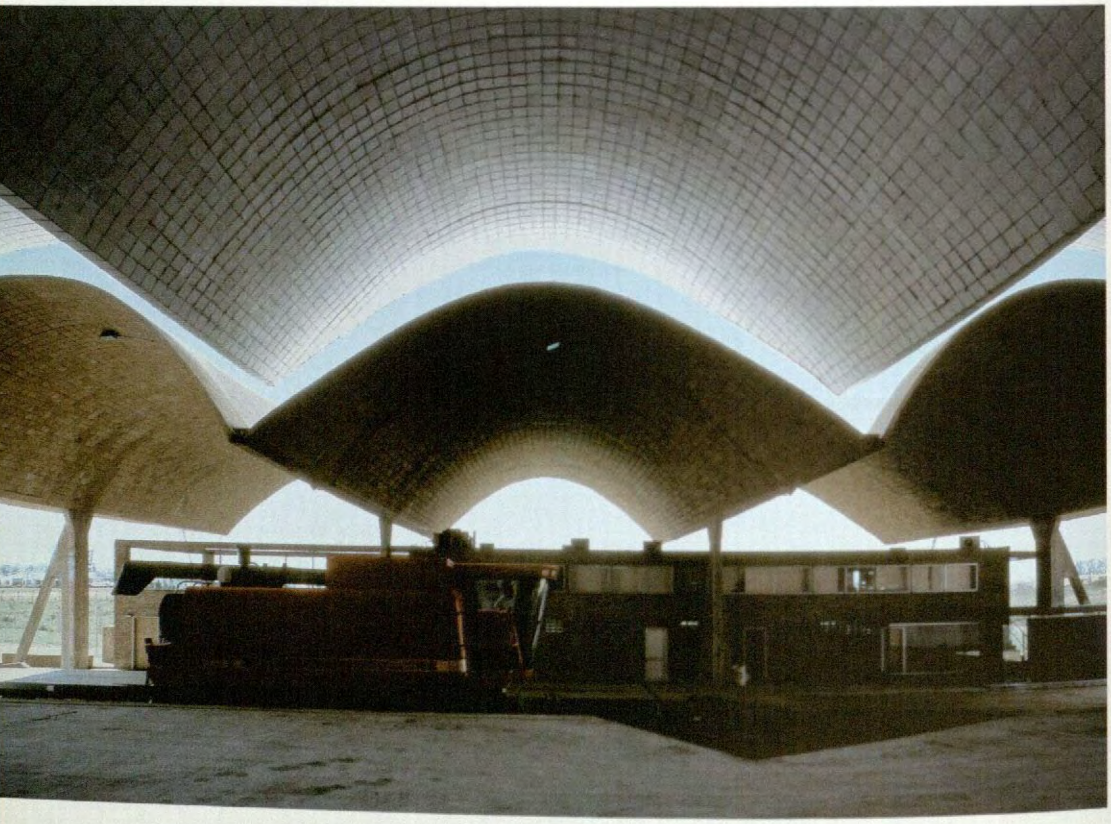
Seven Structural Engineers: The Felix Candela Lectures

Edited by
Guy Nordenson

THE MUSEUM OF MODERN ART, NEW YORK



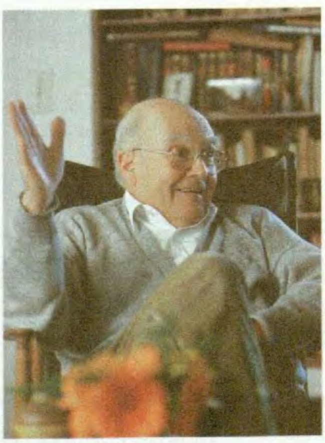
❶
Massaro Agroindustries,
Joanicó, Uruguay. Loading area

Eladio Dieste: A Principled Builder

STANFORD ANDERSON

Eladio Dieste took the construction method of reinforced masonry into radically new territory. A single image suggests Dieste's accomplishment and the reasons that his work deserves attention. At the fruit-packing plant of Massaro (1976–80; fig. 1), a daring set of double-cantilever vaults protects the area where trucks deliver and collect large quantities of agricultural produce and materials—just a way station in a humble process. Most of Dieste's work was for agricultural or industrial purposes, and yet almost every building has true architectural merit. The technology is exceptional; while reinforced masonry had existed in simple ways for a long time, the use of reinforced masonry in an inventive manner is basically the contribution of Dieste. Some idea of his achievement can be gleaned from this image: the three vaults span 12.7 meters laterally and are cantilevered 13 meters in both directions from the single line of four columns. The vaults are very thin, only one layer of brick (10 centimeters thick). We immediately confront an extraordinary technical feat of building: a large covered area with a very thin vault of long, double cantilevers.

Dieste was born in 1917 in Artigas, Uruguay. Schooled at the university in the capital city of Montevideo as an engineer, he never claimed to be anything other than an engineer. Yet most of his works deserve to be understood as architecture. This portrait of Dieste (fig. 2), seated at home, was not taken on the day I met him, but it gives the same impression. He was already suffering a degenerative disease, but maintained his spirit and continued to work until his death in 2000. On the first day that I saw a few of Dieste's buildings, I was taken to see him in the evening. Genuinely enthusiastic from the experience of the day, I extolled the qualities of his buildings.



2 Eladio Dieste, in his home, Montevideo, Uruguay, 1996

Carlos Contrera-CMdF-AFMVD

Dieste looked at me with the same twinkle as can be seen in the photograph and admonished me: "I too follow the laws of physics."

Of course, what alternative is there but to follow the laws of physics? But important points are concealed in this obvious statement. With Dieste there is no willful invention of form; there are rather innovative forms that follow from first principles. Dieste would never have realized his unprecedented works if he had worked according to the conventions of society or of engineering production. The technical characteristics of these buildings were not covered by any code or standard. He had the courage to do what had not been done before. The reason he had courage was that he had been very well schooled in principles starting from his fundamental knowledge of science.

