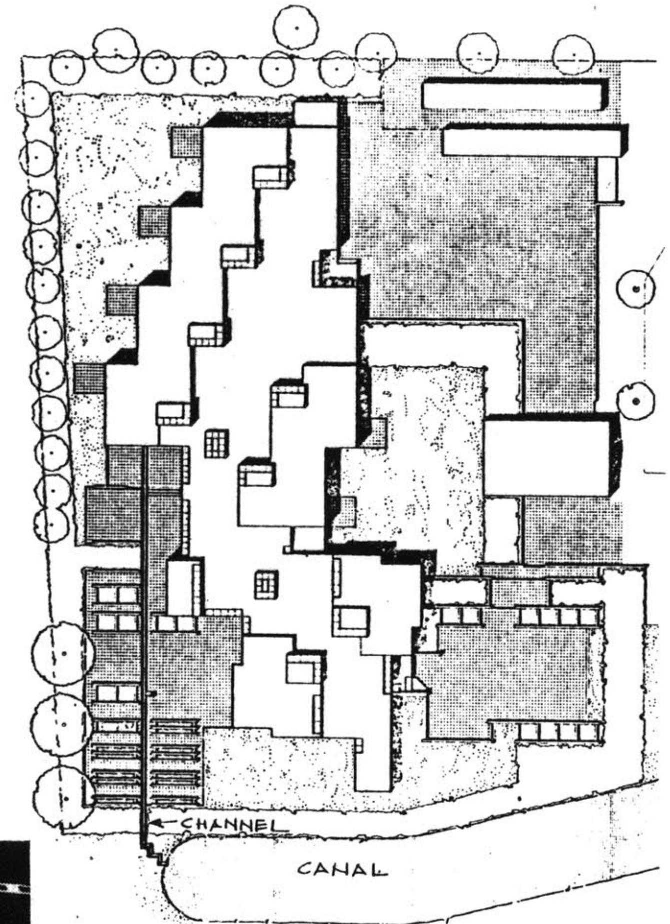


Details
Wells' Office

"The draining of rain and tap water is generally made to happen invisibly and without getting us fussed about it. But open gutters for this purpose are a great attraction for children for their favorite activity, which is not allowed at home, namely playing with water and sand. The open gutter that has been made in the pavement between the garden plots and the sand pit works as a spinal cord for busy goings on with barrows, pails, and watering cans, with which water and sand are transported to and from the sandpits.

Often there is little or no water in it, but even then it is a sort of kerb to sit in and a groove to lie in, which you can bridge over or make a roof on, fill up or dig empty. The drain can be filled up from the tap near the garden plots, and the water flows off into the nearby channel."

Herman Hertzburger
Magazine A & U. #24



The channel refers to the ever-present canals of Holland. It removes rain, and gives the children a convenient stream for play and imitating the work of their parents, who are so dependent on the control of water. The channel, active and delightful when running with water, is no less evocative of uses when dry and is a reminder of the absent rain.

> "Architects must use everything they influence or create to support the people in the struggle against alienation from their surroundings, from each other and from themselves......[architects must] exploit every possibility of making the world less abstract, less hard and alienating..." [14]

He goes on to discuss a place in which use and meaning both serve to include a place in the lives of people, providing reinforcement for their sense of control and belonging.

> "In Estazel.......the river Agly........shows up for only part of the year, when it fills up the entire volume of its bed. The river dominates the village for the rest of the year as well. When there is no water the children make a traffic free play street of the cement riverbed, the large molded public space, backbone of the village, offering the motivation for specific possibilities.
>
> The streets drain off into a gutter in the middle of the giant channel. The little one is to the larger one what the river is to the whole village, the same thing repeated on a smaller scale, not only spatially, but also in the time cycles of flooding and drying up. The children make grateful use of it, in their play it is the river, which on occasion poses many weighty problems...." [15]

Lucien Kroll

The dual concerns of use and the health of the environment are combined in a project by Lucien Kroll, for a village church complex in Belgium.

A fortified farm compound with one open corner was converted into a chapel, living accommodations and meeting rooms, and the corner was filled by a village library, of curvilinear form in contrast to the stone walled rectangle of the existing courtyard. A public footpath runs through the courtyard, providing a passage for the village.

The new library's roof is covered with earth, bearing a heavy growth of plants. Rain falling on this roof is held on the plants and on the earth surface. Slowly, most of the water on the roof seeps to a trough which spills it down a rough masonry wall of the library into a pool. So water is splashing down the wall to the pool for hours after a rainfall, adding the sound and sight of water to the courtyard. The pool, filled with rocks for children's play, is placed directly in the public path across the courtyard - perhaps a reference to village fountains in the centers of towns. As the pool overflows during long rains, the water drops into a channel in the paving, and is carried to a heavily contoured planted landscape in the center of the courtyard. It forms a pond, and eventually percolates into the ground, replenishing the ground water supply.

The downspouts from the roofs of the older buildings empty into channels which carry the water along the surface

Courtyard Pool

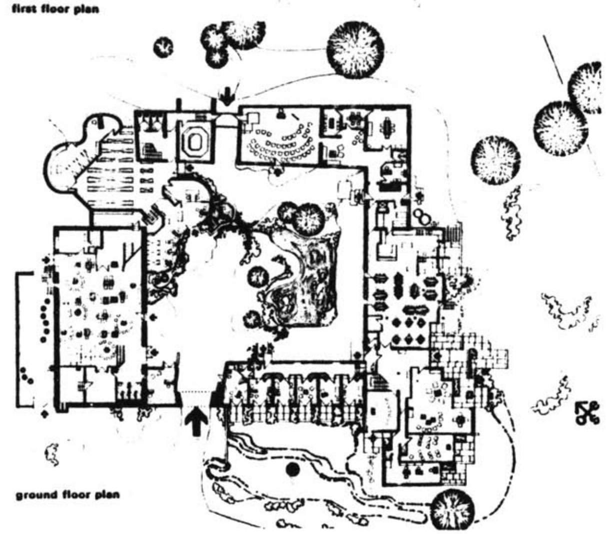
to the pond. These channels disappear under a large stone where the path crosses them, and in this way hint at the disappearance of water into the ground and its reappearance in springs and streams.

The courtyard surfaces are constructed to soak up much of the water falling on them, reducing the amount of runoff that must be accomodated. The paving is set in sand, and the rough textures of the lush vegetation of the landscaping hold water on the surface until it can sink in gradually.

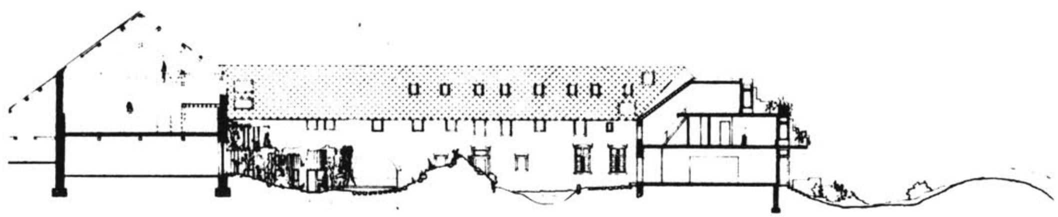
Thus Kroll respects the natural processes of the hydrologic cycle by reducing runoff, grows luxurious landscapes, provides the sight and sound of moving water, and makes a place for play and gesture, while he refers to the commonly held image of the village fountain.

This study has now looked at rain itself, and at its importance to architecture in the past and present. The final two chapters will explore ways that designers can turn the necessity for rain control into an opportunity for richness and responsibility in the environment.

first floor plan



ground floor plan



section and elevation

4. Design Principles

Rain is a manifestation of nature, brought to us however far we find ourselves from forests and oceans. Attitudes toward rain are attitudes toward nature - at a level more mundane, and therefore perhaps more telling, than love of beautiful forests or the sea. The issue of man's relationship to nature has a long history of controversy, but has now reached a point when we must decide on a direction.

> "Until the recent past man had to concentrate his major efforts on safeguarding himself from the inimical forces of the natural world - beasts, cold, sickness and hunger. At this historical junction the real beasts are man created; we face ourselves as the enemy.
>
> We are taking the first timid steps toward what could be called "self-conscious evolution". We are beginning to understand that through social communication, it is within our intellect and emotional power to shape a sounder evolutionary future."
>
> Georgy Kepes
> Arts of the Environment

Mankind, through its consciousness, is in a position to make intellectual (if not intelligent) decisions concerning its relationship to the world. These decisions (including the option of not deciding) can now determine the fate of natural systems such as oceans, forests, rivers, topography, and climate. We have become conscious of our separateness from the natural world - that we are no longer responding to conditions, but setting those conditions, and we have convinced ourselves we are independent of nature. We in the West have not recovered from a long history of struggle against nature to impose our agricultural methods on the land. Now that we have gained some mastery of conditions, we still unconsciously regard nature as an enemy, instead of considering ourselves part of it. Until recently, no well-considered cultural attitude de toward nature and our place within it had developed, so our path through time was at the whim of whatever inventions and habits developed. There was no framework of understanding by which to evaluate the appropriateness of a product or process.

The natural world is an ongoing system that has been in continuous evolution for millions of years, achieving subtle balances and adjustments among all participants. We have come from this world, but are now able to look at it with detachment, and to decide how we wish to participate. Since we are relative newcomers as a determining force in the world, modesty will become us better than our present course of arrogance and the application of brute force towards nature.

Gradually, we have been coming to understand the processes of nature in ways which will allow us to cooperate for a healthy environment while still meeting our goals for comfort and convenience. We can find ways of accommodating ourselves in the world, so that the general environmental cycles are not disturbed, but so that at the small scale, we can go about our activities. This calls for an awareness of the ecosystem that permits us to change the form or content to suit our purposes, but without changing the result.

"....if "space-time" in our architecture means anything, it must mean that the architectural forms of our era might be based on a dynamic geometry which exists in time as well as space, and bears therefore a resemblance to "natural" things whose geometric structure is similarly complex.

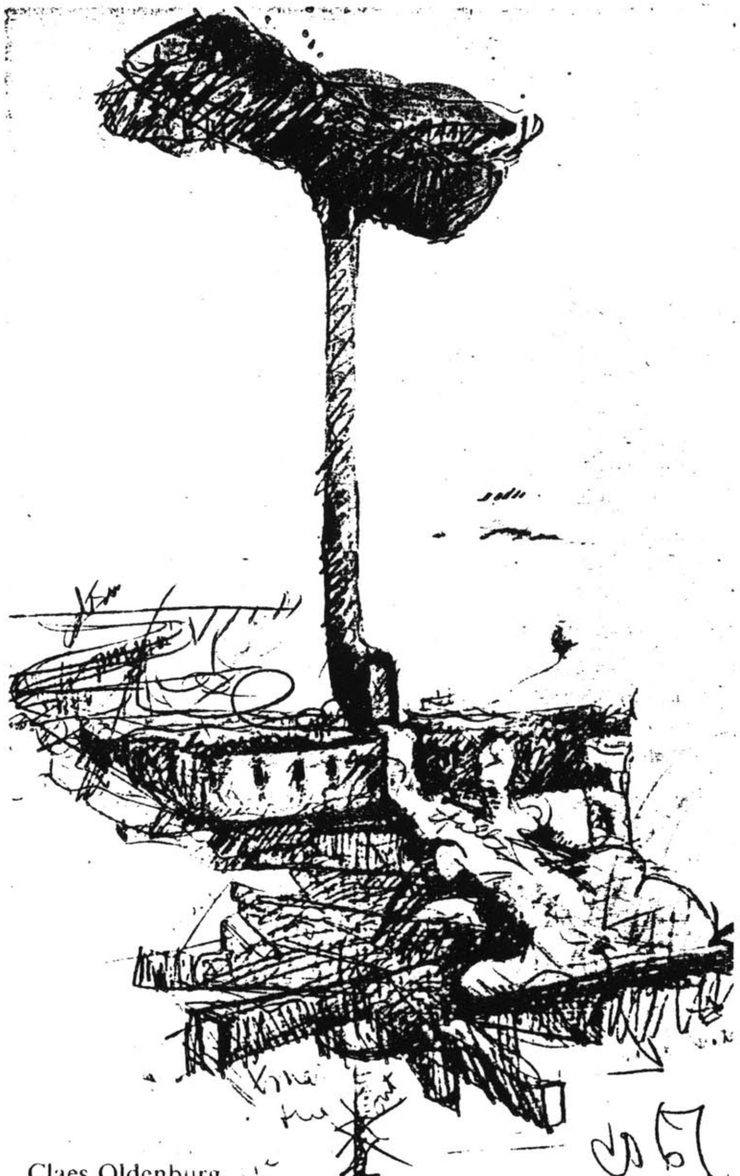
Our designed response to the natural world will then involve neither imposing a simple geometry on it or trying to merge with it, but might involve creating harmonies so composed in time and space that they create a sort of resonance with a sympathetic nature."

Charles Moore
Water and Architecture

Lawrence Halprin has thought a great deal about the interaction of man and the natural world.

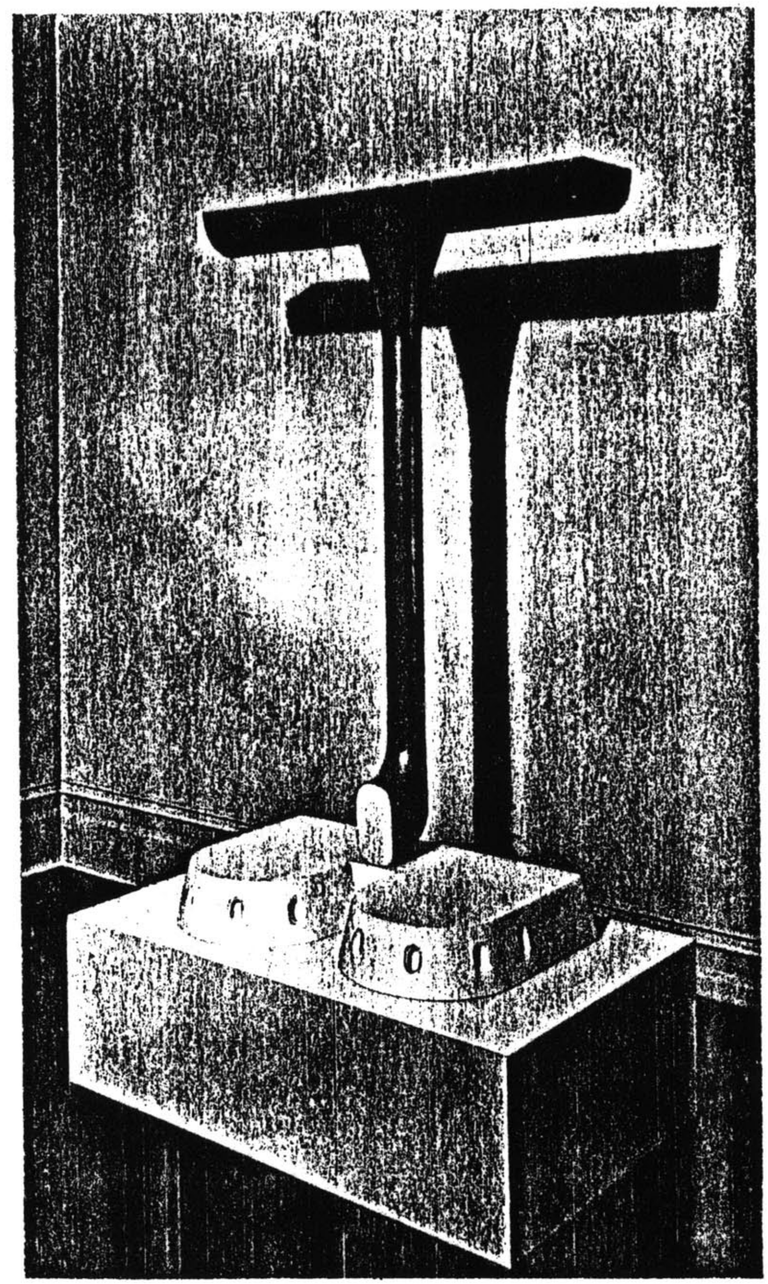
"My view of man's relation to nature has to do with nature's processes rather than her form or meaning...it is to her method of operation not her outward manifestations that we need to relate..." [16]

There are two levels of interaction with the natural world that require our intelligent attention. The first is ecological practice, the need for preserving the natural systems on which we ultimately depend. This concern will result in healthier and more elegant solutions to problems of survival and development of our physical surroundings and resources. The second concern is for the qualities of the environment we develop for our use, and the metaphoric or



Claes Oldenburg,

Proposed Colossal Monument for Coronation Park, Toronto: Drainpipe. 1967



evocative expression of our connections to the natural world. It is important that we seem to do what we do; that our intentions and actions regarding our place in the natural world be clearly communicated in gesture to ourselves and others. Symbolism can reinforce commonly held goals and attitudes and keep them in our consciousness, as well as add richness and meaning to the environment.

