fig. 21: "Sea Gull" (originally the Barbiere and Leggire Service Station), Salto, 1976. Dieste's Refrescos del Norte complex appears in the distance.

fig. 22: Massaro Agroindustries, Joanicó, Canelones, 1976–80. This view is taken from the five-vaulted main sheds to the three double-cantilever, self-carrying vaults at the entry.

fig. 23: Port Warehouse, Montevideo, 1977–79. Note the double-curvature, or "Gaussian," vaults and detail at an end wall.

"DANCE WITHOUT EFFORT OR FATIGUE": THE ARCHITECTURE OF ELADIO DIESTE

Stanford Anderson

"A lightness, a mysterious ease, a concise simplicity, something like dance without effort or fatigue": these are words that Eladio Dieste used to describe the goals for his work.[1] Such were the necessary conditions, he argued, for convinced acceptance of a building by its users.

Dieste wrote those words out of the specific concern that his work should communicate with ordinary people. In the same essay "Art, People, Technocracy," he tells of his experience of a humble woman with coarse shoes covered in mud at his Church of Christ the Worker in the village of Atlántida: "The itinerary that she followed, the places where she paused, the things that she said with complete simplicity and without accolades: these things that made me realize she was really seeing it."[2] Dieste assures us this was not a singular experience. He was certain that people are not moved when a difficulty is resolved by brute force but rather want to perceive a problem resolved with the effortlessness of a hawk soaring in the sky or a flower unfolding in the sun. It is one thing to have such an ethereal ambition and quite another to achieve it. Yet that is what Dieste achieved in his buildings. It is no accident that the phrase "light as a brick" was invented for his work.[3] The buildings of this master and innovator of reinforced brick construction address us so effortlessly, and yet forcefully, that a brief first exposure suffices to assure a deep engagement.

The inexplicable neglect in North America of Eladio Dieste accounts for the fact that my own exposure to his work came late in a long career involved with modern architecture and then, incidentally. In 1998 I received an unanticipated invitation to visit Uruguay, followed a few days later by a coincidental, brief exposure to two or three images of Dieste's buildings. One incident informed the other; soon I found myself touring the work of Dieste and then taken to visit the engineer at his home by one of his former students, Lucio Caceres, a civil engineer and the Minister of Public Works of Uruguay.

Inserted into this meeting of friends, I was soon able to reveal, in effect, my own conviction about Dieste's work as a "dance without effort or fatigue"—though these were words I had not yet had occasion to learn. As genuine and motivated as were my first words to Dieste, perhaps I was too enthusiastic in my appreciation. Though suffering the effects of a degenerative disease, Dieste, with a knowing and friendly sparkle in his eyes, calmed me with the words: "I too obey the laws of physics!"

In the presence of Dieste's buildings, one may sometimes wonder if he truly obeyed those laws. But, yes, he was an engineer, and there the buildings stand. The laws of physics are satisfied. Nonetheless, we must also observe that there is all the difference in the world between engineering work that remains safely controlled within the conventions of ordinary practice and that which challenges convention. Dieste imagined new possibilities and then, yes, observed *only* the laws of physics, not standard practice, both as a critic and a facilitator. Additionally, it must be emphasized that Dieste's innovations are not for the sake of novelty. They are rather the result of a continuous quest, a reasoned approach to building well, addressing the pragmatic problems at hand but also satisfying his own profound demands, ethical and spiritual, that lay behind his dance.

Dieste made himself the master of reinforced ceramics, virtually the only mode in which he built. The vast majority of his structures serve everyday purposes of work and storage. He invented two distinctive forms of reinforced brick vaulting that were instrumental in winning the economic competition to build these utilitarian structures. Serving pragmatic purposes and doing so economically (in terms of time and cost) was the fundamental business model of the engineering firm of Dieste y Montañez. It is not despite these constraints but largely because of them that these buildings rise above their quotidian settings and achieve an ennobling architectural presence.