There are several reasons to attend to Dieste's work. He was a principled builder, who deserves a place in the realm of architectural knowledge, beginning with his innovations in structure. Dieste took up the very ordinary material of brick—perhaps the earliest building material other than twigs and stones—and raised it to a completely new level. Through this achievement with something as ancient and well known as brick, his work suggests the possibility for innovations of equal magnitude hidden in other traditional materials, or, for that matter, in new materials. Dieste thus offers a model of innovation.

Beyond the simple material, Dieste's work employs simple construction techniques and, in many of the buildings (there are some exceptions), the simplest of craftsmanship. It is plausible then to think that Dieste's work could be of interest in other societies that have even less in the way of resources—fewer material resources and limited construction techniques. There may well be places in the world where the direct application of Dieste's ideas is still a fruitful possibility. Learning from Dieste need not stop there. Today, in the schools and practices of technologically advanced societies, methods of representation overwhelm production. Dieste's example does not direct us to neglect the new, but rather to adopt it under rigorous inquiry.

Finally, I return to the principled builder again. This is a man of high ethical standards, deeply concerned about society. He understood engineering and architecture as profoundly implicated in one another and embedded in culture and in ethics. There is a wholeness to his personality and his work that is a model whether one aspires to be a painter or a writer, or anyone who seeks to be productive and ethical in order to contribute to the well-being of society.

Turning to his work, Dieste developed two types of reinforced masonry vaults, one of which he called "self-carrying vaults," as at Massaro Agroindustries in the countryside north of Montevideo (fig. 3). The long vaults for the storage and work area open to the vaults of the loading and office area in the distance. The vaults are prestressed to take bending forces and thus act as beams. Unlike conventional barrel vaults, such vaults do not require continuous support in the walls or in the tympanum. Here 10,000 square meters are covered using only

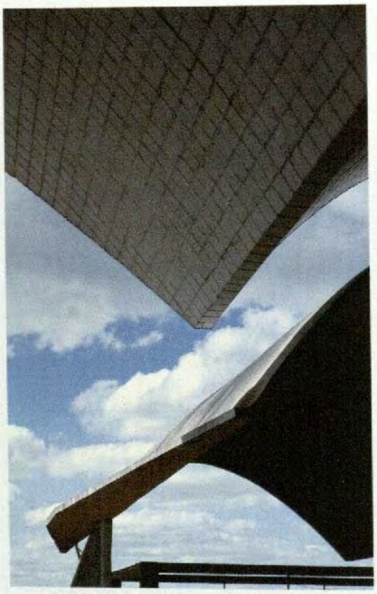
3
Massaro. Main warehouse to loading area

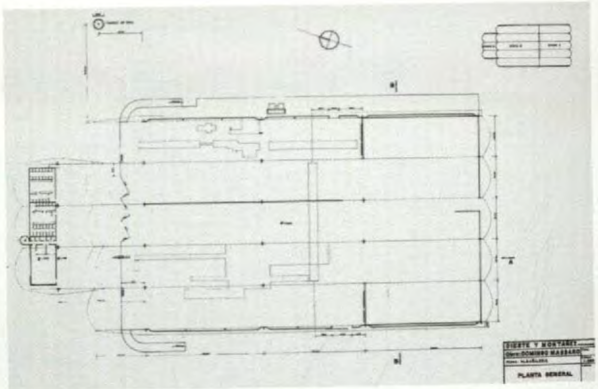
4
Massaro. Detail of vaults

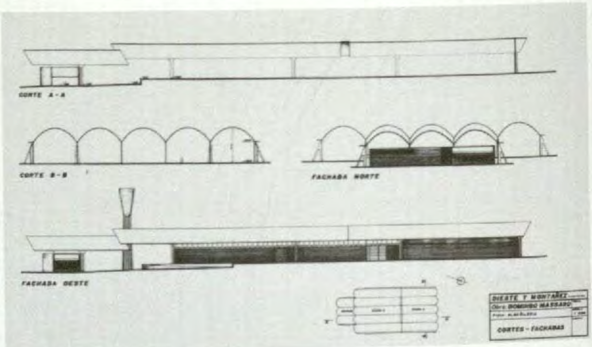
twenty-four columns. The small number of point supports facilitates both circulation and an array of alternative sources of natural light. Additionally, Dieste could meet functional needs that would be precluded in buildings requiring continuous supports.

In the long storage area of Massaro, there are two groups of self-carrying vaults, end to end, each five vaults wide. The longitudinal span between supports is 35 meters. In the three middle bays, the two groups do not meet, and thus provide light in the center of the space. The vaults are also perforated for light. The exterior protective wall of this building is not a bearing wall. Perimeter light below the vaults would have been possible, as seen in other buildings of this structural type. Inside, there is a long span between supports and the 16.5-meter cantilevers (see the middle of figure 3). The narrow valley at the meeting of the vaults is remarkable as the vaults span between distant columns.

The drama of the ends of the main vaults cantilevering over the double-cantilever entry vaults is apparent in figure 1; the radical thinness of the vaults can be seen in figure 4. Such vaults have steel reinforcement between the bricks, loops of prestressing steel and steel mesh in the crowns of the vaults, and a cement parging that secures the bricks and steel and also provides the only roofing material. The cross sections of Dieste's vaults are always catenary curves, the most efficient structural form. When these vaults meet laterally, their opposing thrusts cancel one another and result in the economical, narrow valleys between vaults. When the vaults terminate, the lateral thrust must be resisted. Here, too, Dieste found an innovative and economical solution (fig. 5). Rather than a wall or any kind of continuous support, Dieste uses a lateral edge beam. The edge beam is small at the ends, where it receives the load from a small part of the vault, but widens toward the center as it sustains increasing force. The vertical and horizontal thrusts are finally resolved in a column, triangulated against the lateral force. The plans and sections of Massaro (figs. 6, 7)







❺ *(left)*
Massaro. Detail of vaults and edge beam

❻ *(above)*
Massaro. Plan

❼ *(below)*
Massaro. Sections and elevations

reveal the extraordinary structural economy of this large construction.