> "Architecture is built of materials and composed of forms. For man, the materials and forms have a content; the observer can tell, or ought to be able to tell from the design something about the use of the design, and something about the people by whom or for whom it was built. Water is a natural material, and the unchanging identity which it maintains, wherever it goes, keeps it in evidence as a natural material where it is used in an architectural composition as well as when it appears in nature. Its use in architecture, then, because it is a natural material, should be an indication of the attitude toward the natural world of the people by and for whom it was designed."
>
> Charles Moore
> Water and Architecture

The issues and images discussed in the preceding three chapters generated thoughts about ways to incorporate an appreciation of rain into the built environment. Four processes that seem important are discussed in the remainder of this chapter, and the concluding chapter applies these processes to the design of specific building elements.

Claes Oldenburg,
Proposed Colossal Monument for Coronation Park, Toronto: Drainpipe. 1967

Delay

Nature always attempts to even out extremes: through transferring tropical heat to the polar regions, storing summer heat in the oceans to moderate the winter, heating the earth during the day to provide warmth at night. In the case of rain, the earth evens out the flow of runoff between dry and rainy times by imposing a series of roadblocks to water as it searches for the most direct path to the sea. Runoff is slowed during storms, and continues to flow for several days after. Rain is held on trees, in vegetation, and in the soil, then released slowly to run to streams and to recharge the ground water supply. If nature didn't delay water's movement, the surface of the earth would quickly erode with runoff from rainstorms.

The first principle for design with rain, therefore, is to delay water's passage through the built environment, emulating natural processes by building in delay mechanisms that hold water on the site, allowing it to run off slowly. This avoids destructive storm runoff which causes erosion, or necessitates replacing natural streams with storm sewers. These rain sewers take enormous amounts of runoff from built-up areas, and carry the water at high velocity through their unobstructed pipes, to inundate streams and rivers. Vegetation on the stream banks is killed by the sudden flood, followed as suddenly by low flow. Erosion begins and the streams themselves become candidates for paving. Storm sewers also reduce available ground water needed by trees and wells, as well as robbing us of the pleasures of natural streams.

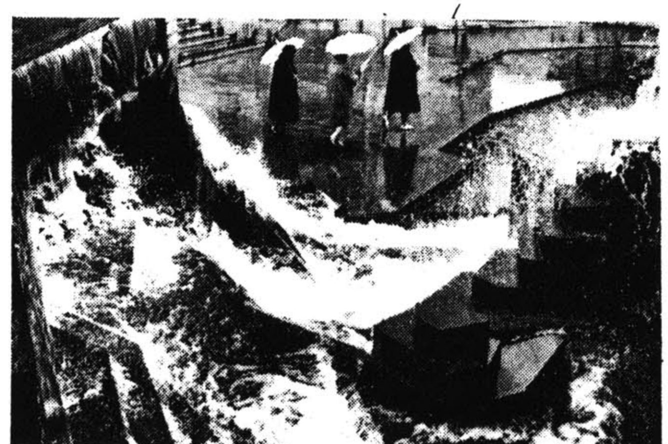
Decreasing surface runoff is accomplished by providing storage capacity on and around the places we build. Capacity can be provided at many levels in the built environment, starting with roof gardens and sod roofs which hold water and let it seep through slowly to drain, as well as taking up some of the water to support plant growth. Roof ponds with special slow-release downspouts can hold several inches of water. Temporary ponds on the ground can hold large amounts of water. The most effective place to store runoff is in the ground, and making full use of this capacity requires heavy planting which holds water to give it time to soak in, as well as requiring porous paved areas.

Gravity

Solar power and gravity are the most powerful forces acting on water, the first raising water through evaporation and providing it with potential energy, and the second putting that energy into play, pulling water out of the sky and then across the earth to the sea. Gravity is the part of this cycle we can influence, through sight, sound, and touch, by keeping water in view as we make it drop and splash from roof to ground and across the surface.

Landscape architect Lawrence Halprin has made studies of the way water moves through the natural environment, and applied this understanding to several fountains, most notably in Portland, Oregon.

Nature is generous to supply us with water at whatever height we can reach, and it is up to us to make the most of the opportunity to bring it to the ground in lively association with our daily experience of the environment.



Lovejoy Fountain,
Portland, Ore.
By Lawrence Halprin


93
leap
bounce
bubble
eddy
eddy
surge
boil
glide
leap
Halprin

Time

Weather has a complex time cycle, bringing rain at irregular intervals. Cyclonic storms traveling through the atmosphere bring precipitation every 3 to 4 days, and local conditions may cause storms which develop and disappear in one day. The weather is a part of nature out of our control and we are subject to its caprices.

In Tom Robbins' novel Even Cowgirls Get The Blues, the philosophy of a sage called the Chink is explained:

> "The Chink sees in the natural world a paradoxical balance of supreme order and supreme disorder. But man has a pronounced bias for order. He not only refuses to respect or even accept the disorder in Nature, in life; he shuns it, rages against it, attacks it with orderly programs. And in doing so, he perpetuates instability.....worshiping order and hating disorder automatically shoves great portions of Nature and life into a hateful category. Did you know that the center of the Earth is red-hot liquid covered with a hard crust, and that that crust is not a single unified layer but a whole jumbled series of shifting plates? These plates are about sixty miles thick and very plastic. They appear and disappear. They move around and buckle and bump into each other like epileptic dominoes New mountains and new islands - once in a long while, new continents - are being created and old ones destroyed. New climates are being formed and old ones altered. The whole thing is in flux. Existing arrangements are temporary and constantly in threat of disruption. This whole big city of New York could be sucked into the Earth or quick-frozen or flattened or inundated - at any second. The Chink says

> the man who feels smug in an orderly world has never looked down a volcano.....the vagrancies and violence of nature must be brought back into the foreground of social and political consciousness, they have got to be embraced in any meaningful psychic renewal......Disorder is inherent in stability. Civilized man doesn't understand stability. He's confused it with rigidity..... True stability results when presumed order and presumed disorder are balanced. A truly stable system expects the unexpected, is prepared to be disrupted, waits to be transformed.....Civilized man is infatuated with the laws he finds in Nature, clings almost frantically to the order he sees in the universe. So he has based the symbologies, the psychological models with which he hopes to understand his life, upon his observations of natural law and order. Pendulum time is orderly time, the time of lawfully uniform universe, the time of cyclic synthesis. That's okay as far as it goes. But pendulum time is not the whole time. Pendulum time doesn't relate to trillions of the moves and acts of existence. Life is both cyclic and arbitrary, but pendulum time relates only to the part that's cyclic."

The principle suggested by the erratic rhythms of rain is that we acknowledge its fluctuating presence, making it an event when we have it, and acknowledging the potential when we don't.

Rainwater systems and pools must be designed for variable amounts of water, like natural streams, which are different, but no less beautiful whether they are flowing full or merely trickling. Roofs, gutters and downspouts can be a reminder of the potential for rain if they make up a coherent system. When rain does occur, the drainage system comes to life - splashing and gurgling; filling and overflowing. The principle of delay also extends the effects of rain through time, making running water available after a rainstorm, when we can be outside to enjoy it.

Transform-ation

The things we build should intensify the qualities of the environment which are available when it is raining.

Designers should consider what materials look like when wet, how they can be detailed to respond to rain. We can make water accumulate in ponds and channels, so we see the rain collecting into bodies of water. The sense of shelter can be enhanced by increasing the contrast between wet and uninviting outdoors, and the protection of being inside. At the weather edge it is important to provide places for watching the effects of rain. Porches, vestibules and entries can reflect more awareness of and opportunity for appreciation of weather.

In J.B. Jackson's essay "The Imitation of Nature", he proposes that a man-made environment must provide some of the qualities of experience that relate us to the experiences to which we have become accustomed in the many thousands of years of our development as part of nature. The weather and how built places respond to it, is an important aspect of this environment.

> "Our basic concept of the world, of the environment, comes through our senses, and it is by means of the senses that we judge whether it is good or bad. The environment must of course be designed to promote harmonious social relationships, just as it must be designed to promote our physical wellbeing, but it must also be designed to provide " a life of sensory joy in a sensory world", it must stimulate our sight and hearing and sense of touch and smell. We

are accustomed to look for these pleasures in the green outdoors where, to be sure, they are present in their purest and most immediate form; but the need for a satisfying sensory experience is with us no matter where we are, and nowhere is that experience more intense (though not always more agreeable) than in the modern city.

The well designed city is one where we everywhere feel at home: it reminds us, everywhere and at all times, that we are in an environment no less natural, no less stimulating than the environment of the country dweller. Its trees and parks and lawns are more than agents of health; they tell us of the passage of the seasons, and its open places tell us of the time of day. If the well designed city cannot provide us with contact with other forms of life, it provides us with the society of other human beings in places designed for relaxation; if it cannot provide us with the sounds of the remoter landscape it at least provides us with areas where the sound of human voices and foot steps are not drowned out by mechanical noises, it provides us with areas of quiet. It cannot imitate all of nature, but it gives us archways and pools of daylight, and flights of steps and views; the splash of water inffountains, echoes and music; the breath of damp cool air, the harmony of colors and unpolluted sun; indeed it gives us so much that our excursions ino into the countryside cease to be headlong flights from a sterile environment, and become a conscious searching for the missing ingredients: solitude in the presence of other forms of life, space and mystery." [17]

Rain transforms the environment, providing opportunities to increase the number of qualities that are available to experience. Surfaces change appearance, bright colors become stronger. (Architectural photographers recognize that wet surfaces enhance the visual environment: photographs of buildings are often taken just after a rain, or water is sprayed around to simulate it's effects.) Water flows, splashes, and accumulates, and pools and puddles reflect the trees and sky. The atmosphere is heavy, smells are liberated from the earth, and people's movements are hurried and concentrated as they rush under the burden of rain. Space is transformed also, as that which was outside free space is now made solid by the presence of rain, while inside space is relieving and open by contrast. People's moods are affected by rain, which often brings on melancholy or contemplative detachment. Shelter becomes more charged with meaning when it is protecting inhabitants from the elements. We are confined to buildings, and edges become important places offering the contrast between shelter and bad weather.

RAINBOW
L. FEININGER 1925

Incorporation of these themes in designs for the built environment will provide a setting for life rich with lush gardens, textured surfaces, pools and streams - in total a more cared-for, man made world reflecting our concern and affection for all scales of life. Design of the architectural elements that shed rain should try to go beyond solving the technical problems of drainage, to use the opportunity of construction to inform and allow interpretation by users of our place in the world and its possibilities.

5. Building under the Weather

Designing for the effects of rain on the environment requires a thoughtful and affectionate observation of differences that usually go unnoticed, at least consciously. Attention to the ephemeral and transitory effects of the weather on built places and on ourselves leads to an appreciation of life, slowed down, and integrates us with the world through all our senses.

The following is a discussion of each of the elements of building as they are affected by rain. It applies the possibilities suggested by the last chapter: delay, gravity, time, and transformation are principles which can inform and enliven design for rain on architecture. The need to keep places dry is taken for granted. This study attempts to go beyond the minimum requirements, in order to explore ways that design for the qualities of rain can add richness and meaning to the environment, while at the same time reinforcing the integrity of the ecological structure.

Site Planning

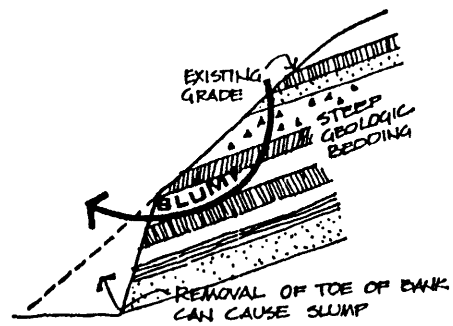
Knowledge of the response of a site to rainfall is necessary in order to locate buildings, roads, and recreation space so that they are not damaged by, nor damage, natural site drainage patterns. If we wish to build in sympathy with natural processes, the aim of site development should be to reduce the changes we impose on the cycle of water moving across the landscape.

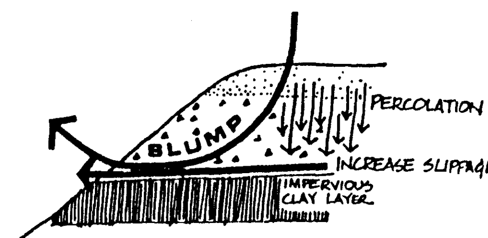
> "Water passes over and through the site in a complex cycle of percolation, interception, surface runoff, evaporation, transpiration, and groundwater flow. This complex process involves cloud formation, rainfall, a watershed of rivers, lakes and streams all interwoven into a dynamic, balanced phenomenon. The word balanced is important, because an undisturbed watershed has achieved over the years a balance among the amount of precipitation, the amount removed by evaporation, transpiration and runoff and the amount stored. Any change of flow within the cycle be it increase or decrease in runoff, ground water storage, evaporation, etc., alters some other portion of the cycle, and the change may or may not be desirable.
>
> Untermann,
> <u>Site Planning for Cluster Housing</u>

Designers need to know how the drainage system of the site works, begining with some notion of geology, soils slope, natural swales, and precipitation patterns.

Geological formations impose topography on the site, and set up conditions for erosion and movement of water from the surface soils into the earth. Rock ledges at the surface may limit or channel erosion; subsurface strata may be tilted, causing the ground to drain to springs; or level layers of rock may hold water above them, creating a high water table which saturates the ground and causes flooding, erosion or dampness. Tilt of the surface caused by underlying geology affects direction fo drainage channels, speed of water flow and therefore cutting power of streams. If geology permits the underground movement of water away from the site, storm water systems can be based on percolation into the soil rather than into culverts. For extensive drainage systems, an understanding of water supply aquifers is necessary to ensure that site drainage underground does not pollute the water in aquifer layers.

Geologic conditions may allow slippage of soils on slopes, leading to landslide problems. Slippage occurs when tilted impervious soil strata or rock ledges hold water in surface layers; the water lubricates the interface between the surface and the hard underlayer, allowing the upper soil to slip over the lower. Slopes with tilted beds may move when undercut at their bases, reducing their support beyond the angle of repose. Changed drainage patterns may direct excess water over a slope, increasing the weight of the soil, and causing it to slip. Understanding of the underlying conditions is necessary to avoid such problems.





SECTION

The makeup of the soil layers and their slopes determines the response of the surface to rain. Clays are impervious, holding water on the surface and causing flooding and overland flow which can lead to erosion. On a relatively stable natural drainage system, the impervious areas are balanced by organized overland flow to permeable soils which take up the excess runoff. Permeable soils are sands and gravel. Silt, loam, and organic soils without a mix of gravel or sand are relatively poor in percolation.

On slopes of 1% or less, water stands in puddles and must be channeled to run off if percolation is not excellent. Four to ten per cent slopes have good drainage characteristics, as water moves slowly enough to sink into the ground. Slopes over 20% will erode unless special measures are taken. If hillsides slope over 50% (1 in 2), terracing or cribbing is necessary, or special drainage structures which eliminate flow over the sloped surfaces.

Designers need to have some idea of the amount of rainfall that can be expected, and usually design to take adequate care of the worst storm likely in ten years, while allowing some ground flooding in more extreme storms. Information about rainfall intensity, duration, and frequency are available from the U.S. Weather Service, and weather almanacs. In New England the worst ten year storm would produce 6" of rain per hour.

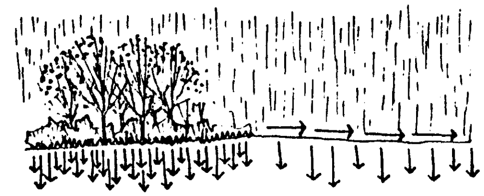
If we know the consequences of different building patterns on the soil, we can predict the overall drainage patterns that will result from our intervention. The implications of building are: an increase in impermeable surfaces, and therefore runoff; changes in drainage swales; and different vegetation with more or less rainwater storage capacity. We should try to:

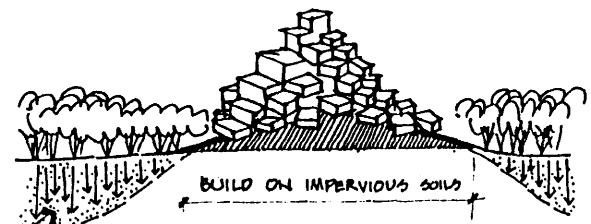
- build heavily on impermeable soils, and drain runoff to areas of good permeability, which are reserved as green space.
- improve the storage capacity of the site to reduce sudden runoff downstream, with holding ponds, rough surfaces and heavy vegetation;
- increase the porosity of built surfaces with porous pavements, and vegetation instead of lawn;
- direct runoff across permeable surfaces with swales and berms.