Of Dieste's two major innovations in structural types in reinforced brick masonry, consider first what he termed "self-carrying vaults." These are barrel vaults with none of the usual

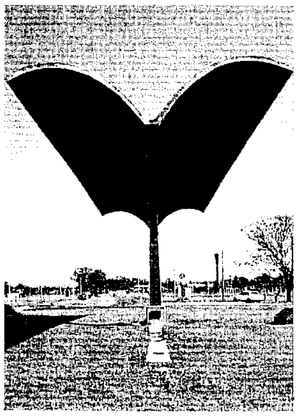
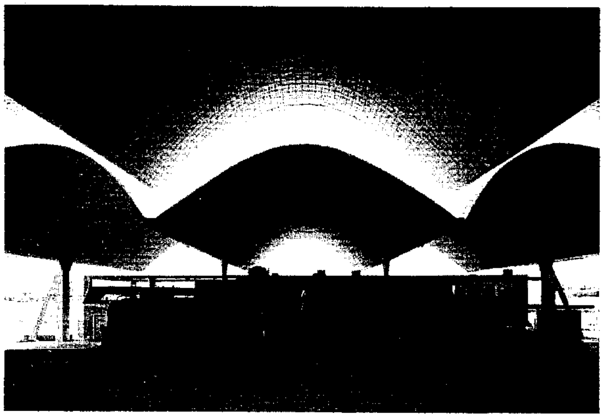


fig. 21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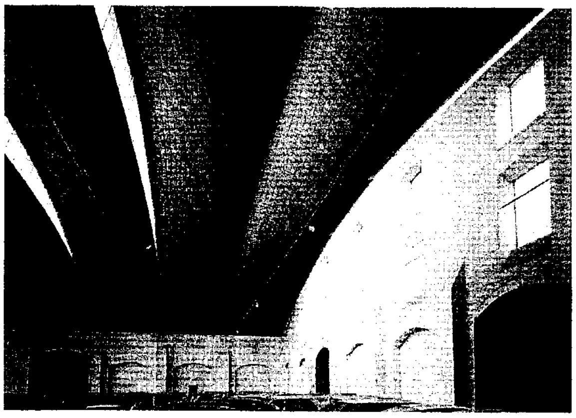
fig. 23

conditions of support for such a vault: no continuous side wall supports or buttresses, no tympanum or arch under the vault at its ends. Dieste's vaults rest on columns—or even a single column (fig. 21)![4] Less demonstrative but equally impressive are the true self-carrying vaults whose basic variants are well illustrated by the sheds for Massaro Agroindustries. The main storage area is formed by a set of five parallel barrel vaults carried on a sparse grid of columns, with a cantilever of 54 feet at one end. Freely sliding under that cantilever are three still more astounding vaults with 43-foot cantilevers in both directions, carried on a single row of four columns (fig. 22).

Such minimal support is only possible, of course, if the vault, unlike traditional masonry vaults, can resist bending forces. This Dieste accomplishes by introducing pre-stressing steel that pre-compresses the vault. In cross section, the vaults are given the most effective structural form—a catenary. This, together with ordinary reinforcing bars between rows of bricks, yields a thin and light vault. This lightness reduces the lateral forces but, of course, the forces are there and must be counteracted. Dieste's characteristic elegant solution is a horizontal edge beam at the outer limit of any group of vaults—a beam that collects the lateral forces and brings them back to vertical buttresses at point supports. In the long direction of a barrel vault supported on columns, the vault acts as a beam, and it is here that the pre-stressing becomes necessary. Atop the brick masonry, successive loops of steel are tensed and then imbedded in a thin concrete layer, applying high compressive forces to resist tension in the finished vault. In these self-carrying vaults, the few and distant points of support and the thin, unsupported ends of the vaults convey directly the seemingly effortless lightness of these constructions.

Dieste's second major structural innovation was in what he termed "Gaussian" double-curvature vaults. Barrel vaults rise high in relation to their transverse span and thus are not well suited to broad spans. However, a thin vault of long span and low rise is susceptible to buckling and thus not sound structurally. Dieste gave strength to such vaults not by making the vault more massive (a solution by brute force that he naturally resisted) but by making the vault in successive transverse bands, each of which was given a greatly increased bending stiffness by means of three-dimensional curvature. At the center of the span where the forces to be resisted are greatest, the band has as its cross section (in the longitudinal direction of the building) a reclining s-shape (fig. 23).[5] Dieste configured the s-shape to be lower and flatter at one side than at the other; when such bands of vault are built next to one another, the disparity of the edges of the neighboring s-shapes leaves a long, curving lunette ideal for illumination at frequent intervals and across the width of the building. Because the vaults are carried on edge beams, Dieste often introduced continuous windows in the walls below the beams. Recurrently, Dieste framed these glazed openings with the simplest of small steel bars. Ever attentive to simplified systems of support, he progressively flattened the full s-shape of mid-span until the vault became a continuous horizontal line at its outer supports. The long span and low rise of these Gaussian vaults result in significant lateral thrusts that were usually resolved with exposed horizontal tie-bars, though Dieste had no love for them. By extending the columns of the Don Bosco school gymnasium in Montevideo, he succeeded in placing the ties above the roof where they are effectively invisible from within. In a variant of the Gaussian vault used in his horizontal silos, where a higher pitched vault reaches the ground, Dieste absorbed the horizontal thrust in the floor or foundation.