The municipal bus terminal in Salto, a provincial city in the north of Uruguay, also employs double-cantilever vaults on a single line of columns (1971–74; fig. 8). The cantilever is 12.13 meters on either side, an instance where the cantilever is used for the specific functional purpose of giving full protection to a bus. Dieste was always concerned with how form gives strength. A simple plane provides little strength. Give it a curved surface, and strength is developed. Enhancing this simple principle by using structurally sound catenary cross sections and prestressed reinforcement allowed Dieste to create these highly efficient vaults acting as beams.

Structural details of the Salto bus terminal appear in figure 9. The partial plan at the left shows the reinforcement through the crown of the vault; this prestressing was accomplished in the simplest possible manner. The drawing shows the prestressing steel in its final configuration. The process was as follows: after the masonry of the vault was in place and still supported with formwork, the workmen laid down loops of steel—a long, narrow loop at the center of the crown of the vault, a longer loop around that, and another loop around that, as many loops as Dieste's calculations required; the ends of the loops were then anchored to the bricks, as indicated by the horizontal lines in the drawing; using a simple carjack, the loops were then pinched together at the middle, stretching the steel and developing the prestressing.

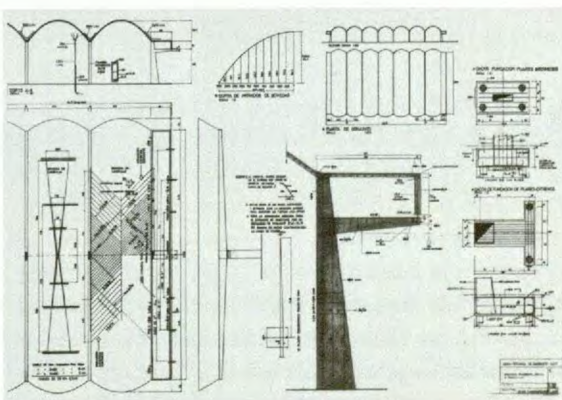
Sophisticated equipment not being available to him, Dieste found a means that would quickly and easily provide the required prestressing.

Rather than cantilevers, the special feature of the maintenance hangers for the metro system of Rio de Janeiro is the provision of generous light throughout a very large work area (52,000 square meters; 1971–79; fig. 10). Here Dieste perforated the vaults, but, more significantly, he alternated the height of adjoining self-carrying vaults, thus creating large clerestory windows throughout the workplace.

For a tour de force, consider this structure (in brick!) that cantilevers four directions off a single column (1975–76; fig. 11). The "Sea Gull" was built as protection for the pumps at a service station in Salto. In Dieste's work, this is a rare divergence from true structural principles. This is no longer a vault, but a beam that requires heavy reinforcement, especially in the central valley. But there is a logic here, too, providing maximum access with minimum support.

(below) 8
Municipal bus terminal, Salto, Uruguay

(right) 9
Municipal bus terminal, Salto. Sections, reinforcing plan, and details



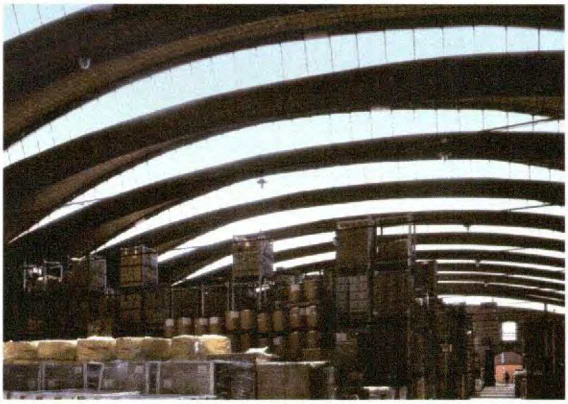
10 *(left)*
Rio metro maintenance hangar, Rio de Janeiro, Brazil

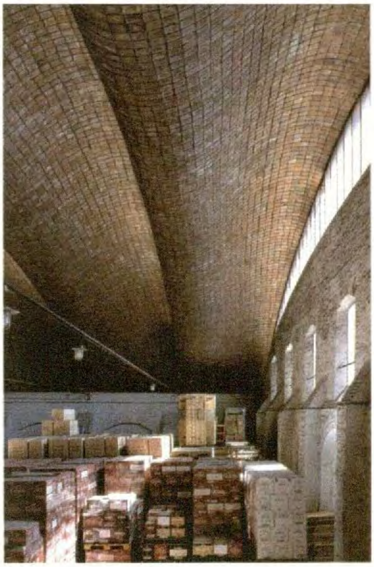
11 *(above)*
Barbieri e Leggire Service Station, Salto. 1975–76; relocated at the south approach to Salto, 1996

⓬
TEM factory, Montevideo, Uruguay. Interior

The second vault type that Dieste used repetitively is the "Gaussian" vault, a vault of double curvature. The TEM factory in Montevideo (1958–62; fig. 12) is an early example of a discontinuous double-curvature vault: double-curvature because of the changing S-section along the catenary arcs of the vault, and discontinous because each vault is complete in itself, except where it joins a neighbor at the springing. The discontinuity provides for skylights throughout the covered area. Double-curvature vaults are typically used when a very long span is required in the lateral dimension—in this example, 43 meters. In contrast, self-carrying vaults can provide a very long span in the longitudinal direction; theoretically, they could also provide a long span laterally, but then the height would be very great. A large lateral span with a relatively low rise presents the problem that the vault is prone to buckle, break, and collapse. If the problem were to be solved by more and heavier material, an inherent negative feedback would result. That way the problem is solved only by brute force, an approach that Dieste would never take. Instead, he developed strength in the section through shape—the double curvature. We are returned to Dieste's principle that form is the critical generator of efficient structure, but also of good architecture.