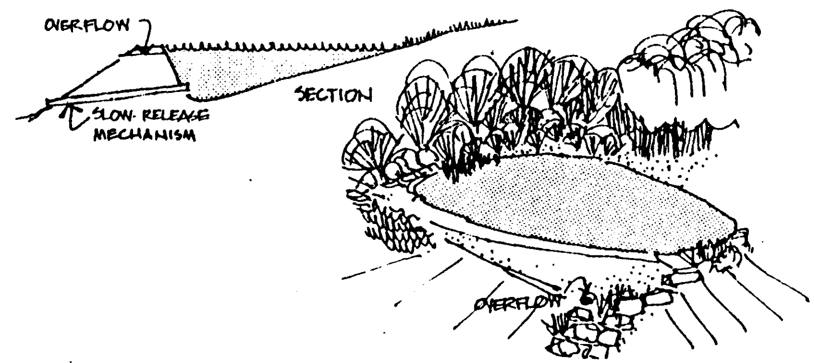
There are four general categories of built drainage systems.

1). Surface drainage with no delay - water is carried in swales across the site to roadside ditches or natural streams. This method can lead to erosion if much runoff must be handled, and feeds water quickly into streams, increasing flood damage.

2) Enclosed drainage - a storm sewer system carries all water quickly to inlets into a series of pipes and culverts. The smooth surfaces and direct flow speed water immediately downstream, creating surges which flood natural streams,







leading to their eventual channelization also. This method minimizes the amount of water that percolates into the ground, thus lowering the water table, damaging plant growth, and carrying surface pollutants into the streams and rivers.

3) Enclosed underground drainage with storage - the storm water system is connected with storage basins and reservoirs which collect runoff and hold it on site, letting it run off slowly after the storm. This is expensive and again does not replenish the water table.

4) Combination - paved surfaces are drained either underground or in surface channels to holding ponds, while surface runoff across vegetated areas allows percolation into the ground, with excess water draining into the slow release holding pond. This method allows replenishment of the ground water, filters pollutants as water passes into the soil, and slows runoff.

If we are serious about our responsibility to participate in the natural cycle, then the last method is the one we should use where possible. Site plans must identify permeable and impermeable soils, and drainage channels, and then build on the impermeable soils, draining water to the permeable areas which are reserved as green spaces. We should improve the permeability adjacent to buildings that must be placed on permeable soils, and minimize the extent of roads, parking and lawns.

Site planning regulations enacted by some local governments limit the amount of excess runoff a project may generate and require engineering studies of existing and proposed runoff amounts. Then a plan based on increased soil permeability or holding ponds must be prepared by the developer for approval. This procedure is likely to spread to many areas, as public activism against the environmental damage of development, combined with attempts to slow down development in general, result in more stringent regulations on building. It was found in a recent cost analysis that it is generally cheaper to provide storm water control on site than to put in elaborate storm sewers.

In a report on the design of the new town of Woodlands, Texas the planning firm of Wallace, McHarg, Roberts and Todd investigated the problems of rainfall and runoff, and recommended a plan which tried to minimize runoff from the site:

> "Orthodox drainage would have required destruction of the forest in order to lay drain tiles. It would also have necessitated costly and ugly open drainage ditches. All of these problems were transformed into factors locating development and creating the major structuring elements of natural drainage and open space. Many apparent liabilities became important assets. Ecological perceptions led to a natural drainage system which preserved the forest and eliminated the necessity and costs of an elaborate drainage system.

The economic benefits of this approach were clearly demonstrated in the first engineering cost estimates. The costs of a natural drainage system were compared by engineers to the conventional method of site drainage. Their construction cost calculations for the storm sewers required for the conventional system were $18,679,300 while the natural drainage system costs were $4,200,400, an incredible savings of $14,478,900. Thus an environmental "constraint" was turned into an asset.

Although the land requirements for the natural drainage system are greater than those for a conventional system, the undisturbed forest of these natural swales offers substantial amenity. The natural swales and floodplains provide vegetation, wildlife corridors as well as open space for passive recreation and a greenway system throughout the new community.

Woodlands New Community

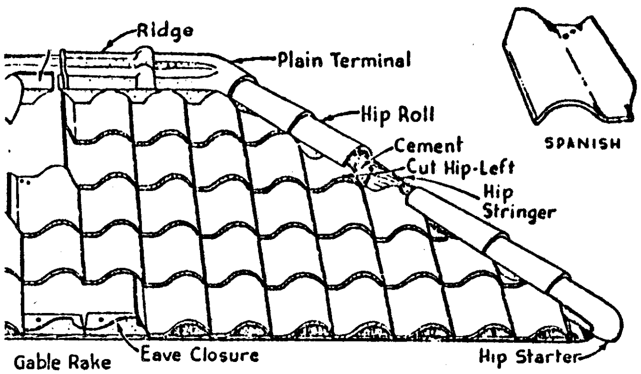
Roofs

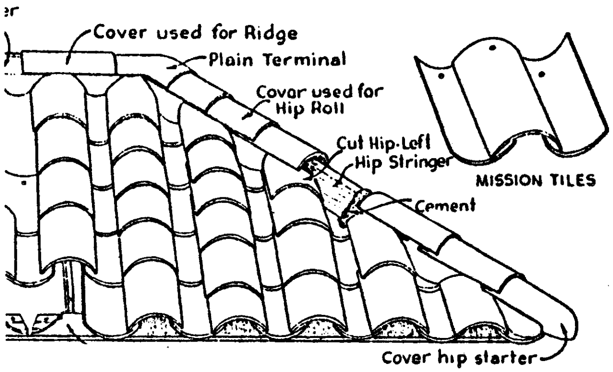
The primary functions of the roof are shedding rain, holding an insulating layer of snow, keeping out cold or heat, and sun shading. If we wish to develop all aspects of building so that they appear to be doing what in fact they are doing, a roof should have the quality of sheltering and shedding. This involves slope, weathering and a sense of direction reinforcing the movement of rainwater on the roof.

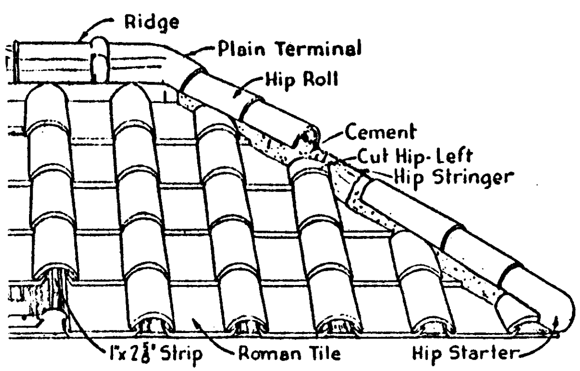
Slope is usually determined by material, as most roofing materials have a minimum slope for resisting wind driven rain.

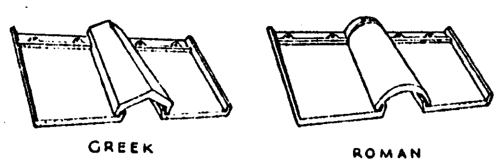
Traditional materials usually have stringent limitations; wood shakes and shingles must be on a slope greater than 4 in 12. When wet they darken, a visible response to the weather. If untreated, they weather gradually to gray, and seem to adjust to nature. Roof and walls can both be in wood so that they respond to the elements similarly, and the building appears as a single mass. Shakes are more dominant in appearance, because their rough surfaces and greater thickness provide shadow lines. Their irregular edges require wider gutters. The relatively smooth surfaces and evenly sawn thickness of shingles produces a more even surface, with less striking shadow lines.

Slate is a relatively heavy roofing material, and due to its thickness, requires steep slopes, at least 6 in 12. It has a bright, soft, reflective sheen when wet, and dormers









in slate roofs afford a view of water trickling in interesting patterns over its surface, running smoothly along the split face of the stone, dropping down the irregular edges and coursing in the valley between the slates, like tiny natural streams.

Slate lightens in color with exposure, and is classified as permanent (slight fading) and weathering. Colors available are black, blue black, gray, blue gray, purple, mottled purple, green, and red.

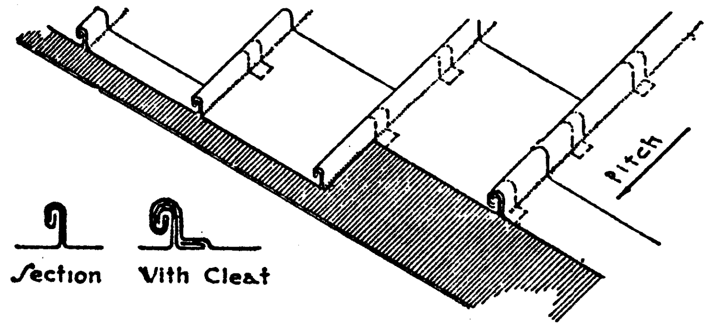
Clay tile is available in many colors and nationalities: French, Spanish, Italian and American. The names refer to the tile shape, and the interlock between tiles. Its minimum slope is 4 in 12, steeper in some situations or patterns. Special shapes for ridges, eaves and gable rakes make a distinctive roof with well defined edges, and the tiles are usually 1 to 1½" thick, producing a highly textured surface, with clear ridges and valleys in the direction of runoff. They do not weather appreciably, but glazed tiles become shinier with water, while the unglazed surfaces of Spanish tiles darken when damp.

Metal roofing is usually ridged or corrugated in long narrow sheets for strength and production efficiency. Ridges run in the direction of rain flow and reinforce the sense of movement of water. The most effective in this regard are standing seam roofs, with 2" high upturned joints between sheets about 2 feet wide, giving a strong series of shadow lines from ridge to eave. Due to the smooth surface of most metal roofing (and slate) some safeguard must be installed at the eaves to break up chunks of ice or snow that slide off the roof. These are either a series of bars, or metal dogs which are spotted on the roofing above the eaves. Painted steel roofing is available in many colors, not intended to weather, though many fade during their 20 to 40 year life. Aluminum is either painted, anodized or natural, often with a quilted pattern embossed. Most steel and aluminum roofing comes as fabricated panels approximately 2 feet wide by 30 to 40 feet long, with upturned interlocking edges which allow its use on slopes as shallow as ½ in 12. Usually gutters and other accessories are available as integral parts or in the same material.

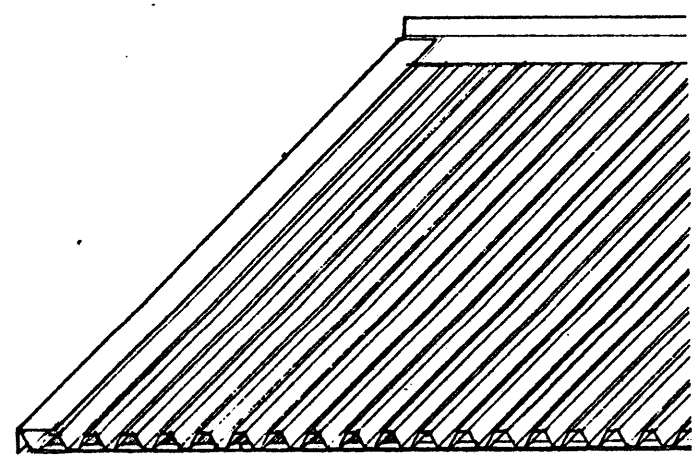
Terne coated steel is an alloy available in prefabricated panels or in sheets for on the job forming. It may be left unpainted, and has a gentle gray surface.

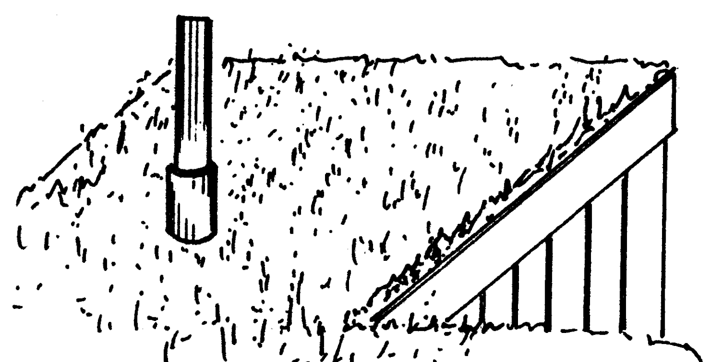
Copper is the classic weathering material, turning a beautiful soft green after 5 to 10 years of exposure. The green surface is a hard mineralized layer, which forms on exposure to water, and protects the metal underneath. Copper is available as sheets, panels, and all accessories, so that the rain shedding and channeling elements can be in one distinctive material.

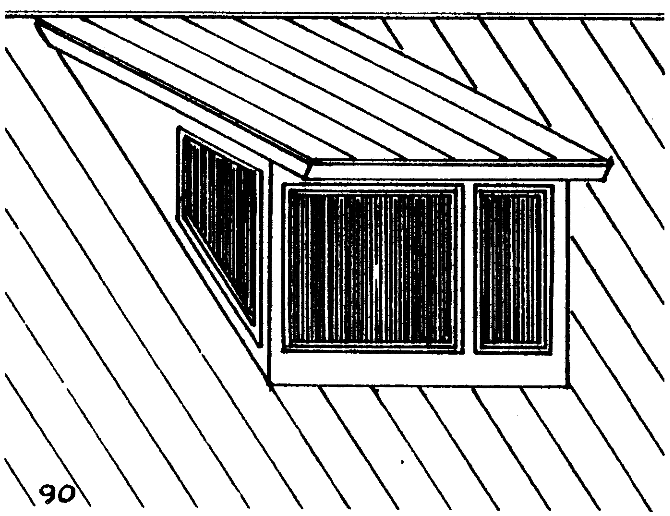
Sod roofs may be used on slopes up to about 3 in 12, providing the soil is thick enough, and the slope shallow



STANDING SEAM ROOFING





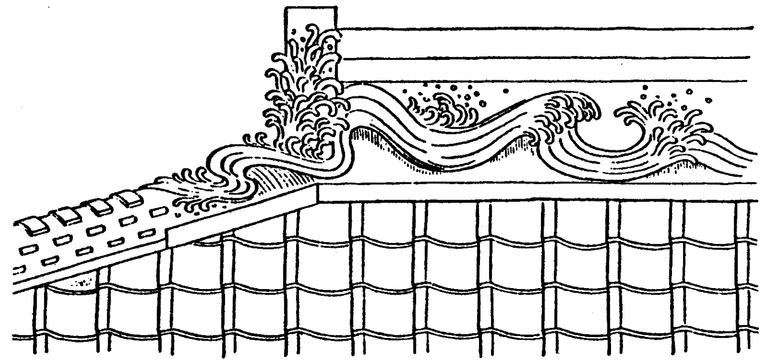


enough to hold some water for the plants. Slow growing grasses with relatively shallow roots are best to avoid root damage to roofs. Sod roofs are often used as extensions of insulating berms, responding to nature by merging with it. They slow down runoff by holding water on the plants and in the soil, providing an element of delay, and reducing the impact of building on the environment.

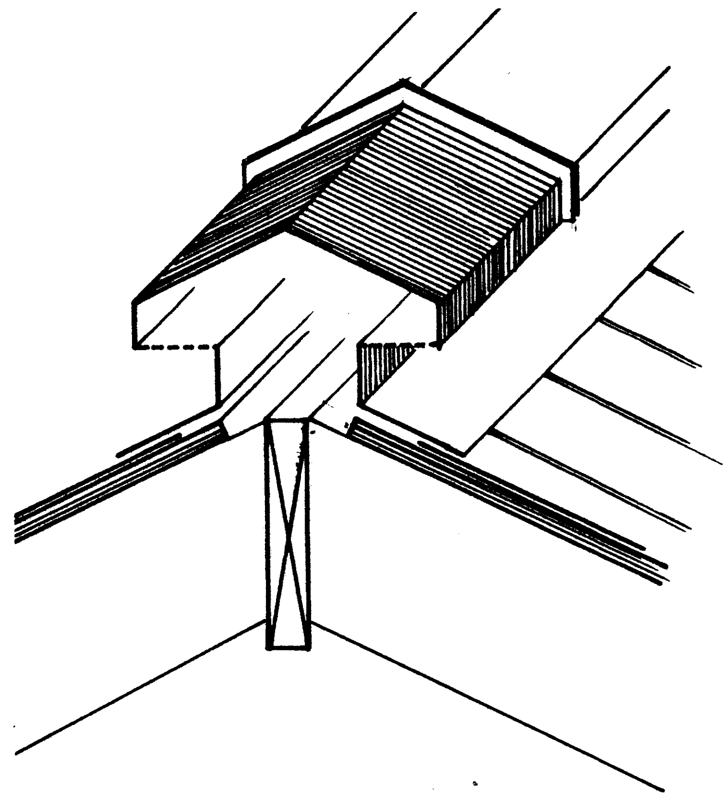
Greenhouses and clear sheet skylights are an opportunity to see rain splashing and water running across the surface, at times pushing leaves or seeds, or plastering leaves wetly over them. The slope affects whether water builds up to flow in sheets, or runs off immediately. Two in twelve is about minimum for an active flow of water, and above six in twelve water will not form up in patterns of sheets, but run off immediately when it hits the surface. Bubble skylights let water sit on top, then run off as rivulets when drops start moving to form radial streams.

Dormers which are carefully placed offer views of water trickling on the roof and running along gutters. Dormers give a feeling of being outside, at the edge of the shelter of the roof, poking through into the weather. Windows in the sides of the dormer increase this sense of exposure.