1 Eladio Dieste, "Art, People, Technocracy," 194 of this volume. Originally published as "Arte, pueblo, tecnocracia," in *Eladio Dieste: La estructura cerámica*, ed. Galaor Carbonell, Colección Somosur (Bogotá, Colombia: Escala, 1987).

2 Ibid.

3 Juan Martín Piaggio, *Leggero come un mattone: L'Architettura de Eladio Dieste* (Parma, Italy: Industria Leterizi Giavarini S.p.A., 1997).

4 The "Sea Gull" is not, strictly speaking, a vault since the cross section cannot act in compression. Its form and construction do, however, owe much to Dieste's self-carrying vaults.

5 There are also those constructions, as at the church at Atlántida, where the Gaussian vaults are a continuous surface, at times penetrated to provide light.

That Dieste built with brick is one of the reasons for his neglect in architectural history and criticism. His career coincided with the prominence of theories of architecture and its history that embraced dubious notions of a modern zeitgeist. An inevitable evolution toward a technologically advanced society demanded, it was said, the use in architecture of "modern materials" such as steel, concrete, and glass. Dieste was educated in the emerging practices of framing and vaulting with reinforced concrete, yet he chose to build in brick. While his innovative brick structures grew out of precedents and practice in reinforced concrete, Dieste quite reasonably argued that new materials do not necessarily displace earlier materials of demonstrated effectiveness.

Dieste found compelling reasons for the use of ceramic materials in the marginalized economy of Uruguay. However, he also supported brick construction for reasons that rely only partially on that local condition. He claimed advantages for brick over concrete, including relative strength for weight, better resistance to temperature changes and aging, better acoustic and environmental qualities, and, in comparable quality, lower cost.[6] In this Dieste provided good, hardheaded reasons for preferring to work in brick. Further, he believed that the tectonic sense of a durable material with agreeable qualities of color and texture, worked with sound craftsmanship, had a general appeal.

A claim for the architectural quality of Dieste's utilitarian buildings, however, goes beyond both the performance characteristics and agreeable qualities of brick. Dieste's effortless dance relies, of course, on the structural innovations we have rehearsed, but belief in the dance relies on the intrinsic architectural quality of his achievement. In those buildings of a single volume, the space is generous and well proportioned; the structure itself is articulated in smaller elements, down to the handheld, often handmade, brick itself. In the buildings of multiple bays, both the clarity of each bay and the associations among them offer compelling spatial experiences. When, as at Massaro, impressive cantilevers overhang one another, there is a wonderful sequencing of open to covered and finally enclosed spaces. Another aspect of this sequencing is natural light. The self-carrying vaults admit light where they overlap or stop short of one another, or where they are simply penetrated. The Gaussian vaults yield very special qualities of light. In addition to the effective dispersion of light throughout these buildings, there is the virtually sentient way in which different aspects of the vaults are revealed as one moves beneath them. From one direction, there is the soft lighting over the curving surfaces of the vaults; from the other, the repetition of the glazed lunettes with views of the sky. The last vault at either end of the series poses here the lower, flatter arch, and there the higher arch of either side of the S-shaped vault section. Characteristically, Dieste demonstrates the difference of the two ends of the series of vaults with different heights of glazing above the opposite end walls. That glazing also allows emphasis of the thin end of the vault and the absence of a tympanum or other structural support.

We know there are buildings that are technically sound without becoming architecture. And there are buildings of widely recognized architectural standing that are open to technical and tectonic criticism. There remains a special place for technically sound buildings that achieve high tectonic standards and thus deserve to be recognized as architecture. This is all the more true when the designers of these buildings also ran the risks inherent in technical and tectonic innovation. Dieste successfully took such risks. His are works that do not indulge the arbitrary, works in which the form of the structure is also the form of the building and the delimiter of space. Dieste stated this more strictly:

> A building cannot be profound as a work of art unless it has an earnest and subtle fidelity to the laws of matter. Only the reverence that this fidelity requires can make our buildings serious, lasting, and worthy partners in our contemplative journey.[7]

The utter directness of Dieste's work—its "earnest and subtle fidelity to the laws of matter"—moves us.