The Port Warehouse in Montevideo, the reconstruction of an earlier warehouse damaged by fire, has a span of 50 meters, the longest such span in Dieste's work (1976–79; fig. 13). Dieste respected the quality of the old building with its historic brick walls (fig. 14), and also saw the economy in retaining these walls. From the exterior, the existing walls and the curvature of the new vaults are apparent, but the interior reveals the quality of space and light gained with double-curvature vaults (fig. 15). Dieste, working under conditions that he also helped to create, found reinforced masonry was the most economical way to build. With this technique he achieved welcome visual characteristics and, most important, remarkable qualities of light. Within these spaces, if one is not looking toward the skylights, there is an even stronger sense of how light diffuses through the space (fig. 15). In the Port Warehouse, the old walls provide continuous support, but Dieste's





(above) 13
Port Warehouse, Montevideo. Interior

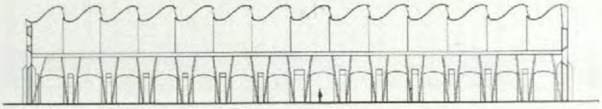
(below) 14
Port Warehouse. Exterior

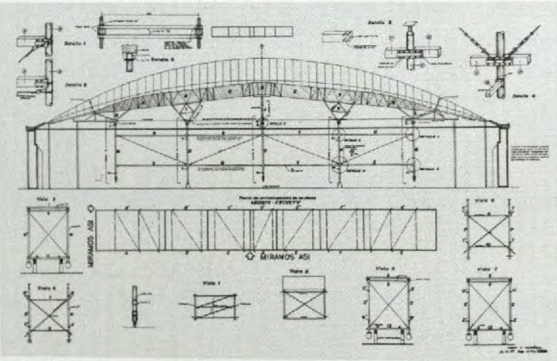
(right) 15
Port Warehouse. End wall and vaults

double-curvature vaults can be carried on rather widely spaced columns, as can be seen in the TEM factory interior (fig. 12).

The longitudinal section of the Port Warehouse clarifies the system of Dieste's double-curvature vaults (fig. 16). At the top of the old brick wall is a new reinforced-concrete beam that ties the wall together, and establishes a uniform height and span to facilitate construction and assure a regular structure. The vault springs from the level beam, such that the first bricks are in a straight line. A movable formwork allows the construction of each unit of the discontinuous vaults (fig. 17). The formwork is shaped to change from the flat springing to the pronounced S-shape at the crown of the vault. Between those two points, there is a continuous transition from the straight line to the S-curve. In the transverse direction, every line that can be drawn is a catenary curve of a different amplitude, yielding not only the S-curve, but also the low and high terminations of each unit of the vault, and thus the opportunity for light.

In all his work, Dieste invented efficient construction techniques. With concrete, the formwork has to remain in place for days as the concrete cures. With brick, there is little wet mortar, and the bricks are already stable. Consequently, Dieste could build one of these vaults in a day, leave it overnight, then drop the form and move on to the next

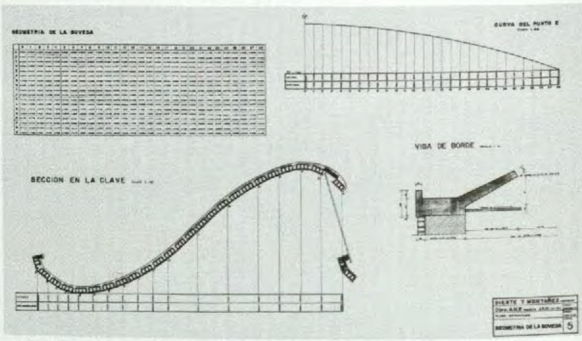




⓰ *(above)*
Port Warehouse. Longitudinal section

⓱ *(left)*
Port Warehouse. Formwork details

⓲ *(below)*
Port Warehouse. Vault section



bay the following day. Because of this quick process, the mortar could still be tooled to give the good finish of the underside of the vaults. The construction process was always one of Dieste's concerns, for he was a builder. He looked for economy in structural concept, in materials, and in construction, both as a matter of principle and because he had to win commissions that involved economic competition. The detail section at the crown of one vault (fig. 18) shows that the construction is only one brick thick. Here the brick has some dimension as it is shaped and has cavities, but it is still only approximately 12 centimeters thick.

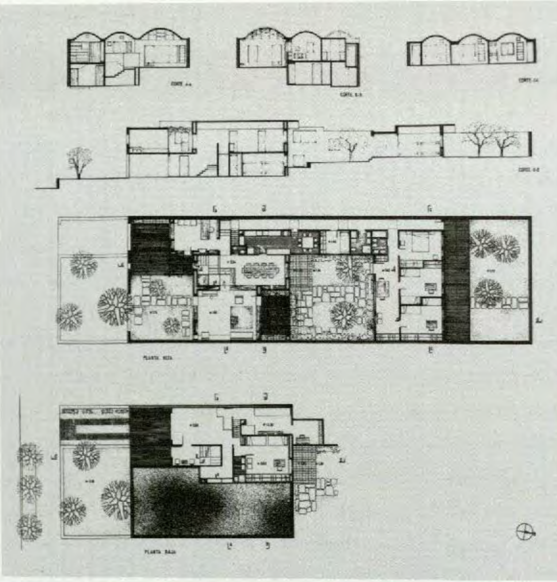
Dieste wrote, "If I had to synthesize what has driven our search, I would say that it is the perennial value of the surface itself." "Surface" for most of us is a rather dangerous word. It seems to suggest things like "surface treatment" and "surface coating" or superficiality. But clearly Dieste understood something truly fundamental in the idea of surface. He recognized that the surface offered a realm of formal exploration that could, in turn, solve structural problems. Again, solving the problem of buckling in the Gaussian vaults, giving strength in the center of these spans, is solved by the shape that is given to them. Dieste always looked for the way in which the forming of space, the shaping of the volumes, the use of the surface, would give economy and efficiency to his structures.