An important part of awareness of roofs is defining their edges, so the roof can be seen as a plane with a clear beginning and end. In traditional wood shingle roofs, the ridge was formed by projecting the top course of shingles on the stormier side, to protect the joint on the lee side. Wood trim was sometimes used the same way. In Japanese houses, the ridge is an essential part of the roof design, giving a definite top to the house. The threat of fire was constant, and a traditional ridge decoration had a reference to water, either with the character for water, or stylized waves.



In present practice, the ridge usually doesn't have much impact. On asphalt shingle roofs, half shingles are bent over the ridge, and worked from one end to the other. Metal roofing usually has some ridge, and some ribbed sheets have a cap with a strong shadow line. Clay tile roofs have special ridge tiles which give a pronounced projection above the roof plane, either continuous, or serrated by caps and valleys.



The need for roof ventilation on gable roofs offers an opportunity to use continuous ridge vents, both for air movement through the roof construction, and visual capping of the roof. They are now manufactured to be nearly invisible, but are merely visible enough to be distracting. If they had an interesting profile, they could be a bold design element, defining the roof's top edge, similar to the ridges of traditional Japanese houses.

Greenhouses are magical places in the rain, with the sound of raindrops hitting the surface, and sheets of water coursing down the glass. There is a feeling of tenuous protection from inundation, a delightful and unsettling contrast.

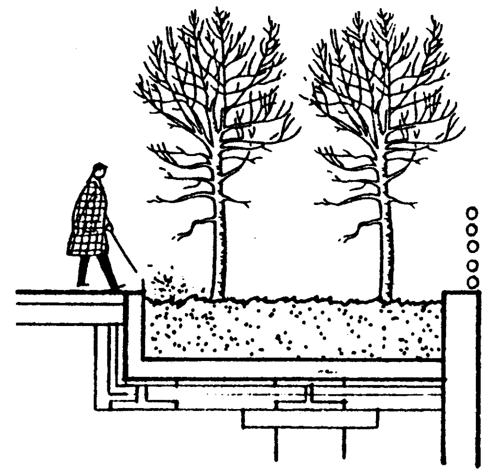
Canvas awnings are alive to the weather, moving by the wind, and drummed gently by raindrops. Water runs off the lower edge, and sometimes the awning bulges with collected rainwater. They are tentlike and equivocal about the shelter they offer.

> "There is a very special beauty about tents and canvas awnings. The canvas has a softness, a suppleness, which is in harmony with wind and light and sun. A house or any building built with some canvas will touch all the elements more nearly than it can when it is made only with hard conventional materials."
>
> <u>A Pattern Language</u>

The sense of shelter from the weather is an important part of awareness of, and response to, rain on a level beyond the utilitarian. The importance of a roof is dependent on its visibility and the directness with which it appears to shelter. Obviously steeper slopes are more visible, as are strongly textured surfaces and overhanging eaves.

> "Slope the roof or make a vault of it, make its entire surface visible, and bring the eaves of the roof down low, as low as 6' 0" at places like the entrance, where people pause. Build the top story of each wing right into the roof, so that the roof does not only cover it, but actually surrounds it."
>
> <u>A Pattern Language</u>

Flat roofs are an opportunity to cooperate with nature by the use of sod roofs and roof gardens, which delay roof runoff and thus take pressure off overloaded streams and surface drainage areas. Dense foliage holds water in its leaves and around roots, and the sod provides additional storage.



Le Corbusier writes of his roof garden in Paris, abandoned during the Second World War:

> "1940 Disaster! Exodus!
>
> Paris empties. The roof garden on the 8th floor left alone. Dog days of 1940 and 1942, winter, rain or snow...the abandoned garden reacts, will not let itself die. Wind, birds, insects all bring seeds. Some find the medium to their liking. The rose bushes have revolted and become very large briar bushes. A cytisus is born, a false sycamore. Two lavender twigs have become bushes. The sun directs, the wind (up there) directs. The plants and small trees become oriented and make themselves at home, according to their needs. Nature has reclaimed her rights.
>
> From that moment on, the garden is left to its own destiny. No one ever touches it, mosses cover the earth, the soil becomes depleted, but the vegetation finds what it needs." [18]

At Seidlung Halen, in Bern, Switzerland, the architects Atelier Five have used roof gardens with every unit, resulting in a development which becomes a grid, which from the air seems to be in the process of reclamation by the surrounding forests. The impermeable area is thus reduced considerably, to the hard surfaces of roads; car parking is under the buildings. (Photo right)

From Roof Gardens:

"Choose plants that are hardy, and will tolerate conditions of limited growth space for roots."

Distribution of weight on rooftops must be carefully controlled and calculated. If (as is usual) a grid structure is used, loading ability varies from over columns, to over beams, to between beams.

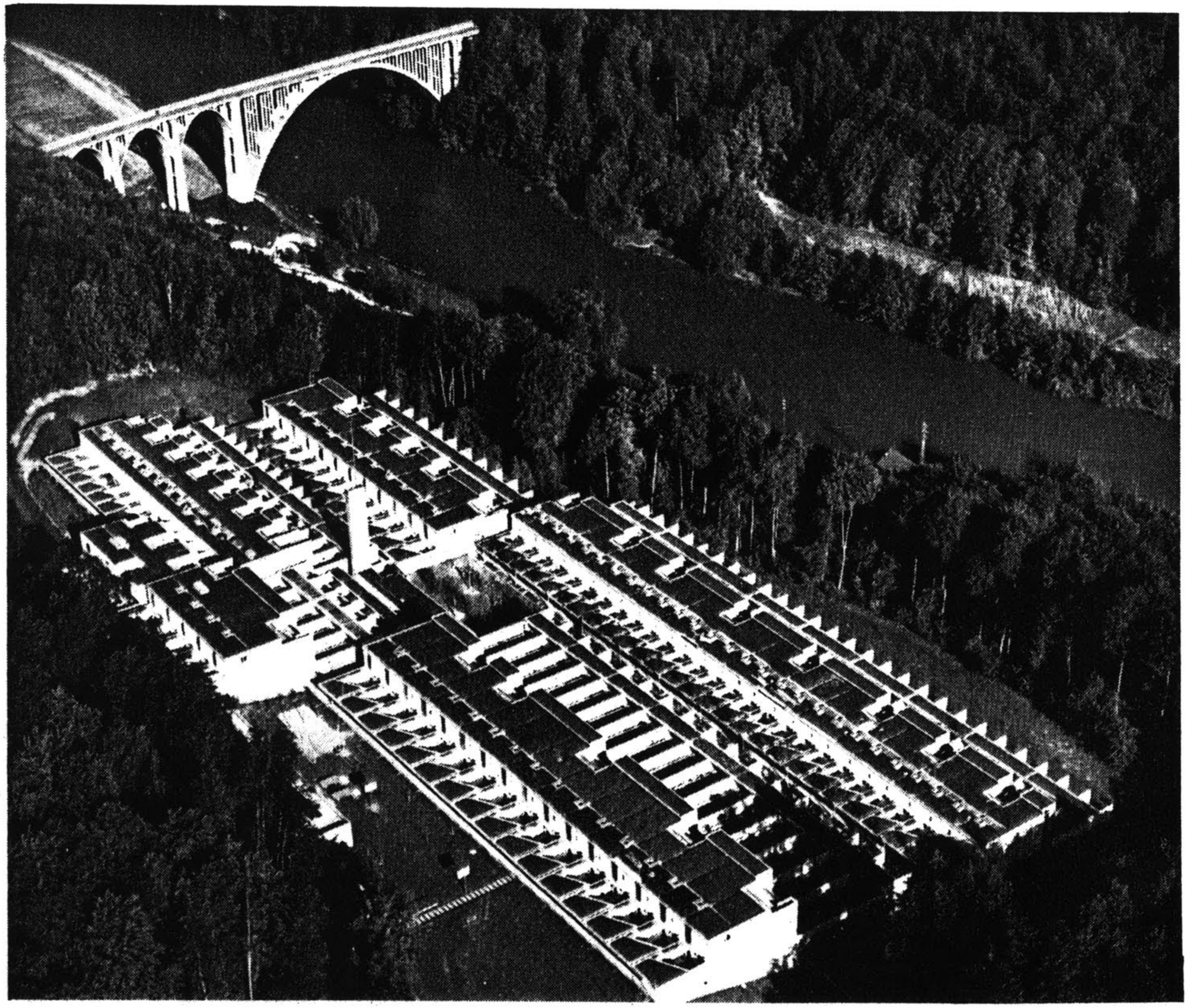
The artificial soil must be rich, but not too rich, which might be the tendency with manmade soil. Sand may be a large part of the mix to allow drainage. Drainage of the slab under the roof planting is imperative. Special care should be taken to avoid damp areas which kill the turf and might damage the roof membrane." [19]

Architectural Graphic Standards recommends the following soil thickness and composition for roof gardens:

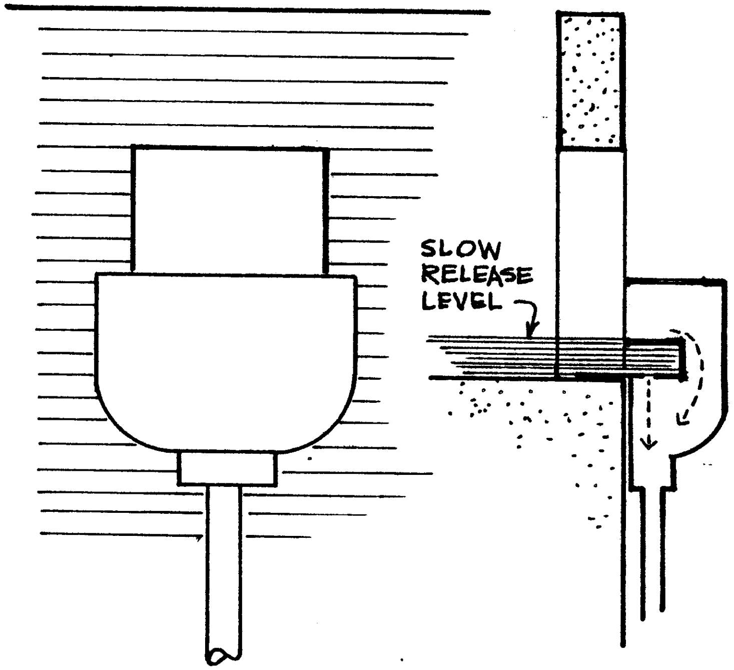
	soil	clay	gravel
lawn	12"		4"
shrubs	24"	2"	4"
minor trees	30"	2"	4"
major trees	36"	2"	4"

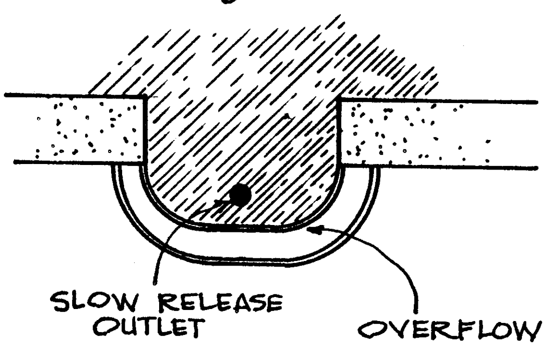
Drainage must be provided within the gravel.

An alternate method of delaying water's entry into the stream system is designing flat rooftops with parapets so that they can hold up to 3" of water.



Seidlung Halen, Bern, Switzerland.





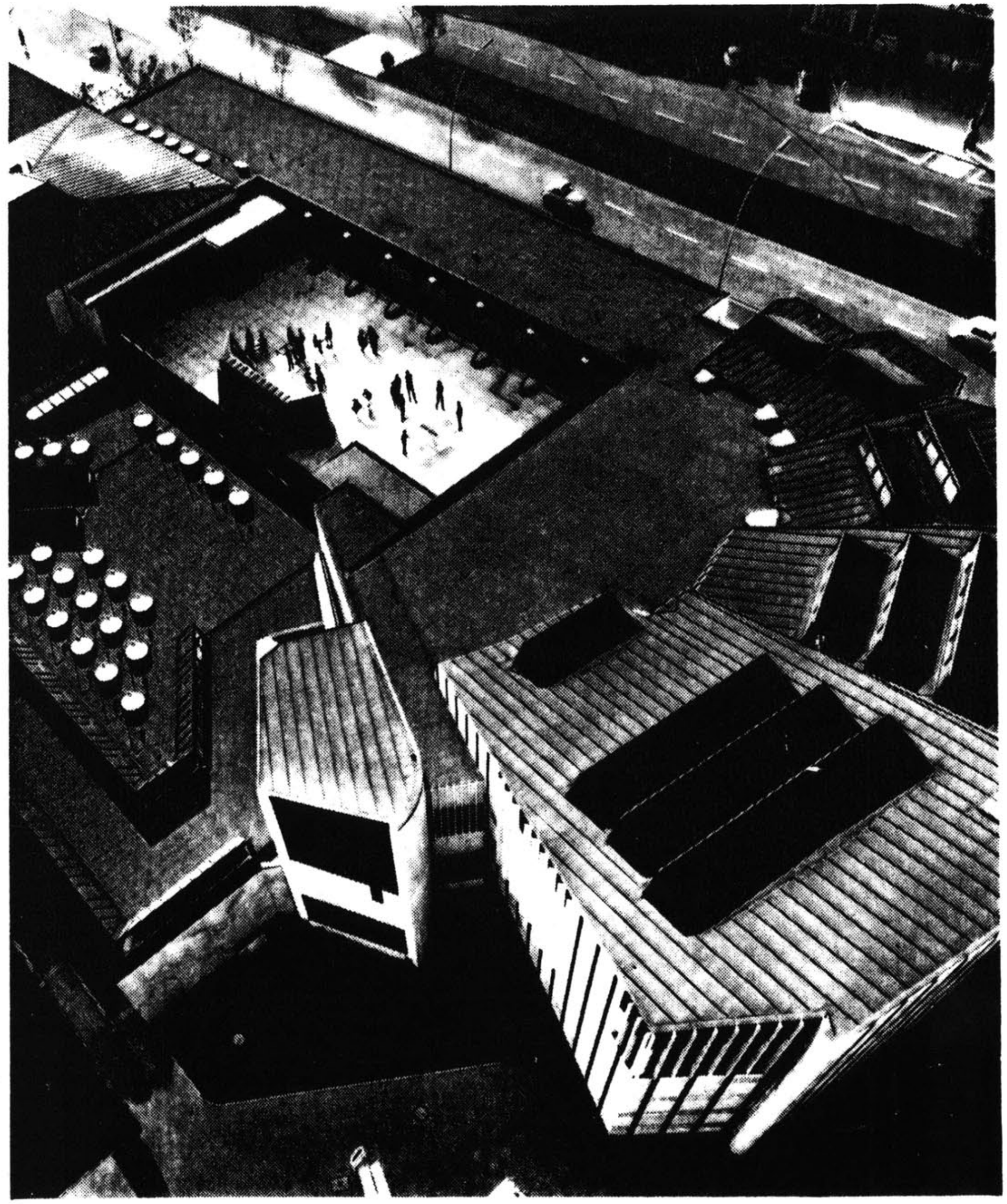
"Flat rooftops may be used for rainwater storage provided a suitable built-up edge is installed. The edge (about three or four inches high) contains the water which is stored until after the storm when it is released slowly. Two downspouts are necessary: a slow release one to duplicate the rate of natural runoff, and an emergency drain for overflow purposes. Obviously, the roof has to have enough structural strength to support the weight of water without collapsing. An energy conservation advantage of rooftop storage is that water provides a blanket of insulation."

Water in Environmental Planning

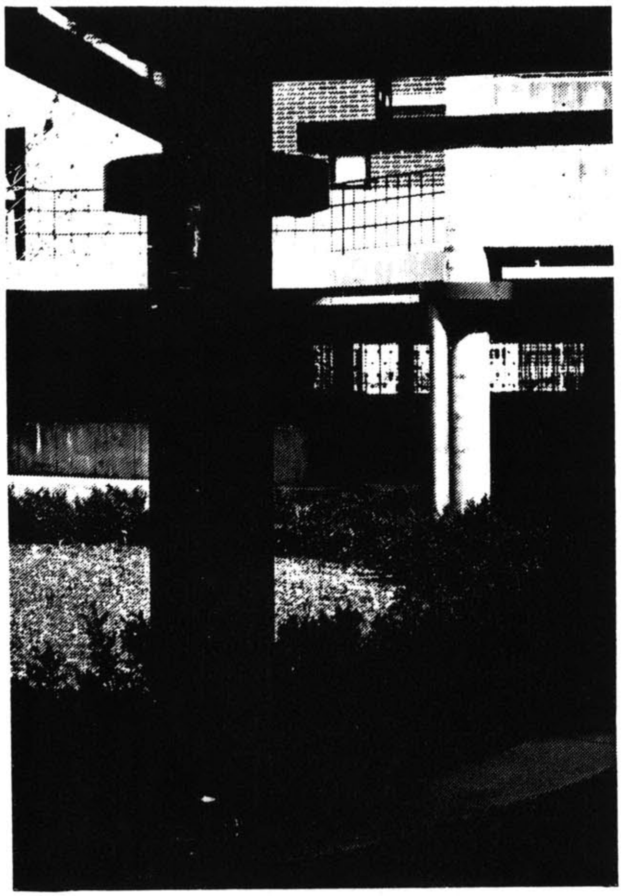
Duckboards can provide a walking surface above the roof pond. Smooth elastomeric roofing can be used as the roof surface, available for use between rains.