Within his oeuvre and beyond the types of buildings already mentioned are a few works that are especially integral to Dieste's contemplative journey. Dieste's best-known work is the Church of Christ the Worker in Atlántida. It is all the more remarkable for having been created early in his career. It is both proof of Dieste's architectural capacity from the outset and an inventive variation on the system of Gaussian vaults. A detailed discussion of this impressive structure can be found in the essays of John Ochsendorf and Remo Pedreschi contained in this volume.

The Dieste House in Montevideo, built between 1961 and 1963, is located on a street that parallels the River Plate.[8] The house rests on steeply rising ground on the landward side of the street, providing a view south to the sea. The house with its courtyards occupies most of a narrow but deep lot, as was necessary for a large family of eleven children, even if the accommodations are economically organized.

The driveway makes a steep ascent to a broad terrace that is both carport and entry to the lower level of the house. The entrance is compact but ascends immediately via an L-shaped stair to the living room, built on grade less than a full story above. The living room is truly the center of the house and possesses varied and excellent relations to the exterior. To the south is a two-level open space, planted as it extends from the living room; and a hard-surfaced, partially covered terrace, which forms a roof over the entrance. To the north (which here, in the Southern Hemisphere, is the direction of the sun) is a constructed terrace under an openwork brick vault that opens to a generous courtyard garden.

Back in the living room, three steps bring one up to the dining space that is continuous with the living room except for the low storage units that further define the change of level between the two areas. This main level of the house is roofed with self-carrying vaults of a small span. Even at this scale, these vaults fulfill most of the claims Dieste had made for brick construction.[9] They serve important architectural purposes as well. The continuity of the living and dining areas is also articulated with their separate vaults. These main spaces of the house, with their undulating vaults, achieve both an intimacy and a generosity that no flat ceiling, high or low, would offer. From the living room to the sunny courtyard, the vault first offers a high, protected source of balanced light, beyond which is the perforated vault of the terrace that nuances the light both of the terrace and the interior. The shape and the perceived warmth of the vaults significantly ease the compactness of smaller spaces like the bedrooms and Dieste's study.[10]

There is reason to suppose that Dieste knew of Le Corbusier's famed Jaoul houses, built between 1954 and 1956 in Neuilly, outside Paris, which use walls of brick and thin-tile vaults.[11] The structures are, however, very different than Dieste's. The vaults of the Jaoul houses are not reinforced and

6 The full list of advantages appears in Antonio Jiménez Torrecillas, ed., *Eladio Dieste: 1943–1996*, trans. Michael Maloy and Harold David Kornegay (Seville: Consejería de Obras Públicas y Transportes, 1997), 34–36. This list, lacking a final point on low cost, first appeared in Eladio Dieste, "Acerca de la cerámica armada," *Summa* (Buenos Aires) 70 (Dec. 1973). It is considered more fully here in John Ochsendorf's essay on page 103 of this volume.

7 Eladio Dieste, "Architecture and Construction," 188 of this volume. Originally published as "Arquitectura y construcción," in "Eladio Dieste, el Maestro del Ladrillo," sp. no., *Summa: Colección Summarios* (Buenos Aires) 8, no. 45 (July 1980): 84–93.

8 An essay by Antonio Dieste, one of Eladio Dieste's sons and himself a civil engineer, provides a description of the family home and insights that only a family member could give. See 18–31 of this volume.

9 Antonio Dieste notes that these spans could have been achieved more efficiently and economically with prefabricated concrete slabs. Of course here Dieste was not in economic competition for the commission, but neither was he merely advertising his business of building vaults.

10 Dieste's sense for the making of domestic space is revealed in his story of his encounter with an elderly woman in her humble, but humane and beautiful, room. See Dieste, "Art, People, Technocracy," 196 of this volume.

11 Aside from the renown of Le Corbusier and the Jaoul houses, Dieste, through the design of his first reinforced brick vaults for the Berlingieri house in 1946, had early association with the Catalan architect Antoni Bonet, who had moved in the circle of Josep Lluis Sert and Le Corbusier. See Ochsendorf's essay on page 96 of this volume.

fig. 24: Church of St. Peter [San Pedro], Durazno, 1969–71, axonometric section
fig. 25: Church of St. Peter, axial view from the nave to the sanctuary
fig. 26: Church of St. Peter, axial view from the nave to the rose window over the narthex
fig. 27: Church of St. Peter, view up into the light tower of the sanctuary
fig. 28: Church of St. Peter, angle view from the west side aisle to the sanctuary

