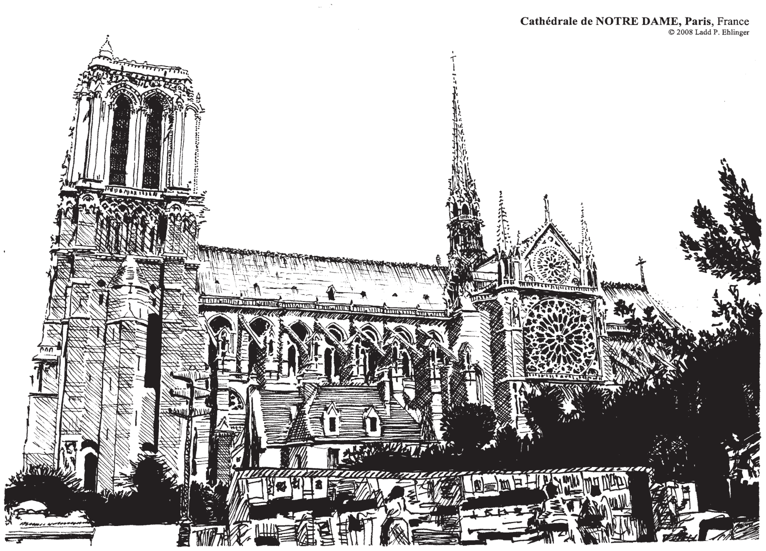
ARCHITECTURE

EHLINGER & ASSOCIATES FOURTH QUARTER 2008

Ehlinger & Associates extends Seasons Greetings to all of our friends who receive the newsletter. Merry Christmas, Happy Hanukkah, and Happy New Year.



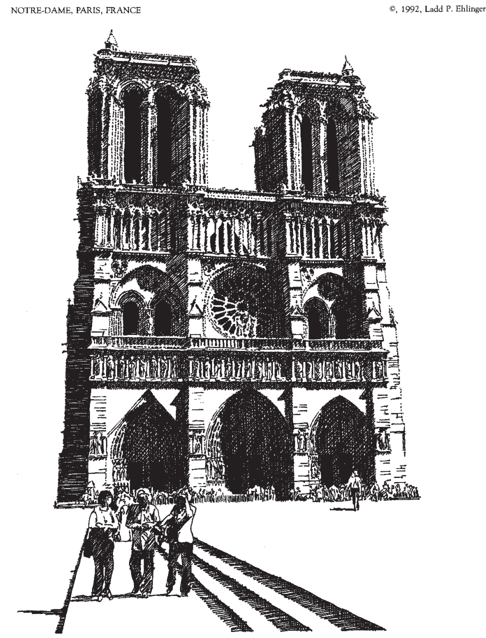
Cathédrale de NOTRE DAME, Paris, France

This issue's limited edition print of a sketch by Ladd P. Ehlinger is of the southern facade of Cathédrale de Notre Dame, Paris from the left bank of the River Seine. This view was the only view available to the townsfolk until after World War II, when the buildings which crowded the western or front facade were demolished and their grounds converted to a viewing plaza. The outline of the walls of these removed buildings were used as different colored stone in the paving patterns in the plaza to echo their historic locations.

In a previous issue (4th Quarter 1992) the print published then was of the western facade (shown here in a thumbnail sketch), which is probably the finest and most characteristic in France and served as a model for numerous later Gothic cathedrals. Containing the main entrance, the view is spectacular due to the vista created by the viewing plaza. We promised in that issue to show the remainder of the building in a three quarter view perhaps from the rear. This issue's view is not quite that view, so we may feature it again from the rear. This is one of the few Gothic buildings of which it is difficult to decide the view that is the most interesting.

Bishop Maurice de Sully began the construction of Notre Dame Cathedral in Paris in c. 1163, and it was completed in 1325, almost 200 years later. Notre Dame is typical of French Gothic cathedrals being the quintessential example. Located on the Isle de France in the middle of the River Seine in the center of Paris, it rises alone and magnificent from its flat island site. It is the ultimate French urban Gothic church of the townsfolk, originally a public meeting place for the common people, as well as a religious and ecclesiastical monument.

Equally spectacular is the view from the left tower of the western facade. All of the splendor of Paris is available in successive panoramic views. This tower is open to the public and serves as a strenuous test of one's cardiovascular system, as there is no elevator to the viewing level of the arcaded screen that



connects the two towers (approximately 120' high) only stairs at a rather steep angle.

The western main facade has three deeply recessed portals with successive encircling tiers of statued niches. The central doorway is divided by a statue of Christ on a pillar. Above the three portals stretches a band or frieze of statues depicting the kings of France. Above this in the center is a wheel window the great rose window of exceptional beauty. Flanking the rose window are high coupled windows, over which again is the pierced arcaded screen or frieze that was previously mentioned that connects the two towers.

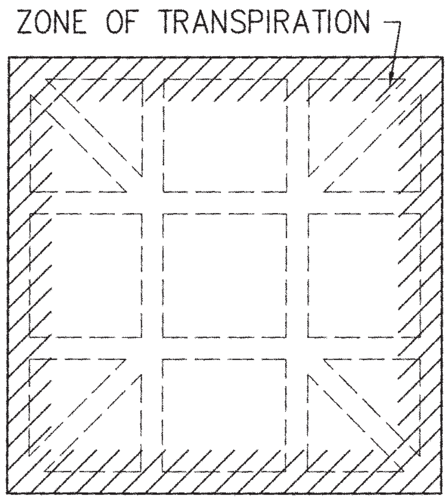
The main facade of Notre Dame shown in the thumbnail sketch functions as a portal to another world. Architecturally, it hints at the other world in the view by teasing one with the partially visible buttresses on either side. The remainder of the exterior of the building is composed of the typical Gothic fare walls pierced by large windows, braced by incredible flying buttresses, decorated by gargoyles and finials. The east end has very slender flying buttresses with chevet chapels nestled between them along with the view of the delicate fleche *(literally an arrow, actually a tower shaped like an arrow over the* *crossing, the intersection of the nave and the transepts)* soaring 300' above the ground presents an ephemeral ambiance.