To a person on the ground, any sense of the rain-shedding of a flat roofed building depends on the leader heads that collect water at the parapet; on chutes which continue the roof surface through the wall and down the side of the building; on walls over which roof drainage flows (such as Lucian Kroll's church complex discussed in section 3) or by conspicuous gargoyles as at Ronchamp Chapel, where the grand rain spout is sized to the vast roof it drains.

If flat roofs must be designed with drainage to a central point within the perimeter parapet walls, the design of the drainage elements and pattern is important if the roof is to be used, or overlooked by taller buildings. In the Wolfsburg Cultural Center, Aalto neatly directs all drainage to a channel along the edge of one parapet, which appears as a dark recess in the roof. Paving blocks set in the gravel of built up roofs provide an inexpensive surface for use.



Gutters, Leaders, and Downspouts

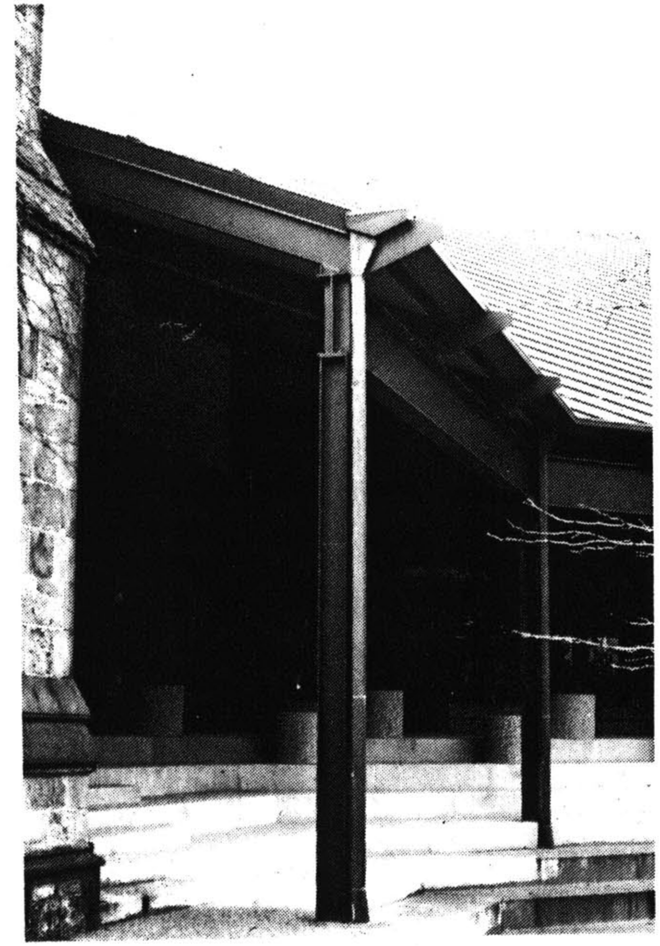


The external plumbing of rain control is an opportunity for a layer of richness and inventiveness in counterpoint to other systems making up the building, or can be deployed to reinforce larger graphic goals of the facade. If they are to stand as a clear added system on the building, the rain-water conductors should be a coherent set, so that they add an enriching layer to the building, instead of several in-congrous and distracting elements that never build up any significance. Material can also tie together the system, if it is in enough contrast to the rest of the building. As we have seen, Boston's Back Bay is full of houses on whi which complex systems of roof ridges, gutters, leaders and downspouts are all integrated as a subsystem because the copper of which they are made has weathered to a beautiful soft green, contrasting with the brick or stone or slate.

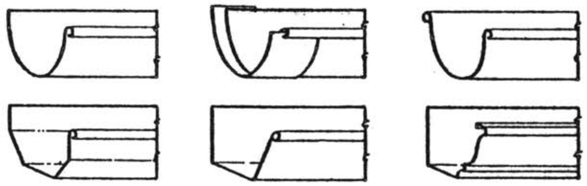
The integrity and clarity of the rain gathering system fulfills another of the goals of design for rain: that the building seem ready for rain, acknowledges its inevitability and unpredictability. When rain occurs, the system comes to life, streaming and gurgling, and providing splashing torrents at its base. If the system has some holding capa-city along it, water can continue to spew out after the rain has stopped, in the same way that nature delays and evens things out.

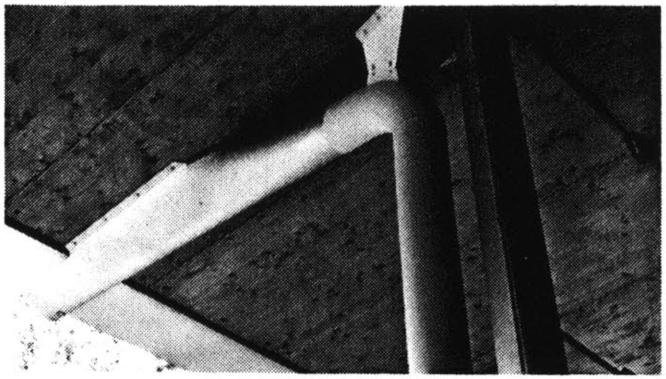
Leader heads, joints and changes in direction are all opportunities for slack in the system, generosity of size to recognize that we are not making pipelines, but responding to a natural force. In the Pierce School in Brookline, Mass. by William Warner, rectangular tubes suspended from the slab of a deck bring water from several directions to a central column, to be conducted to the ground. Instead of a maze of plumbing fittings, which untangle themselves into one pipe, converging conductors drop their load splattering into a 6' diameter red painted metal tray which surrounds the column. Water is then drained out by a round pipe.(P. 98)

The scale of gutters and downspouts to other building dimensions is important if they are to read as significant elements in the construction, and not incongruous afterthoughts. In the First Church in Boston, by Paul Rudolph, the great expanse of standing seam roofing sheds water into a large specially fabricated gutter, with heavy projecting supports, sizes befitting the amount of water it receives, and the importance of its location along the entry porch.

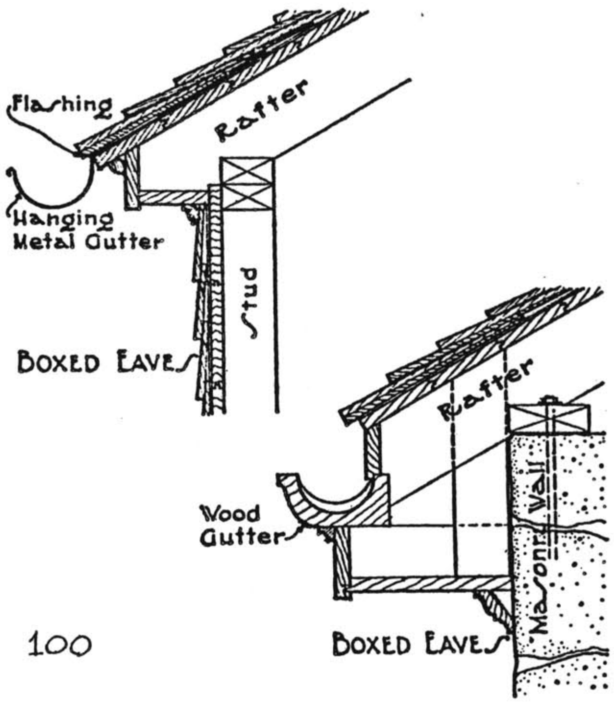


Gutters are often the only trim on building eaves, sometimes even shaped into classical moulding silhouettes. Half round gutter, standing clear of the fascia board, are clean decorative elements reinforcing the form of the roof, but keeping their own identity as a subsystem. When connected to round downspouts, the family of cylindrical tubes can provide consistency to the rain carrying apparatus.





Detail, Jean Prouve.



Gutter shapes vary with different materials:

Half-round: galvanized steel, copper, plastic
Ogee: wood, aluminum, galvanized steel, copper
Rectangular: aluminum, galvanized, copper

Special shapes can be made up on the job in galvanized steel, copper and fiberglass. Rectangular or half-round profiles are usually chosen for large buildings with simple eaves, or for draining the low end of a flat roof. Rectangular shapes are easily integrated with the roofing system.

Half-round gutters adjust to slanted eaves, and some brackets for hanging them are shaped to the arc of the gutter.

In situations in which no downspout is necessary, water can run out the ends of the gutter to fall in a stream. Wood ogee shapes are often used for this, since their profile when not shaped is interesting, and the wood can support itself when cantilevered beyond the eave to keep the splash away from the walls. Ends of open gutters should have some small notch and perhaps a lip to channel small amounts of flow into a coherent stream rather than scattered drips.

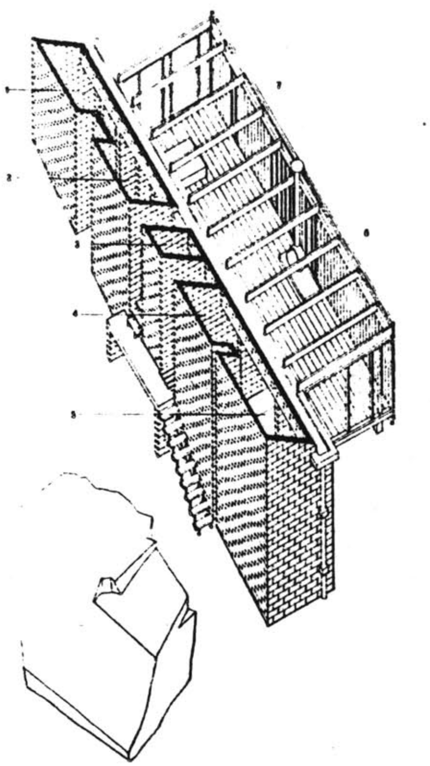
At the Wharton Esherick Studio in Paoli, Pennsylvania, a 4 foot tall stone pelican with wings half spread stands in a terrace with its back to the corner of the building about 8 feet away. The bird's back is streaked and weathered to a puzzling degree, but looking up, it is apparent that the bird is placed to receive the stream of water from the roof gutter three stories up, breaking the force of the water and marking the distance the water is thrown.

To slow water from the gutter, while still seeing it move, chains are sometimes hung from the gutter end, and water runs down the chain, in a controlled flow.

If rainwater is allowed to run off the roof edge without a gutter, it forms a stream like a beaded curtain on uniform roof surfaces such as asphalt or wood shingles, and separate streams on corrugated metal. The ground below the eaves should be protected from the cutting action of the water. In Japanese thatched roof houses, a path of gravel corresponds to the eaves, breaking the force of the water and allowing it to soak in.

Projecting spouts and gargoyles throw water clear of the wall, allowing us to see a waterfall and its satisfying splash. In masonry buildings, the masonry can turn out to form the spout, lined with the roofing material or flashing. On a high school in Switzerland, Dolf Schnebli has designed a concrete channel which projects from the wall, and flashing appears as a lining, protecting the concrete, and accompanying the water out.

As with most other elements in the rainwater control system, designers must be aware of the variation in flow in different intensities of rainfall. While sometimes the chutes or gargoyles may be spilling a great crashing stream, at others only a trickle may be available. The edge must be designed to channel this low flow in a way that gets as much liveliness as possible and avoid the dissolute drip-



ping from an undifferentiated edge.

Open scuppers are a variation on projecting rain spouts. Water flows off the roof and runs down the surface of the wall, channeled by a tongue of roofing material or flashing attached to the wall. Water is seen to stream in flat sheet flow and can thus run into drains or fall from the end of the flashing to splash on the surface.

Valleys

Multiple gable roofs are a case calling for extreme response to rainfall. All rainfall on two slopes ends up at one point on the wall. The extent of the problem often calls forth dramatic solutions. In a house by Edward Cullinan, in California, the house is covered by two narrow opposing shed roofs, over areas of different function and construction, which meet in a valley corresponding to a strip of storage closets between the two areas. This valley projects beyond the building face, where a downspout is divided into several sections by clearly delineated joints, which are points of attachment to the wall, and modulators of its length.

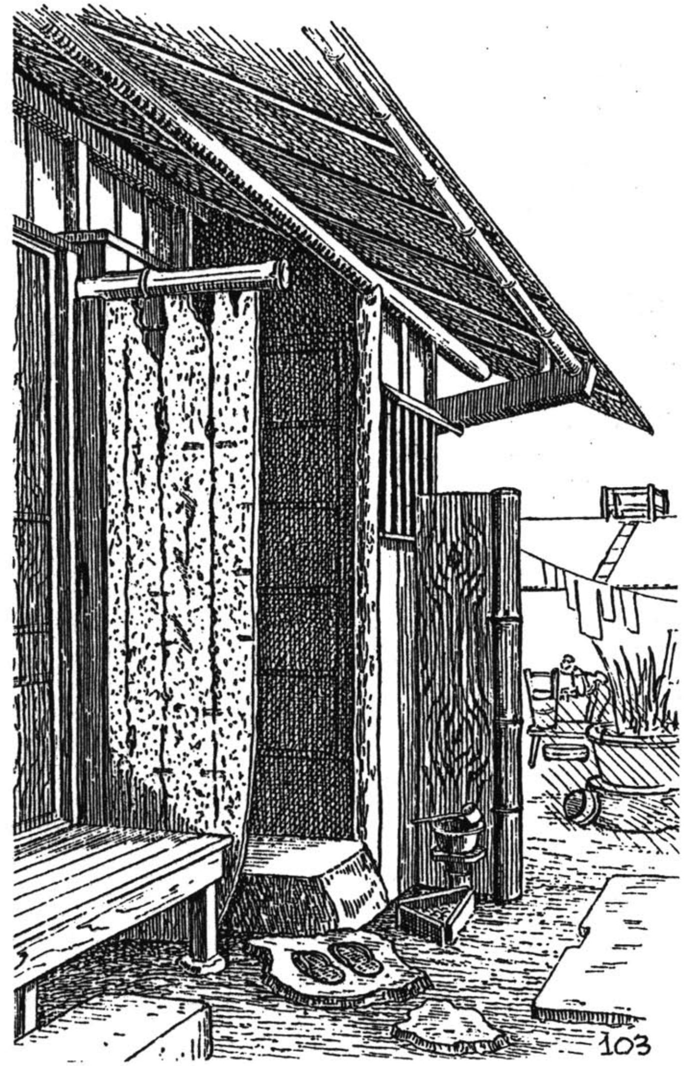
Leader heads transfer water from gutters of sloping roofs or parapets of flat roofs to downspouts. They are often highly developed decorative metalwork, large enough to read as objects in the linear system of rain control. Their size helps to relate the thin gutters and downspouts to the building mass. On flat roofed buildings, leader heads are the most important evidence of the effects of rain, and their shape should suggest their function.

Architectural Graphic Standards recommends use of a leaderhead at the top of any downspout over 40' tall. In the past, leaderheads were almost invariably used, in good quality construction, as a receptor for the gutter's flow, channeling it into the downspout. This was an opportunity for the gesture of generous size in response to rain.

The joint between the gutter and downspout on buildings with projecting eaves is often awkward, as the downspout must leave the building face to cross diagonally to the gutter. A projecting leader head could catch rainwater falling from an opening in the gutter, and channel it to the downspout.

Downspouts are vertical pipes which conduct water to the ground, in cases where its fall must be controlled. While gutters are always in direct correspondence with roof edges and eaves, placement of downspouts is a design issue of some importance, because of the prominence of the popes on the facade. In planar wall construction, they are sometimes the only delineators of territory, or modulators of scale.

On larger buildings where heavy use is expected, the downspout often empties into a cast iron rectangular section firmly bolted to the wall. They usually protect the bottom 6' of downspout, and are an opportunity for the rain system



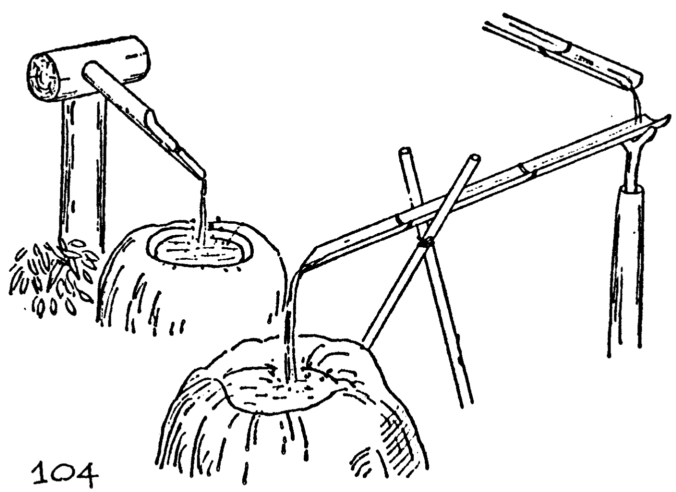
to respond to the presence of people: to a dimension of use.