Dieste rejected reliance on rectilinear frame systems, but he also resisted structural solutions that relied on two-dimensional curved forms such as arches and ribs. Such approaches were an invitation to solutions based on additional material rather than on structural efficiency. To the contrary, Dieste's structural innovations relied on the efficacy of surfaces with particular formal properties. The simple catenary curve of a reinforced self-supporting vault allowed it to perform as a beam. The S-shaping of each band of Gaussian vaults gave it the stiffness to span great distances. Of course, these vaults are of material and have thickness, but their shape is still more fundamental to their capacity. Dieste wanted us to know this. Another look at figure 4 readily reveals that the physical facts of Dieste's buildings directly convey his idea of "the perennial value of the surface itself."

Dieste was, then, a master of structure and construction, but other qualities are also recurrent: the proportions of whole and part; the economy and elegance of the materials; the detail of the parts; and, above all, the knowing use of light as it plays on, and especially as it is admitted into, these buildings. These are the qualities of the work of a fine architect.

Brick. That Dieste built in brick is not a matter of nostalgia, but it is no doubt a significant aspect of why Dieste's work has been comparatively neglected in the historical and critical literature. Why should we allow historiographies that honor so-called modern materials to have a privileged place in our thinking when Dieste demonstrates that traditional materials can be used so innovatively? Dieste won the opportunity to build so much because he could build more economically than those who would use steel or reinforced concrete. Structural economy and rapidity of construction are not matters of nostalgia. Dieste made still other claims: about thermal qualities, aural qualities, and more. Consider that the color photographs presented here were taken two years ago of buildings that are thirty, forty, and almost fifty years old. It is evident that the quality of the material as it gives effect in terms of space, light, surface, and texture is very positive, whereas we know so many buildings of exposed concrete that, in a shorter time, have had great difficulties. Yes, Dieste was also aware of the charm, the visual quality, the human scale of bricks. Still, it is not nostalgia that his buildings evoke, but the sum of the very positive qualities of a material that could be supported on fundamental grounds.

Central to my concern with Eladio Dieste is to emphasize, more than others before me, that Dieste was not only an engineer but also an architect. Despite Nikolaus Pevsner's famous dismissal of bicycle sheds in evoking true architecture, I consider everything illustrated so far—Dieste's factories, warehouses, and other utilitarian structures—to be architecture. Dieste also had a few opportunities to work in building types that are unqualifiedly recognized as architecture. We now turn to three such: a house and two churches.



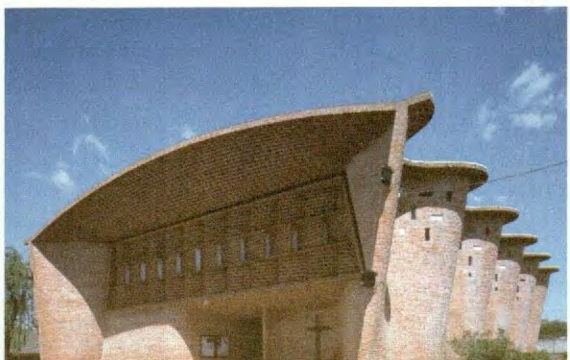
19 *(left)*
Dieste house, Montevideo. Plans and sections

20 *(below left)*
Dieste house. View from top of entry stair to sitting area and courtyard

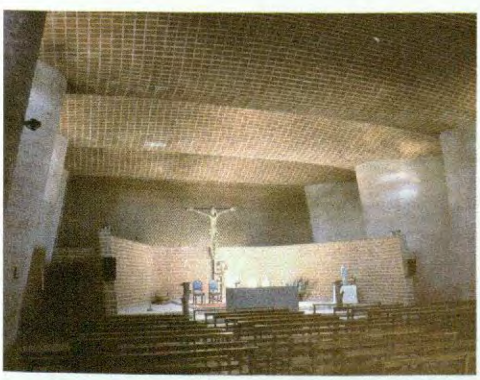
21 *(below)*
Dieste house. View from sitting area to dining area and courtyard

Dieste built a house for his family in a pleasant part of Montevideo, overlooking the broad La Plata River that separates Uruguay and Argentina. The long, narrow site (12 x 50 meters) is fully occupied with the house and its consequential open spaces: the front area, raised front terrace, internal courtyard, and back garden (fig. 19). From the lower level entrance of the house, one rises to a point that is effectively the center of the house: the sitting area opening to terrace and courtyard (fig. 20), and the dining area a few steps above (fig. 21), with the kitchen and private areas beyond. The house is early in Dieste's work (1961–63) and early in the development of the self-carrying vault. The vaults are small (4.25-meter spans). As seen in the relation between the sitting and dining areas (fig. 21), the form of the vaults gives identity to each of the places, but Dieste's self-carrying technique also gives continuity between them. The vault of the sitting area continues over the terrace, perforated to provide a transition of space and light. The heavy, cellular quality of Le Corbusier's earlier and comparable Maisons Jaoul at Neuilly-sur-Seine, France (1954–56),which also employ tie-rods, provides a telling contrast to the lightness of Dieste.

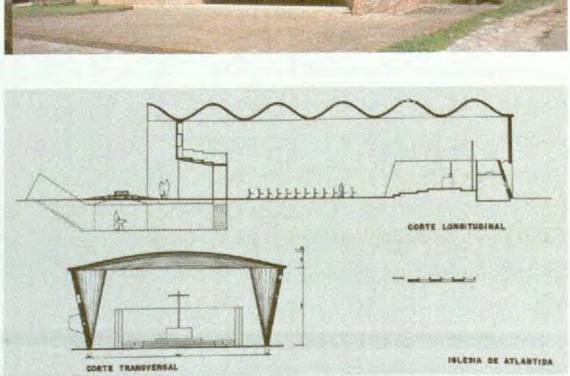
Also early in his production, Dieste was afforded the opportunity to build a church in a small community of agrarian and manual laborers. The Church of Christ the Worker in Atlántida (1958–60; fig. 22) was intended as a simple construction, but Dieste made of it an extraordinary work. The interior of the church possesses remarkable qualities of light and space (fig. 23). Dieste's religious position is also on view in the close relationship of the congregation to the priest—and this before the mandates of Vatican II. Viewed from the exterior (fig. 22), the continuous double-curvature vault of the roof (maximum 18.8-meter span) begins over the main entrance, supported by the undulating walls composed of ruled surfaces. In the sections (fig. 24), it is apparent, but surprising, that these two curved surfaces, wall and roof, meet in a level plane. The sections also show that the low point of the vault is flat; in this way, Dieste was able to place a tie-rod within the vault itself and take up its forces in the edge beams at the top of the walls. An image from the late stages of construction (fig. 25) shows these structural features, and dramatizes the fact that the building is structurally sound without the end walls. From inside, looking toward the entrance wall (fig. 26), Dieste notes the structural independence of