The plan of Notre Dame is on a bent axial line. It is unknown whether this was intentional or an accident and is a major flaw in an otherwise beautifully engineered compressive stone structure. Nevertheless, it is a typical Gothic plan: with a wide nave and double aisles, transepts of a shortened projection almost in line with the nave aisles, and an exceptional chevet with double aisles and radiating chapels between the buttresses. The interior has been said to be impressive but somber with a nave arcade with cylindrical columns with Corinthian-esque capitals that carry pointed arches and shafts to support the ribs of the lofty sexpartite stone vaulting that is approximately 110' high and spans about 36'.

EXPANSIVE CLAY FOUNDATIONS

There are two fundamental methods of foundation design to accommodate expansive clays. Expansive clays undergo volumetric change (swell or shrink) with change in water content of the soil. They are characterized by a high PI (Plasticity Index). Testing can be performed to predict the amount of volumetric change to be expected with changes in moisture content. That part of the building most away from the perimeter is in shadow all of the time, and is not as subject to rapid ground moisture evaporation if a slab is used in the foundation design. The perimeter (usually to 5' in-board) though, is most subject to moisture change as it is next to the zone (the exterior) where the moisture change can be dramatically large and rapid, being subjected to sunlight and air. It is in this perimeter zone where most of the volumetric change that takes place in response to wet and drought cycles in the weather gives most of the foundation problems. Other aspects that factor in are sewer and water line breaks under the building, landscape irrigation, and planting. Oak trees in particular can quickly desiccate the soil they are rooted in and the surrounding area as the rate of transpiration per day can exceed 150 gallons of water loss per tree.

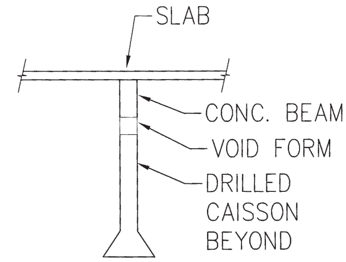
One of the two fundamental methods of foundation design is to either remove 2' to 6' of the upper clay materials (depends upon how high the PI is and the calculated swell pressures), and replace with an inactive material, preferably granular, and increase the soil overburden to counteract swell pressures in underlying expansive strata. Then the foundation is designed as a monolithic waffle slab where the ribs / beams are 10' to 15' apart, and there are diagonal ribs / beams at the corners. This done under the 'beam on an elastic foundation' method. The ribs / beams are anywhere from 2' to 4.5' deep in order to



RIBBED MAT SLAB PLAN

be very stiff. Stiffness (Moment of Inertia) is more of a function of the depth of the beam than the width. The formula for stiffness is: $I = bh^3/12$, where b = width, h = depth, and I = Moment of Inertia. What the designer does is to design the slab (including superstructure loads) for no ground support of the slab at the perimeter 5' zone (in the shrinkage or drought mode); and then to design it again for the slab being supported only at the outer 5' perimeter zone (in the wet or swell mode). The designer then uses the larger of the two designs to accommodate both conditions.

The second fundamental method of foundation design for expansive clays is to support the entire building on drilled piles / caissons that are filled with reinforced concrete at a level in the clay where there will be no vertical movement due to swell pressures in the clays due to moisture change because the weight of the strata above supersedes the total swell pressure at this depth. The depth of the piles / caissons is usually between 15' and 30' deep. Usually structural grade beams and possibly pile caps are supported on the tops of the piles / caissons, and structural reinforced concrete slabs span between parallel grade beams. There is a designed in void or space between the underside of the grade beams and slabs to the soil to allow room for swelling of the upper expansive clay strata during wet



SECTION OF CAISSON & SLAB BEAM

periods without impacting the underside of the foundation. This void may be achieved by placing the concrete on cardboard void forms that are manufactured to withstand this limited exposure to the environment. The void forms disintegrate upon multiple exposures to water and result in only the space afterwards. Another way to achieve the space for the volumetric change to take place is to hard-form the grade beams and slab 3' to 5' above the finish grade and thus create a crawl space under the first level.

Some soils engineers also recommend a combination or blend (a hermaphrodite) of the first type with the second type, but omit the stiffness requirement of the monolithic grade beam that one gets in the first method, by floating the slabs. A 5" to 6" thick slab has very little stiffness with respect to these magnitudes of swell pressures, where one can expect 4" to 6" of vertical movement. The soils engineer will recommend proper, steeply sloped, site drainage; roof drainage in underground conduits; a perimeter concrete apron to move the zone of transpiration outboard; all to mitigate the possible failure of this foundation recommendation . This method may fail anyway however, even if the mitigating slopes, drainage, and apron are used because of the high PI of the soils. I have been involved in a number of cases where this type of combination design was used and failed, especially on sloping sites that were both cut and filled. The only time that I have seen it successful is when there was a 4' to 6' overburden of inactive material placed over mildly expansive native material — considerably more than is normally recommended. *Ladd P. Ehlinger*