Downspouts must translate the force of falling water to horizontal, to avoid gouging the soil, or saturating the ground around the foundation.

On old sidewalks, the path of water from the downspout to the curb is delineated by a channel in the paving, or a specially carved stone, keeping water from spreading on the sidewalk. Sometimes the downspout continues under the sidewalk to emerge in the curb. The foot of the downspout is turned out, and the force of the water is broken, emerging onto a splash block, gravel area or pile of stones. The length of the drop from spout to ground could add a view of water being thrown to the ground, without letting it spread too far.

If water is to drop onto the ground to some effect, there is no need for the downspout foot to have a top; thereby the water can be seen to hit the bottom of the downspout foot, then splash out to fall again to the surface of the ground, or into a reservoir.

The design of the foot can either provide a flat surface for noisy spattering, or be curved smoothly to throw water out in a stream. With round tubes, such as metal or especially plastic, the foot design can be simillar to bamboo pipes in Japanese gardens, which are cut at an angle so that the bottom of the bamboo projects farther as a lip. This also focuses low flow.



Walls and Weathering

One of the major effects of rain is to change the appearance of wall surfaces, through general exposure as well as permanent staining due to unique conditions.

Rot resistant redwood, cypress or cedar may be left to weather naturally, responding to rain by turning a soft geey With shake or shingle roofing of the same material, roof and wall will weather equally, if exposure conditions are simillar. Deep overhangs will keep water off the walls, delaying their weathering.

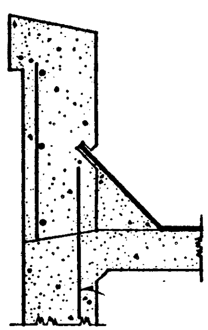
Stains are water repellent coatings which soak into the wood, allowing the texture to show. They must be reapplied every 5 to 10 years. Stains with too much repellent will collect dirt, and rainwater will not be able to wash it off. The wood is darkened by staining, and doesn't show any change when wet.

Brick, because it is usually dark in color, does not show the effects of wetness, although it absorbs water which reduces runoff over the surface. The mortar joints are more susceptible, and should be protected from streams of water.

Most steels must be covered to protect them from rust, but several metals are available which form a shield of surface corrosion that seals the metal underneath from damage. Copper's green patina is such a cover, caused by the surface turning to a mineral state, which is inert. Stainless steel and aluminum are likewise covered by a surface film which protects the metal from corrosive attack.

Weathering steel forms an oxidized surface on exposure which protects the steel underneath. The surface turns a deep russet color; during the initial weathering the surface runs, staining other materials. This must be allowed for,,either by separation from other materials, or by reveals and recesses which hide the stains.

Concrete, because it is porous and light in color, is most susceptible to staining. Water on the surface turns the concrete a darker color, sometimes uniformly, but in other cases in large zebra patterns. These are caused by differences in permeability that comes about during the initial setting, and can be remedied by etching the surface to equal porosity. Projections such as sills leave areas underneath which are not washed by rain, and therefore darken. Edges of sills may be washed by wind-driven rain off the sill, which causes light streaks. Wide sills, flush to the surface, collect water which runs off to wash the area under the sill cleaner than the surroundings. This can can be avoided by channeling water to vertical grooves designed to run water to the ground, or by directing water to a projecting lip which throws it clear. Parapets which drain their top surfaces to the facade also leave a fringe of wet concrete along the top. This can be avoided by draining them to the roof side of the parapet. Many stains are caused when water washing down a wall carries dirt with

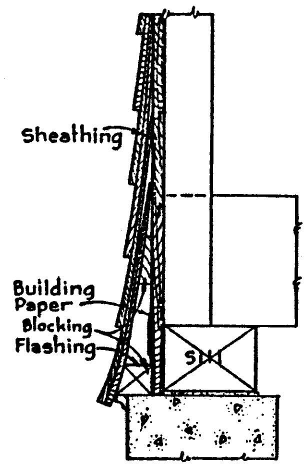

Parapet Wall

it, but there is not enough water to run to the bottom of the wall. Evaporation and absorption take up the water, leaving the dirt in long streaks.

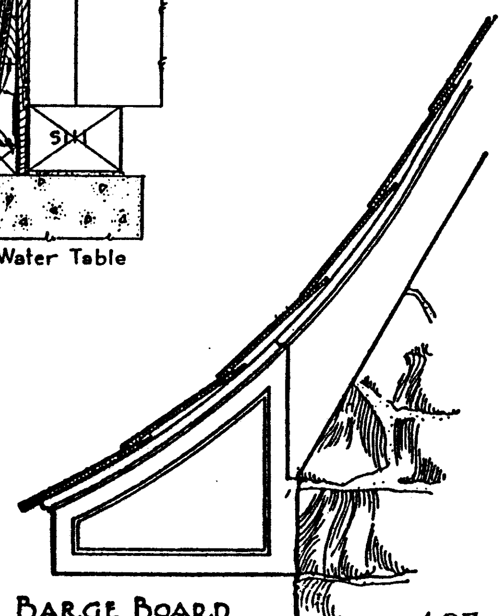
Staining can be made less apparent by using ribbed or textured surfaces to break up the flow of water and hide differences in color behind the strong pattern of shadows. Exposed aggregate concrete breaks up the flow of water, and the projecting stones cause rainwater to drip off. The stones also shine when wet, giving the surface more life. White concrete is often used because the contrast between wet and dry is reduced.

Any horizontal surface will collect dirt and should be provided with either a projection with a drip groove, or some way to keep water from running off its surface across the wall below, carrying the dirt to stain the wall.

Drip mouldings cause water to drop free of the walls. They are also used as water tables where wood construction sits on masonry foundations. Projecting eaves protect the wall from rain, as well as keeping sun off. Windows can be left open during rainstorms if protected by eaves.



Water Table



BARGE BOARD

Pools

A rainpool, in contrast to a basin with a regular water supply, must be designed for fluctuation in level, indeed part of the point of the pool is to register the changes in nature.

Streams running full to their banks are interesting for the surging of water and extent of surface. The stream comes up to tree edges on both sides. During low flow, the stream trickles through rocks and sand, which become the major visual interest. We need to design rainwater pools to offer qualities at any level of water availability. Use of natural materials is one way to insure an interesting surface, whether the surface is wet or dry. Making the vertical enclosure irregular to hide the edge is another, which prevents the waters edge looking like an emptying bathtub. Planting in association with pools can hide the edge. Lucien Kroll makes temporary pools which are continuous with the paving, so that when water runoff accumulates, low parts of the paving become pools, and then the pools gradually disappear as the water seeps through the permeable paving, leaving the undulating surface of the ground.

In Moorish fountains, a small amount of water was made to seem larger by being surrounded by shiny tiles. Pools can be designed with no fixed water level, but one which fluctuates across the field of a shiny surface, such as ceramic tile or polished stone.

If the rain pools are not designed to allow water to seep through into the ground (and they probably shouldn't if they are near building walls) then they must overflow into channels which will carry off the excess to permeable areas or storm drains. If the pools fill during a rainstorm then slowly empty over several days, to fill again with the next rainstorm, then water does not have a chance to stagnate. If possible, intermediate storage could be provided between the roof and the pool, to allow the sound of the pool filling for a while after a rain. Sod roofs and rooftop retention ponds accomplish this. Any storage, on roofs or in pools, helps reduce the stormwater runoff, and make the project more ecologically cooperative.

Pools must be scaled to the amount of impermeable surface available to fill them.

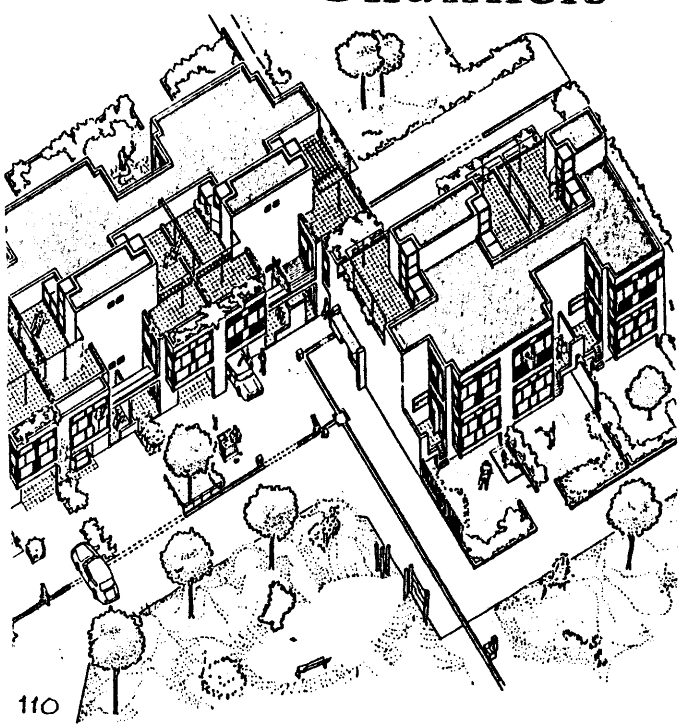
In the northeast, precipitation occurs about one day in three, and weekly rainfall amounts to less than 1".[2b] So it would be safe to assume the pool could be filled regularly if it is designed to hold about ½" of water times the roof surface. The pool should be oversized to store more water during heavy storms, which is the time storage and delay are most critical. Slow release drains are available, graded according to the amount of water they drain per hour.

Pools in public areas should provide edges to sit on, and the possibility for children to play inside the pool. They may have the effect of a village fountain as a magnet to activity.

The principle of the siphon can be applied occasionally to make water in one pool disappear, welling up mysteriously in another, just as water seeps into the ground, to reappear later in springs.

Smaller pools can be provided under downspouts. These would act primarily to break the force of water by dropping runoff into pools, an alternative to flat splash blocks. The pools offer more noise and less splatter. The hollow would also hold water for a time after the storm.

Channels



In order to get more enjoyment out of rainwater when it is available, and to distribute it to its various ends, we can direct it through troughs and channels, seeing it move swiftly in narrow paths, like natural streams. If there is sufficient fall across the site, it can bounce and spring in waterfalls, and provide delightful music. The landscape could come alive during and after a rainstorm, as water swiftly forces its way down slope, falling from roof to pools overflowing the pools into channels which direct it through the landscape, splashing its way until it is allowed to rest and sink into the ground.

> "Rainwater can be allowed to assemble from roof tops into small pools and to run through in channels along garden paths and public pedestrian paths, where it can be seen and enjoyed.
>
> A Pattern Language

As in other rain conveying elements in which water is meant to be visible, designers must consider both full and dry conditions. Channels must be a part of the landscape when not in use, integrated with paving or planting, or forming an element in a composition such as at the Imperial Palace in Kyoto, in which a hard edged stone channel follows t the eaves, to pick up roof runoff, tracing the shape of the house on the ground, and providing a sharply shadowed line in contrast to the sea of raked gravel in which the palace sits.

Water channels are a reminder of the imminence and the changability of the weather, and a recognition by man that he is in cooperation with nature and therefore must make some graceful built acknowledgement.

They are meant to convey water, to move it by gravity. We must try to make the most of the energy in this system to animate the environment, with sudden level changes and rough surfaces which bring water to life. Lawrence Halprin's fountains are based on studies of natural streams, how water drops, what sounds it makes in different size pools, and how the shape of the channel affects the surface flow. Japanese gardeners recommend spreading 3/4" diameter gravel on the bottom of a shallow (less than 1") stream, to give a murmuring sound. On slopes over 1 in 80, the stones must be set in mortar.[22] Water channels can be designed in conjunction with the movement of people, reinforcing the definition of

paths and moving with or against people walking beside. Water might drop down slopes in association with stairs, emphasizing changes in level.

The geometry of water movement might reflect its tendency to sinuous motion, with channels that swirl or drop in in spiral fashion at level changes or drains. In this way built places will be making a gesture to the natural forces in water instead of always imposing a rectilinear grid on it.

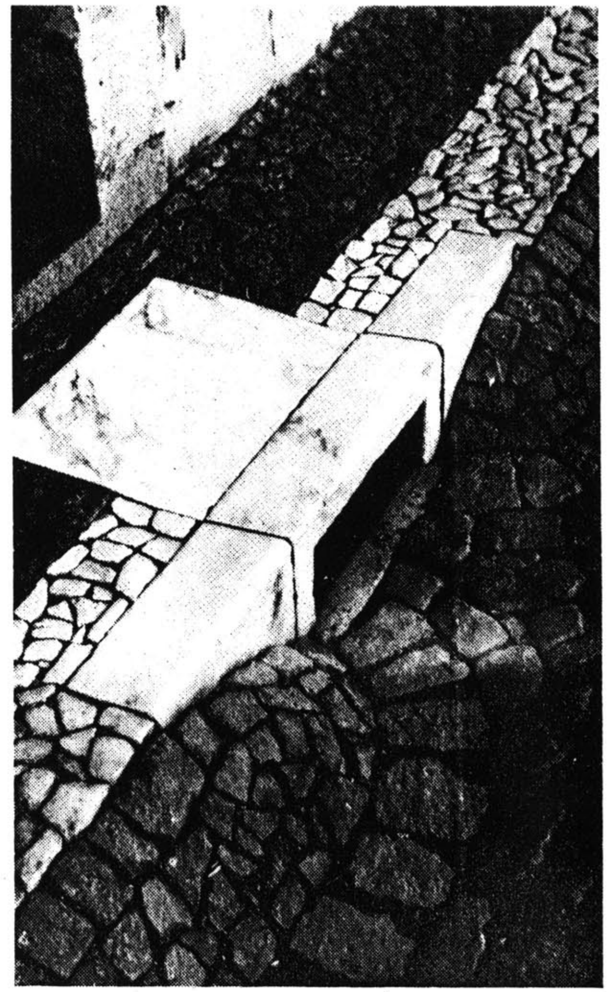
In Indian royal gardens, water was directed over sloped planes called chadar, which had a surface set with small projecting stones that broke the surface of the water and caused it to sparkle in the sun.

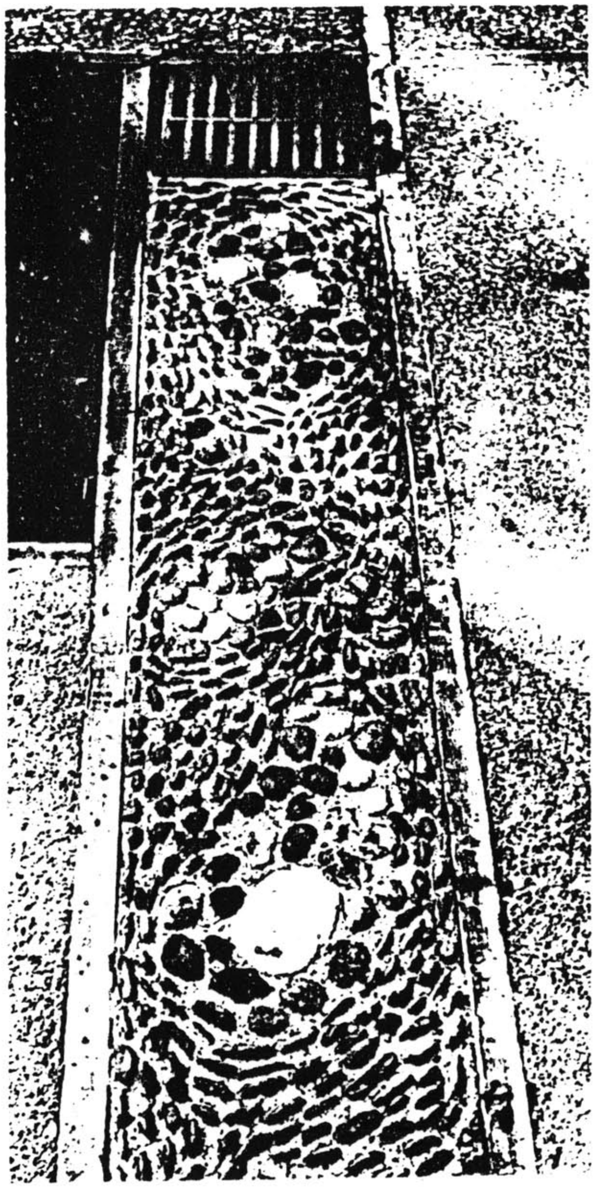
The example of the Japanese dry cascade can be useful to thinking about the design of rainwater pools and channels. They could be designed to suggest the flow of water between rainstorms, to explain their function and to present the image of running water. Channels in sinuous shapes, or visually active construction at waterfalls can be reminders of the absent water, as can surface patterns that reflect motion.

Pools and channels are opportunities for children's play with flowing water when it runs, but also as evocative constructions when dry. Pools, by their nature as enclosures, provide places to get into, like outdoor rooms, and troughs can serve as highways, paths, or if large enough, as enclosures also. In large drainage systems with some delay of runoff, a smaller channel within the larger focuses available water in a small stream, leaving the rest of the bed dry for play at the edge of the running channel.