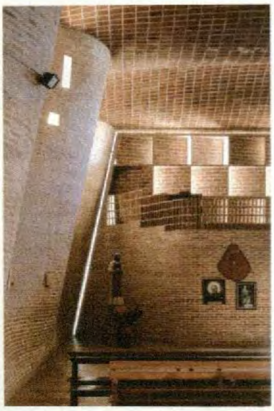
(right) 22
Church of Christ the Worker, Atlántida, Uruguay



(below) 23
Church, Atlántida. Interior view toward altar



(right) 24
Church, Atlántida. Sections



25
Church, Atlántida. View in late stages of construction

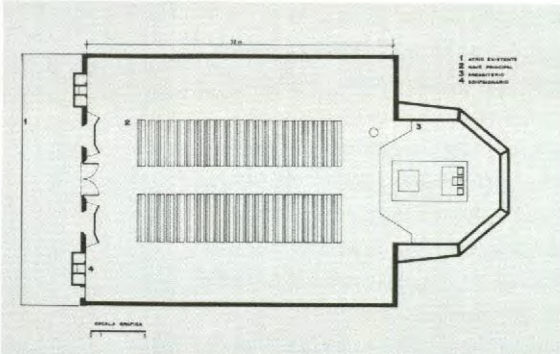
26
Church, Atlántida. Interior view toward entrance wall

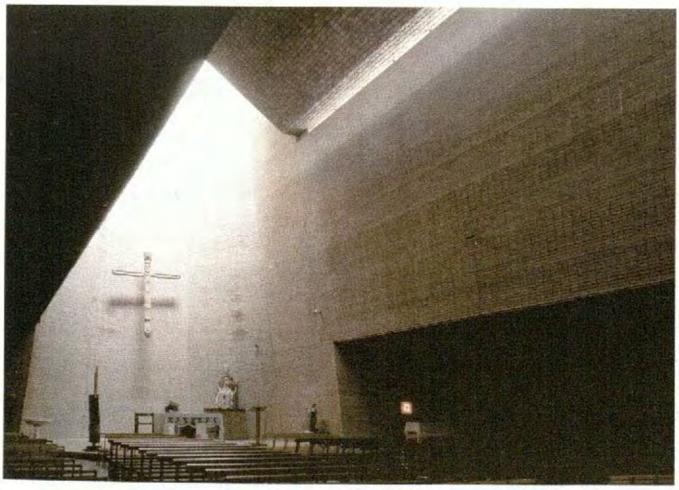
this wall with a line of light around its edge and with the obviously nonstructural louvers for indirect light. The other main source of light is the penetrations in the reverse curves of the walls. Thus none of the sources of light are apparent to a person entering this church with its luminous surfaces and space (fig. 22).

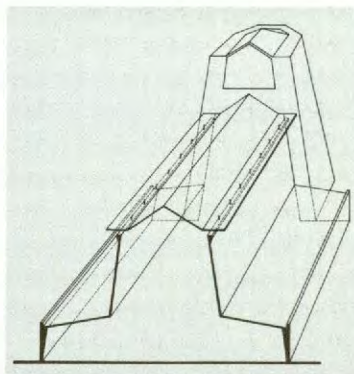
An opportunity that became another remarkable church by Dieste was occasioned by the destruction of the early-nineteenth-century Church of San Pedro in the provincial town of Durazno (1967–71; figs. 27, 28). The narthex that supports the high bell tower of the facade survived, but the entire basilical nave and its roof were lost. Dieste transformed the commission for a simple reconstruction into what I claim to be one of the great works of architecture of the late twentieth century (fig. 29). Light diffused throughout the space makes the exquisite brickwork almost radiant, culminating in the burst of light over the altar. One is first absorbed with the experience of light, space, and craftsmanship. Then more practical questions present themselves. How is it that the side aisles, unlike other basilicas, are completely open rather than separated by a row of columns? How can there be a continuous light source between the wall and the roof? The answers to these questions are best revealed in an axonometric section (fig. 30).

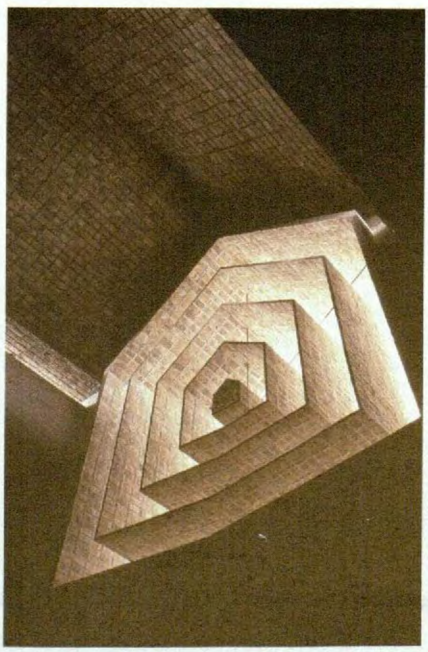
Contrary to normal expectations, the structure does not span across the width of the church. Rather, the nave walls are actually very thin, but densely reinforced, high beams that span 32 meters from the narthex wall to the presbytery. The roof is a thin, folded plate construction in brick (7.8 centimeters thick), also spanning the length of the church. The small steel studs between the wall and roof are not bearing elements, but rather transfer wind forces between the wall and roof. It is the structural daring of the church that allows the unanticipated and effective lighting. Turning to leave, one is surprised by another source of light, a rose window at the inner wall of the old narthex—a rose window in brick, floating in space (fig. 31).