The first objective in paving design is to provide pedestrians with a dry, safe walking surface, by running water off and texturing so that the paving is not slippery. Patterned surfaces can be grooved to pick up surface water and carry it to the edge or to a channel. The general principle of pavement design in use today assumes that we can construct all paved areas so that they drain to provide a relatively dry surface, and that pavement needn't be discontinuous with any surrounding unpaved areas. This optomism is not usually borne out in practice, as paving settles or is not installed to such close tolerance of slope and consequently puddles form. If we surrender the notion that we can control water with such subtlety, we can begin to provide more differentiation between areas that will be well and carefully drained, and those surrendered to the water, serving as receptors for the intended dry areas. The path available is thus affected by the weather, and one walks in comfort alongside places clearly wet, with puddles and running water. Likewise, outside waiting areas such as bus stops can be seen as islands, raised from the general level of inundation; even if the surrounding pavement is reasonably dry, it is associated with level ground, which we recognize as damp and flooded.

Paving





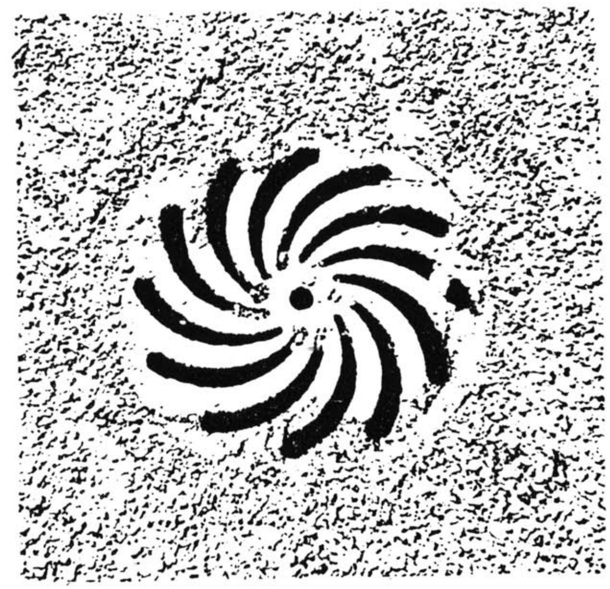
Paving texture must provide safe footing, and this is an opportunity for attractive surfaces, for example the pitted face of naturally split stone, which holds small puddles after a rain, providing beautiful natural shapes to reflect the sky.

Paving stones of one or two foot dimensions provide footing because of their joints, and can have grasses growing between them. Concrete has many suitable finishes, both in small scale pattern on the surface, and exposed aggregate work or pebbles tamped into the surface of wet concrete. Rough trowelling, or brushing with a stiff broom are more usual finishes. Dark concrete, perhaps gray or colored, will reflect light, while uncolored concrete is usually rather dull when wet. Precast concrete pavers are an opportunity for the durability of concrete, along with the small scale associated with stone or brick.

The black surface of asphalt paving becomes very reflective when wet, mirroring trees and sky by day, and reflecting the dull light of rainy days, or the artifical light at night, like long ribbons of brightness. Pools or puddles can be constructed which fill during rain, and then slowly disappear through a slow release drain, merging with the rest of the continuous surface. Asphalt can be used with other materials which break down its extent of surface; brick or stone strips, or concrete or wood dividers. Asphalt pavers provide the soft feel of sphalt and its adjustment to irregularities, while also breaking down the scale into step sized pieces.

In order to minimize the impact of storms on drainage systems, paving must be designed where possible to allow some water to trickle through to replenish groundwater supplies. Stone, brick and Concrete pavers can be set without a concrete base, if they are installed over sand or gravel sub-bases. Gravel, pea gravel and pebbled surfaces all are good permeable surfaces.

Grates of various sorts collect surface water and let it drop into subsurface storm lines. In the past, many grates have been fabricated to reflect the swirling of water as it descends. They can be incorporated into the paving pattern.



Tree growth in paved areas requires some adjustment of the paving to provide water to the roots. Cast iron tree grates are large, patterned elements adding another texture to the ground. Water may also be allowed to reach the roots through loose paving with large open joints, or by eliminating the paving altogether.

The necessity for moving water across paved surfaces is another opportunity for richness and appreciation in built response to the weather, integrated with other elements in the rain shedding system from roof to rain water's disappearance underground. Pavement can be designed to define water's path to storm drains or storage basins, or the drainage pattern can be incorporated into the overall paving plan.

Water into the Ground

As we have seen in the discussion of site analysis at the beginning of the chapter, the earth develops a drainage system over time which is balanced: adjusted to carry as much precipitation as is usual, without erosion, through a combination of groundwater flow and surface runoff. Impermeable soils in one area are balanced by well developed swales to more permeable areas, or to nearby streams. In forested areas, leaves, branches and tree trunks slow the force of water, and hold up to 50% of rainfall in the tree canopy. The majority of the water that falls through is held on the ground by leaf litter, brush and exposed roots, eventually soaking into the ground. So only a small amount of a normal rainstorm ever becomes surface runoff.

Development necessarily involves increases in impermeable surfaces; paving, lawns, roofs and reduced vegetation all lower the permeability of the soil. Natural swales and streams are disrupted, and valuable permeable soil may be covered, rendering it useless. Water is carried to streams more quickly and in greater quantity than in the natural forest, and pollution picked up on the surface is not filtered out, as it would be if water soaked into the ground. Storm sewer systems are proposed by local authorities to "solve" runoff problems, but they merely move the problem farther downstream, pouring out enormous quantities of runoff quickly into streams and rivers - water that should be going into the soil where it falls to replenish the ground water suppy, thus promoting healthy vegetation and suppling water for our use.

Our task as designers should be to minimize the impact of development on the landscape and to cooperate with the already established natural cycles of the particular place.

> "The basic principle in developing systems for runoff disposal is to maintain runoff volume and speeds at predevelopment levels, called zero-percent increased runoff; then existing drainage patterns can be maintained. Runoff disposal systems allow storm water to percolate into the ground or be detained in holding basins until a storm subsides when it can be returned to the natural drainage system without causing erosion and flooding."
>
> Untermann
> Site Planning for Cluster Housing

Reducing the area of impermeable surface requires careful thought, but has the added benefit of adding more greenery and texture to the landscape, and encouraging building methods which are more modest and intelligent about our relationship to nature. Analysis of natural drainage swales will allow building to make use of the existing system, and help structure site decisions.

Road embankments that run in relation to drainage swales and areas of permeable soil can be used to channel and impound water, so it soaks into the ground. Groundwater recharge basins hold water behind berms, giving it time to per-

ROADS CAN DIRECT & IMPOUND RUNOFF

colate. Basins must have a designed overflow to avoid damage to the top of the berm in extreme conditions, and may have slow release outlets at the bottom so the basin drains fully, or may remain as a pond or swamp year round. Retention ponds can be formed either by excavation or berming.

The soil itself can be modified by mixing more permeable material such as sandy or gravelly soils into the surface layer. Rough, irregular surfaces associated with the natural landscape increase the surface area of the ground, and provide depressions that hold water. Terracing or heavy vegetation hold water on steep slopes, keeping it from building up erosive velocities. In Frederick Law Olmsted's park designs, slopes are heavily treed and have thick underbrush, to keep people from walking on and damaging slopes, and to slow runoff.

Terracing steep slopes provides horizontal surfaces for planting or building, and holds water on the surface that would otherwise rush down slope, causing erosion and reducing the amount of ground water buildup. Channels can be run along the terraces, criss-crossing as they slowly make their way down slope. Water pressure building up behind terrace walls attempts to overturn them, but use of porous walls such as dry laid stonework, wood or concrete ties will allow water to trickle through, as well as allowing planting in the wall. Solid retaining walls must have weep holes and foundation drains.

Porous pavements and gravel surfaces allow more water into the soil than conventional pavings, though gravel might require occasional maintenance if it becomes tightly packed.

Vegetation is the most important element in reducing runoff. Trees hold water in their leaf canopy, and reduce the force of the drops which make their way through. Vegetation roughens the surface of the ground, and roots hold water near the surface, to increase the humidity of the surface, and therefore even out potential temperature swings.

The best protection for the earth is a variety of sizes and types of planting, offering a canopy of high trees, lower bushes, and ground cover with many leaves and branches to catch and hold water. Lawn is not particularly good for water retention, as its density of surface roots and smoothness of trimming encourage runoff. Landscaping should be designed to maximize the diversity of scale and texture of planting.

> "Ecological integrity is the way all individual natural processes relate together on a site to produce overall stability. This is achieved through a diversity of site elements, because with many different forms of life the overall structure is complex, producing many interdependencies which serve to buffer the system from sudden change. (Although all land is continually changing, it must be protected from certain types of rapid change.) Thus diversity indicates the health of an ecosystem. Sites that lack natural diversity such as the dune grass areas,

meadows, tundra, and swamps are more sensitive to man's impact."[23]

In The Pattern Language is a description of a diversified, easy to maintain garden. The pattern is "Garden Growing Wild", and describes:

"....the quality which brings a garden to life the quality of a wilderness, tamed, still wild, but cultivated enough to be in harmony with the buildings which surround it and the people who move in it. This balance of wilderness and cultivation reached a high point in the oldest English gardens.

In these gardens things are arranged so that the natural processes which come into being will maintain the condition of the garden and not degrade it. For example, mosses and grasses will grow between paving stones. In a sensible and natural garden, the garden is arranged so that this process enhances the garden and does not threaten it.

In the garden growing wild the plants are chosen, and boundaries placed, in such a way that the growth of things regulates itself. It does not need to be regulated by control. But it does not grow fiercely and undermine the ways in which it is planted. Natural wild plants, for example, are planted among flowers and grass, so that there is no room for so-called weeds to fill the empty spaces and then need weeding. Natural stone edges form the boundaries of grass so that there is no need to chop the turf and clip the edge every few weeks. Rocks and stones are placed where there are changes of level. And there are small rock plants placed between the stones, so that once again there is no room for weeds to grow.

A garden growing wild is healthier, more capable of stable growth, than the more clipped and artificial garden. The garden can be left alone, it will not go to ruin in one or two seasons.

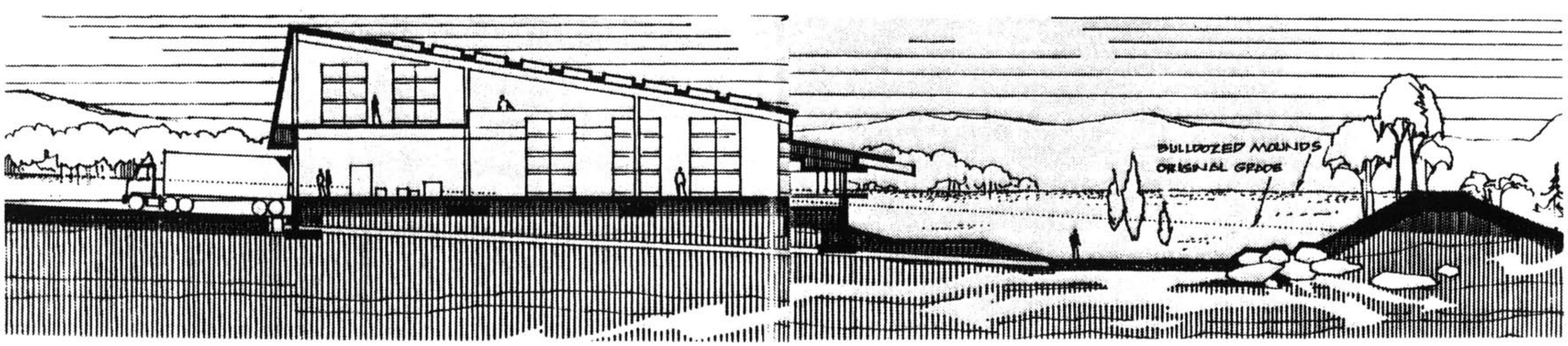
And for the people too, the garden growing wild creates a more profound experience. The gardener is in the position of a good doctor, watching nature take its course, occasionally taking action, pruning, pulling out some species, only to give the garden more room to grow and become itself. By contrast, the gardens that have to be tended obsessively, enslave a person to them; you cannot learn from them in quite the same way."

As it is unlikely that we can increase the permeability of the soil in developed areas so that it matches the undeveloped state, the next step in reducing the impact of construction is to hold excess runoff on the site until after storms. Calculations should be made of the amount of runoff release by an area in its original state, and compared to projections of runoff by the final site plan. The difference is the amount that should be held on site for slow release. Relative coefficients of amounts of runoff from various surfaces are:[26]

roofs	95% runoff	bare clay	30 - 75% runoff
pavements	95% "	vegetation over sand	5 - 30% "
bare gravel	30 - 60% runoff	vegetation over loam	10 - 40% "
bare sand	10 - 50% "	vegetation over clay	15 - 40% "
bare loam	20 - 60%		

Existing drainage patterns can be shaped into retention ponds to store water until after the highest flow, with small drainage outlets. Grass is a good surface for protecting drainage ways from erosion. Grasses must be chosen to withstand submergence, and small amounts of sediment which may be deposited.

In a project by Malcolm Wells, the site for a 20,000 square foot office and factory building was developed to work with natural processes, and in fact repair damage done by earlier earthmoving. Runoff from roofs, parking lots and truck loading areas is channeled to a sunken sculpture court bedded with several feet of broken stone. Water is allowed to pond and then sink slowly into the ground. Rain fall is directed to the drainage channels by earth berms surrounding the site. The soil, which had been stripped of topsoil by previous owners, is being reclaimed through the planting of a hardy vegetation, crown vetch, which holds some water on the surface, provides cover for small animals, and adds nitrogen to the soil.



Rainwater for Domestic Use

In some places rainwater is the only water available. All water for use in Bermuda is supplied by rain, since the island is porous limestone. Rain falling on the surface seeps in immediately, and moves directly down, not reappearing in streams, nor pooling underground for wells. Roofs are limestone slates, concrete tiles, or concrete with a cement finish. The hip roof is sorrounded by a turned up lip which directs water from the daily rainstorms to a low spot, from which a pipe conducts it to the cistern under the house.

Collection of rainwater for use was common before municipal water systems and automatic pumps became widespread. Rain water is soft, mineral free, and useful for washing, since it forms a lather readily with soap. It is not pure enough for drinking unless treated.

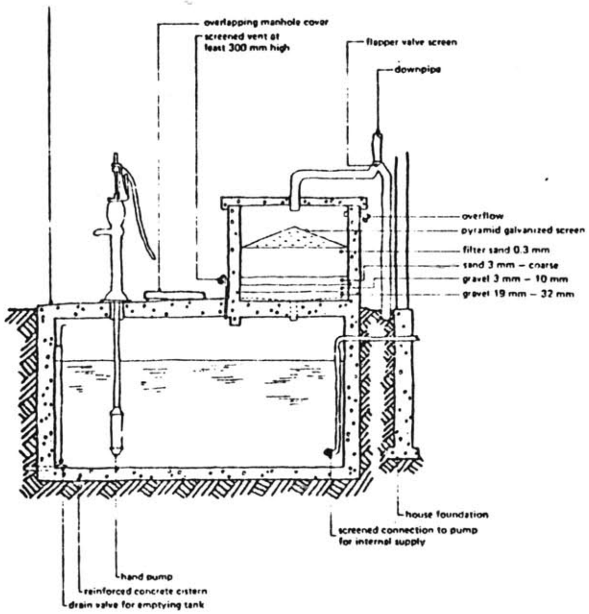
Its use today is limited to areas without adequate groundwater or surface water supplies, and for use in gardening. As a primary water source, precipitation must be fairly dependable, and not too polluted by air and surface impurities. It may be treated for drinking, cooling and washing, or it can be used directly for toilet flushing and gardening.

The amount of water required and the amount of precipitation will determine the extent of collection surface. It should provide a smooth, steep slope so that the first run of water over the surface can wash off dirt, leaves and bird

Water supplied by rainfall:[27]

Annual Rainfall	Water Available in Gallons per sq. ft. of roof per year
10"	4.2
15"	6.2
20"	8.3
25"	10.4
30"	12.5
35"	14.5
40"	16.6
45"	18.8
50"	20.8

This includes 1/3 losses due to leakage and evaporation.



79 *Underground concrete cistern for rainwater with integral slow sand filter (after US Public Health Service, Joint Committee on rural sanitation, 1950).*

droppings. Glass is ideal, but metal and tile roofs serve well. In cases where all water must be supplied by rain, it may be necessary to provide additional collection area on the ground, in a fenced hard pavement, draining to a cistern opening.

The collection system must be designed to discard the first few minutes' flow from the roof, which has washed the surface clean. Usually, after this first separation, the supply water passes through a sand filter into a concrete tank. The size of the tank is dependent upon the requirements of the house and the frequency of rainfall. One source calls for storage of one fourth of the annual requirements of the house. In order that collection areas not be too large, some reuse of water should be assumed for economy. In areas where there is sufficient purified water supplied, rainwater might be collected for gardening for which it can be used without treatment. Buried tanks will eliminate the danger of freezing water damaging the tank.

Greenhouses often have integral gutters which lead water to underground tanks. The purity of the water is beneficial to delicate plants.