At the end of these considerations of Dieste's buildings, it is important to note a general aspect of his architectural conceptualizations.









27 *(top left)*
Church of San Pedro, Durazno, Uruguay. Plan

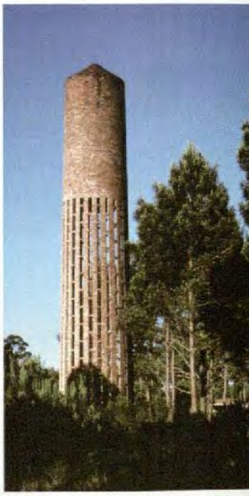
28 *(top right)*
San Pedro, Durazno. Retained facade on the main square

29 *(center left)*
San Pedro, Durazno. Interior, angle view toward altar and side aisle

30 *(center right)*
San Pedro, Durazno. Axonometric section

31 *(bottom left)*
San Pedro, Durazno. Interior, rose window

With the exception of an uncompleted church in Montevideo, all Dieste's buildings—even the richly curved church at Atlántida—begin from a simple rectangular plan. If the plan of San Pedro (fig. 27) were all we knew of this church, we might easily find it a rather uninteresting, even dumb, conception. Here, as in all Dieste's buildings, it is not the plan, not the exteriors, but the sections, both transverse and longitudinal, that yield all the critical qualities of structure, space, and, perhaps still more importantly, light. Axonometric sections, as that for San Pedro (fig. 30), are key to the understanding of Dieste's work. One must emphasize that this observation is not about architectural graphics, but rather about a fundamentally important conception of architecture.



32
Water tower, Las Vegas, Uruguay

Before reaching some concluding remarks, one should note a few other characteristic types of structure by Dieste. Among his towers are the campanile at the church in Atlántida, a 60-meters-tall television tower in Maldonado, and numerous water towers, including a rather small one at the resort town of Las Vegas, near Atlántida (27 meters tall; 31,700 gallon capacity; 1966; fig. 32). The perforated shaft occurs in many of these towers and was a matter of careful consideration by Dieste. The perforations reduced wind loads and admitted light to the access stairs or ladders. Perhaps most important was the matter of construction: planks could be placed across the diameter of the shaft, from one opening to another, thus providing an efficient self-scaffolding. But visual matters were of similar importance. The perforations yielded vertical piers that emphasized the upward thrust of the shaft.

Dieste weighed the effects of having horizontal rings of perforations versus the diagonally displaced ones that he used. Visually he recognized that his solution enhanced, again, the vertical thrust of the shaft as opposed to an apparent layering from rings of openings. Further, since the shafts are tapered as they rise, the circumference changes. With the staggered perforations, the changing dimension can be taken up in the openings, thus preserving piers of constant dimensions without cut bricks. The towers again demonstrate Dieste's attention to architectural nuance while solving his problems of structure and construction.

Dieste built several horizontal silos, the last of which, and the largest, was that for the Navios company in Nueva Palmira (77,500 square feet; 1996–97; fig. 33). Light is a negative for a grain silo, so this is a continuous double-curvature vault. The site development of the project is almost that of an art installation. With a span of 45 meters, the scale is vast and the effect commensurate (fig. 34).

The poet Rafael Dieste (1899–1981) was an uncle of Eladio. One of his poems speaks of a miller building his mill and engaging in his trade. The poet observes that all the miller's work was directed to practical purposes, down-to-earth and necessary ones, but he also finds deep meaning in his work. The horizontal silo is one of the more humble kinds of structures Dieste built, a volume just to hold wheat. But, in the end, here too there is poetry, something of the sublime, in the structure and in the wheat.

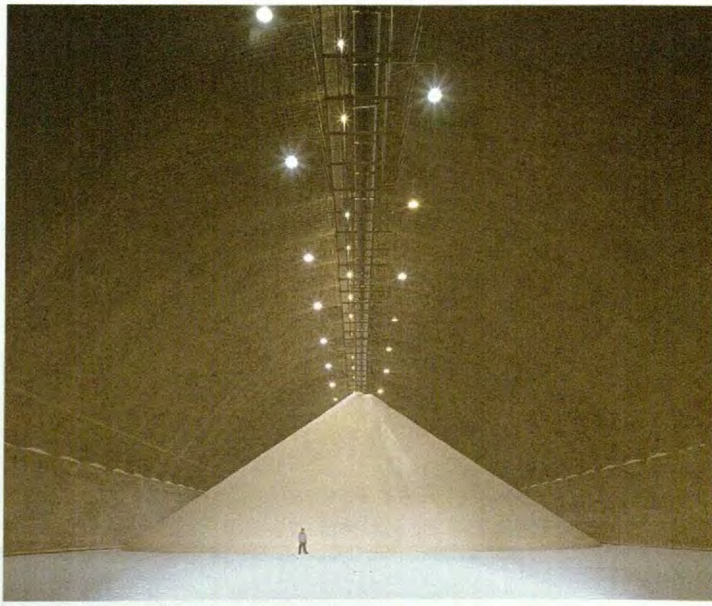
An image of an earlier silo facilitates an understanding of Dieste's construction techniques (1975–78; fig. 35). A huge movable formwork, shown here as it has been lowered and is being moved to the next position, allows construction of one unit of a double-curvature vault (30-meter span). The timber surface of the formwork has a grid of little sticks that allows unskilled laborers to position the bricks. Small reinforcing bars are laid between the bricks, and the joints are mortared. Depending on the design, additional reinforcing is laid over the bricks before the entire surface receives a cement parging that is simultaneously structural and weather-resistant.