Rain might have a better reputation if being out in it were optional. Buildings can provide the means for people to walk under cover. Porticos can be created by recessing the ground floor, exposing the columns, or by cantilevering the upper level construction. Whole towns in Spain, Italy and Switzerland are connected by these covered paths along the fronts of shops. Zoning codes might offer incentives to developers who include covered ways in their projects on major streets.

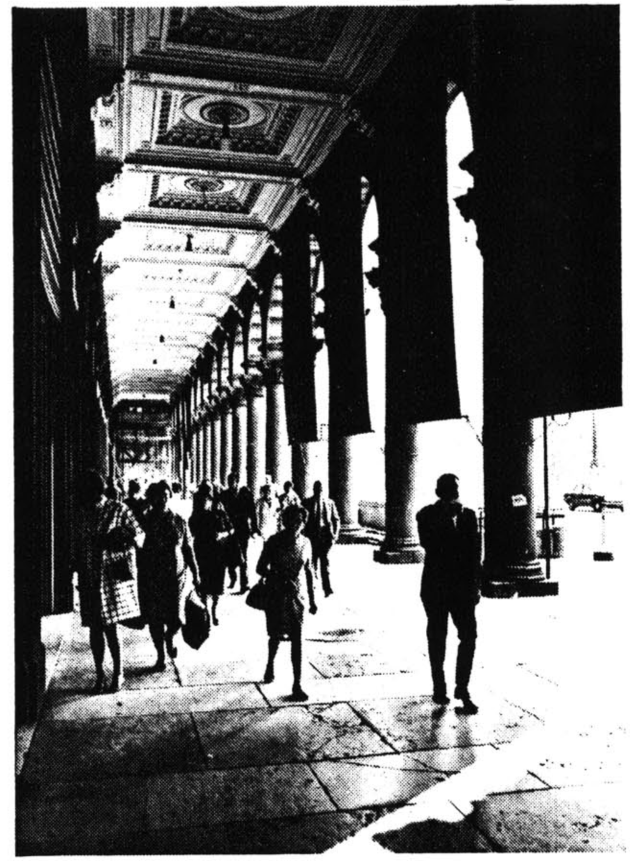
Arcades are usually covered passages through or between buildings. They offer weather protection without a sense of the weather, and perhaps an interesting change, when one emerges from the other world of the arcade to confront the weather again. Rain on skylights, or internal drainage can connect people to the weather.

Traditional American main street weather protectors are canvas awnings unfurled when the weather looks threatening or the sun fierce. They respond to breezes, drip at the edges, and resound drumlike with the impact of falling rain. In southern European cities, each window in large buildings may have its own brightly colored awning.

Many buildings provide light, shedlike roofs along the street front to shelter their shop windows and protect window shoppers. These are often glazed structures, allowing filtered light to pass through.

Two qualities of awareness of weather can be differen-

Plan, Section, and Building Type



tiated which will be of use in deciding on the kind and amount of exposure to the weather built places will have. One is providing a knowledge of weather conditions as a way to connect people to the outside world, and give information about conditions. The other is experiencing the qualities of weather in a more direct way than observation alone; through sound, smell, and close up association with flowing water.

The first seems applicable to places where people have no option about their exposure to whatever conditions are designed into the place. In offices, schoolrooms, stores and workplaces, people must stay in one place, and so any strong qualities such as sound or running water might be distracting.

This less intense sort of involvement with the weather might require views of trees shaken by the wind and dripping with rain, or spouts of water off nearby buildings. Streaks of rain can be seen against a dark or deeply shadowed surface opposite. Pools and puddles show the splash of raindrops on their surfaces. However, in lounges, cafeterias, and circulation ways, more direct contact with the qualities of rain might be welcome, because people have the option to move around or leave. In these places, the sounds of water, or closeup views of running water would be appropriate.

In housing, weather experience of a more direct and evocative sort is possible, to increase the contrast bettween the protection of home and the world outside. Places with very direct edge exposure to rain can be provided, since occupants are free to move around in the house to adjust their relationship to outdoors as they desire. Thus the experience available can range from places which keep one from getting wet, but otherwise exposed to all the characteristics of rain, to places of retreat from the weather and the world.

In apartment buildings, the quality of rain on a piece of ground is desirable, as well as a place on the edge which projects out into the weather for the experience of the dramatic exposure to storms that comes with height. Terraces which are partially protected, but have some exposure to rain will provide the sound and sight of splashing water. If part of the terrace is uncovered then people must acknowledge the elements by adjusting their patterns of use. Partial shelter allows doors to be opened to the sight and sound of rain.

Trees, pools, and street life in view are important in letting people know what conditions are like.

Most row housing has front and back yards; the front more a separation from the street and an opportunity to express the individuality of the owners. The street yard is small, and therefore might not be able to take up the roof runoff, which will necesitate draining water to the street.

This is an opportunity to expose roof runoff, so that each house could be pouring out water as one walks down the street. Intense planting will hold more water than lawn or carefully tended garden.

The rear yard is usually more of a living space and often large enough to soak up all the roof drainage that comes down.

Each unit usually has control of its own rain drainage system, which can be used to individualize the facade or add richness.

Single Lot Line Housing is an alternative to detached houses in the center of a plot of ground. Each house is built against one side lot line, facing the blank wall of the next.

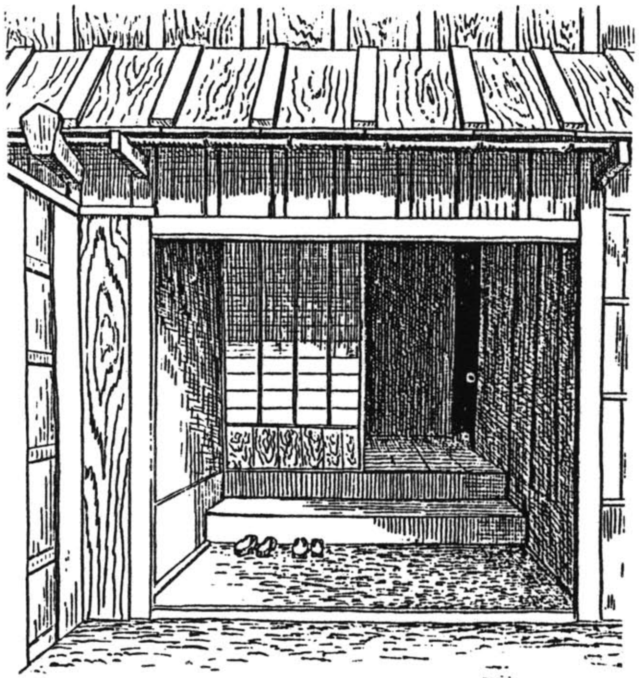
Outdoor areas are not large, so they are more extensively used and more intensely developed. Privacy provided by the wall means all outdoor areas can be extensions of rooms along the edge. Increased privacy means that the house can be more open to the outside, and the effects of rain will be increased by the hard surfaces and intense planting.

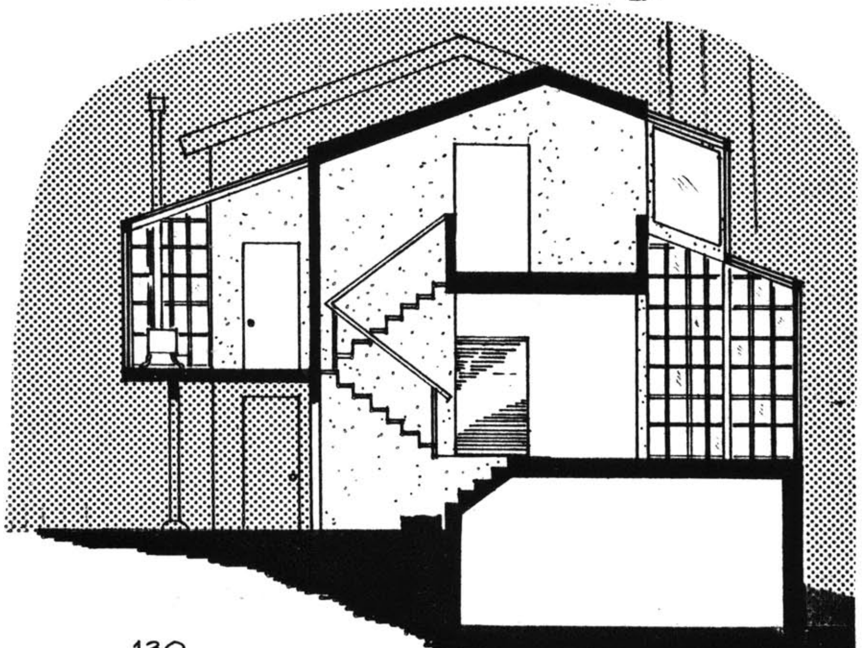
When people are constrained from going outside by the rain, they are drawn to windows and other edges, from which they can view the action of the weather. It should be possible to know what the weather is doing, its intensity, from windows. People should be able to see the surface of some pond or puddle, to guage rain intensity, windiness, and be able to see some sort of show of water, a result of all the wetness in one place, as in a waterfall or sluiceway.

Small places along the edge may take advantage of the melancholy and contemplative mood that rain sometimes evokes. This could be a small place on an edge, preferably projecting into the weather, with as many physical attributes of a rainy day present as possible: sloping glass roof, glass walls, and water beading and running across the surface. The outlook must be some far or middle distance view, or if close up, a natural scene or water moving with no people passing close by to disturb the reverie. This place should be detached from the main activity of the house, either a retreat at a distance, or above, or at least as defined as a window seat.

Verandahs originated from a need to protect windows in hot, humid climates, so that they could be left open for ventilation during rainstorms, They serve a similar function to the arcade in Hispanic cultures. In traditional Japanese houses, the verandah is necessary to protect the delicate paper wall screens. Verandahs make it possible to enjoy the rain through large openings without the danger of rain entering the house.

In climates with less severe rainfall and ventilation problems, the verandah has been condensed into a porch,





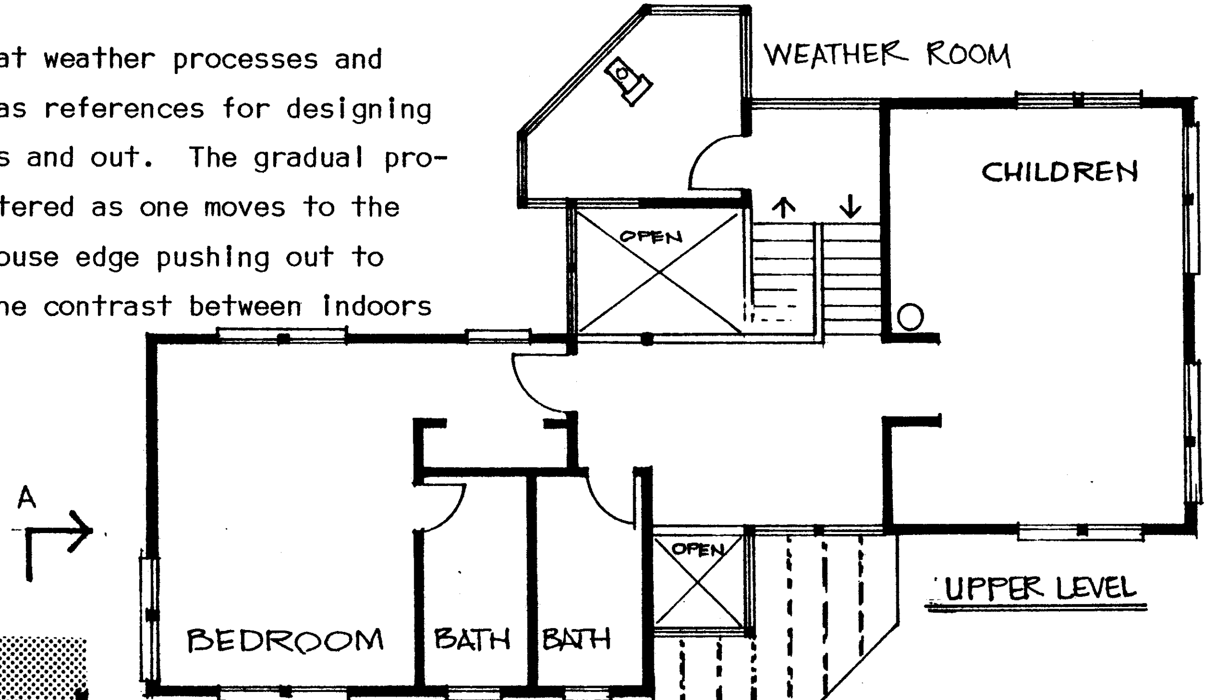
Section A-A (Plan at rt.)

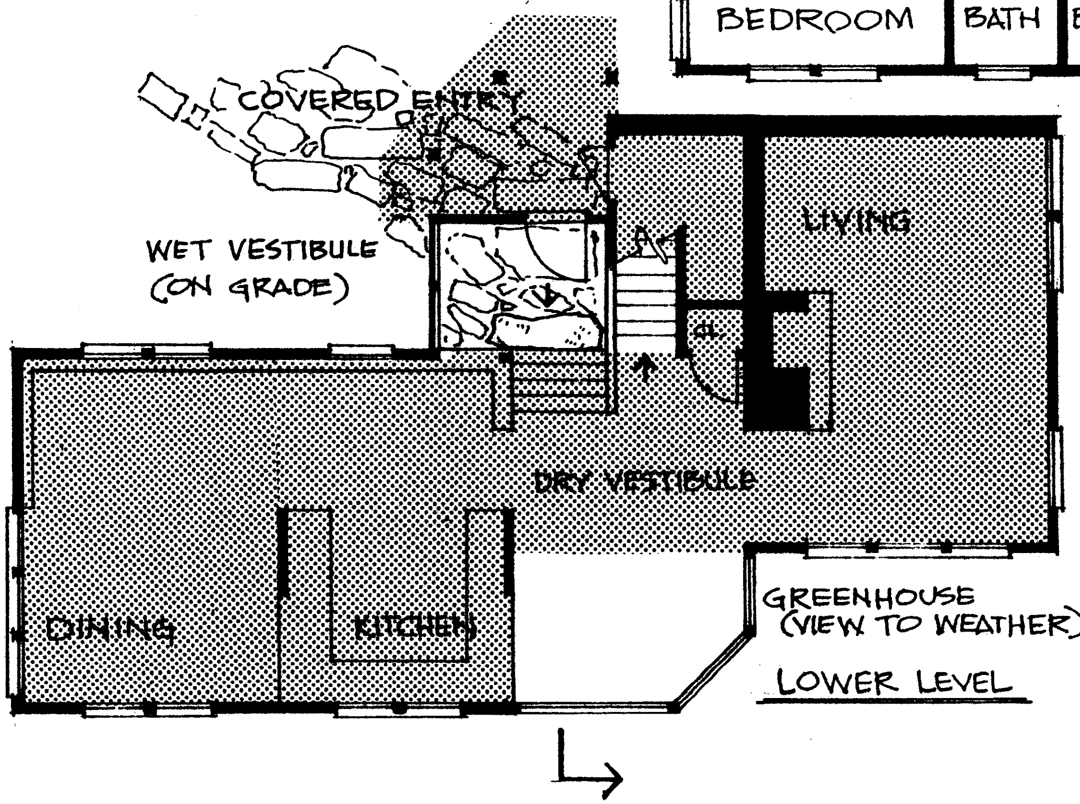
which provides a place to sit out of sun and rain, but open to the outdoors. Porches went out of fashion for a time, but their value is being recognized again. The dimension of overhang is important to keep slanting wind-driven rain off, and provide shade from the summer sun. Enjoyment of the excesses of rainstorms calls for water running off the eaves, the sound of rain on the porch roof, and a view of some stream of water moving

The relief that one feels when arriving at a place of shelter in a rainstorm should be given some built acknowledgement. Expansive space under cover, before actually entering the building, will reinforce the relaxation and sense of freedom of coming out of the rain.

Vestibules are rooms generated primarily by weather considerations. They are air locks protecting the warm house from cold outside air arriving with guests; places to shed clothes and umbrellas before continuing into the house, and for redeploying these bulky objects to confront the weather again. Umbrellas, ponchos, raincoats and boots all require generous dimensions, and surfaces that can tolerate getting wet. The vestibule is an in-between place that needs a connection to the outdoors so people can see the weather outside they have just faced, or get a view of conditions that await. Entering, the connection to the weather increases the quality of relief and shelter by the visible contrast.

The reciprocal patterns that weather processes and water flow suggest can be used as references for designing the relationship between indoors and out. The gradual process of entering and being sheltered as one moves to the center is reciprocal with the house edge pushing out to provide places which increase the contrast between indoors and out.





Sketch for house, illustrating movement gradually from outside, to covered porch, then into a vestibule on grade where rain wear is removed. Then upstairs into the center of the house, where coats are stored. Finally, the visitor arrives at the greenhouse, confronting the weather he has just left from the shelter of the house.

The reciprocal of this progression into shelter is movement through the house to a weather room, exposed to the elements through glass walls and roof, on the stormy side of the house, and heated by a wood stove.

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