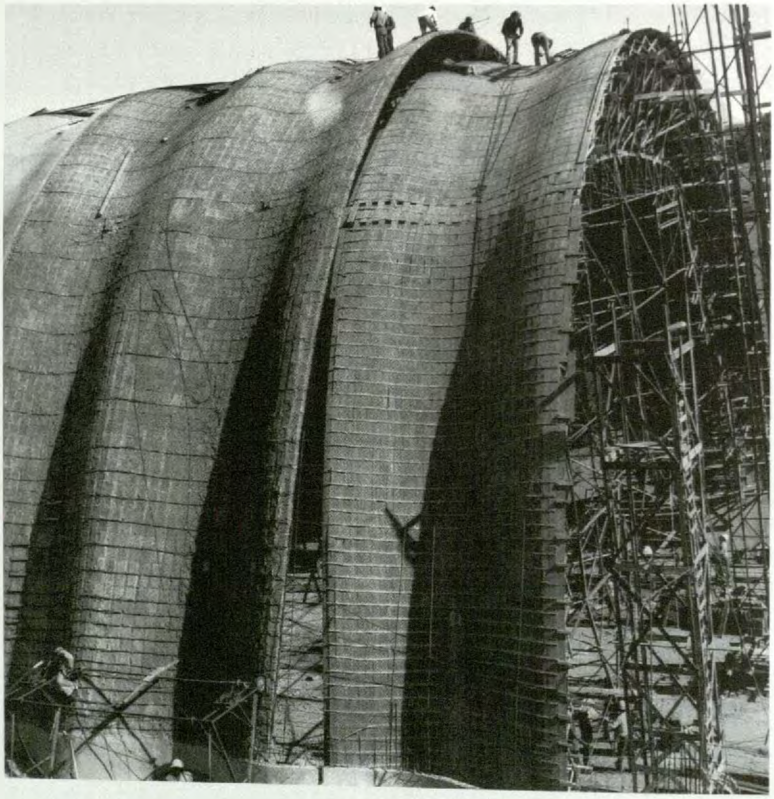
One of Dieste's sons, the structural engineer Antonio Dieste, has raised questions about the viability of his father's building program in today's economy, even in Uruguay. And, in North America or Europe, it seems even less viable.[1] He also asked: What innovations are necessary to preserve and advance reinforced ceramics? Such questions are ones that his father would have recognized. Today, the firm of Dieste y Montañez continues under the direction of another son, Eduardo Dieste, and with a long-time, excellent engineer-collaborator, Gonzalo Larrambebere. As we speak (2005), Dieste y Montañez is building another of the vast silos at Nueva Palmira.

So Dieste construction continues, but it may be well to consider whether this building program, with its simplicities and efficiencies, may not hold special promise for those lands with severely diminished resources. The contemporary, noted Finnish architectural firm of Heikkinen and Komonen, architects of the high-tech and elegant Finnish Embassy in Washington, D. C. (1990–94), has also taken the responsibility to aid in construction of necessary social facilities in the

33 Navios horizontal silo no. 4, Nueva Palmira, Uruguay

34 Navios silo, Nueva Palmira. Interior





35
CADYL horizontal silo, Young, Uruguay. Construction photo

African nation of Guinea.[2] They did not employ unusual structural systems, but together with their collaborators they trained local people in the production of ceramic elements of several kinds and designed model buildings in masonry and limited use of wood. There is every reason to think that Dieste's techniques, using wood only in formwork, could address an even wider range of problems effectively. One example known to me is the water tower constructed by one of the communities in Auroville, India.

In reaching a few concluding remarks, I ask the reader to keep in mind the image of Eladio Dieste (fig. 2) and of his rose window in San Pedro (fig. 31). I want to comment further on Dieste's strong traits of rationality, architectural acuity, and social responsibility, but I would also like you to bear in mind the twinkle in his eyes that is mirrored in the tour de force of the rose window. Dieste's face reveals both intelligence and charm, suggesting that he could accomplish something very serious and at the same time entertain pure inventions for the sheer joy of it. In San Pedro there is real substance to his thinking in the folded plate construction and the entire conception of the space, but also a playfulness and wit.

Dieste was a builder who worked from first principles, innovating with traditional materials and providing a model that might be applied in other ways. The significance of Dieste does not end there. He was born, lived, and dominantly built in Uruguay, a small country of high educational and cultural level, but not of generous resources. His choice of materials and still more the economy, not only financial economy, of his works systematically addressed the conditions of his country and potentially those of many under-resourced countries in an era of superpowers and globalization.

Dieste knew full well that ample resources, wealth, and power were not enough to assure a sound environment or humane society. Contending with constraints may deny many material advantages, but not the opportunity to think and work contributively—still less the opportunity to build a fulfilling social state. Dieste appreciated the simple farmers and workers of his country. The church in Atlántada is essentially for and dedicated to them.

Dieste was also a man of culture. He loved classical music. His care for literature is witnessed in his affection for his uncle, the poet Rafael Dieste. He moved in the avant-garde circle that developed around the modernist painter, Joaquin Torres-Garcia (1874–1949), who became a Dieste family friend. Dieste wrote about his engineering innovations and accomplishments, of course. Yet those accomplishments lay at the core of ever-expanding concerns. He saw the negative impact of much of modern development on cityscapes and the countryside. He understood that art and architecture were integral to the making of the admired buildings and cities of the past and had to be part of any desirable future.

Dieste was a man of religion. This is evidenced in the sheer architectural, and one can only say, spiritual quality of his churches. The way in which his churches intentionally unite the worshipers with the clergy is evidence of his embrace of the liberalizing forces in the church. But religion makes little appearance in his writings. His concerns were for social justice, for the opportunities of the less-resourced peoples and countries, for thought and action through what he termed "cosmic economy." His life, his thought, and his work were integral and integrated.

Notes

1 Antonio Dieste, "A Prospect for Structural Ceramics," in Stanford Anderson, ed., *Eladio Dieste, Innovation in Structural Art* (New York: Princeton Architectural Press, 2004), 220–22.

2 Mikko Heikkinen and Markku Komonen, *Before Next: Learning the Roots* (Helsinki: Museum of Finnish Architecture, 2002).