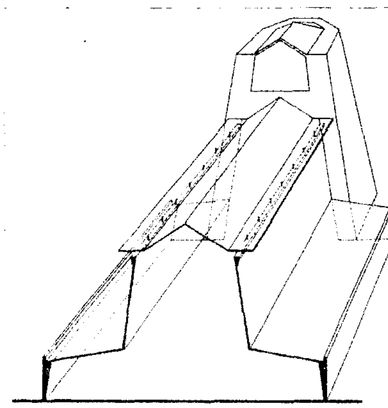
fig. 24

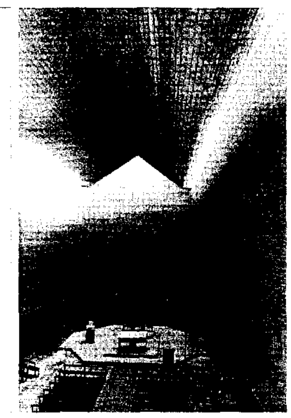
fig. 25

thus span between heavy walls or concrete beams and employ exposed tie-rods. The structural system is conventional and strongly cellular in its definition of space. The materials of the two houses suggest a relation, but Dieste's structural innovations opened new architectural potentials that he realized.

Beyond such claims for the vaulting, the architectural achievement of the Dieste House also rests on the compelling organization of the site and the house. The positive potential of the sloping site is realized. The changes of level, the several special relations of house and garden, the knowing use of light, and—employing all of these features and more—the appropriate distinctions of public and private are all the marks of a fully realized architectural proposition.

The most uncharacteristic work by Dieste is also the most subtle architectural achievement of his career: the Church of St. Peter in the provincial city of Durazno. The task at hand may well have seemed unpromising at first. In 1967, the original timber roof of St. Peter burned and only its replacement was envisioned. The church is located on the south side of the town's principal plaza, and presents only a façade to the square. The façade bears relation to both Romanesque and Renaissance precedent. Its gable top rises sheer into a square bell tower topped by a cylindrical colonnade with a high, stilted dome. The cubic bell tower directly over the entry requires a second strong wall parallel with the façade for support, the two walls framing the narthex. All this survived the fire and was incorporated into the new design.

The plan of the old church was a simple, three-aisled basilica with lower side aisles beyond a row of columns. Had the intention for rebuilding remained solely the addition of a fireproof roof, there would have been little of architectural consequence. However, the intention came to be a rebuilding of everything beyond the narthex, and Dieste made the most of this opportunity.

Any new design was constrained by the rectangular site in the middle of the block. Dieste's design has a deceptively simple plan (see fig. 56). It is a squat rectangle of a ratio of approximately 4:5, suggesting no strong directionality. To the south, the nave continues into a sanctuary that is five sides of a slightly irregular octagon. The transverse section of the nave is also simple, yet this is the first step in achieving a remarkable spatial organization (fig. 24). The section is once again basilical; however, no columns or piers—remarkably nothing—separates the nave from the long, broad side aisles. Since the side aisles together are wider than the nave and comparatively low, the central vessel, the nave, does achieve a strong horizontal directionality. The high side walls of the nave tilt inward such that the width of the nave at the roof line is only about half that of the nave height, and the apparent height is intensified. The horizontal and vertical directionalities obtained with the high, inclined side walls of the nave are all the more emphatic and resonate with symbolic significance by flowing seamlessly into the walls of the octagonal sanctuary. These walls rise well above the roof of the nave, sheltering a large concealed north window that brings direct sunlight streaming down the windowless south wall.

The roof of the nave is a strong complement to the powerful walls, with their continuity into the seemingly boundless height of the sanctuary. Like all other surfaces, the roof is wholly of brick, fashioned into long folded plates that form a low gable (fig. 25). The end of that low gable at the south provides a strong central focal point and sharp shadow line against the light in the sanctuary. The broad gable plates of the roof are stabilized laterally by horizontal plates that extend beyond the nave walls, acting as horizontal beams. To our surprise, there is a thin continuous band of light between the top of the nave wall and the roof, giving a soft illumination throughout the church without competing with the focal light over the altar. The horizontal band of clerestory windows does more than admit light. In this building so redolent of craftsmanship and sound tectonics, the seeming impossibility of that light source leaves the viewer with a conviction that here the material world itself has been overcome.

Due to the ingenious section and structure, the nave is, after all, a powerful directional force where form, tectonics, and light are in total congruence, subtly focusing attention on the most sacred part of the church. The spatial continuity of

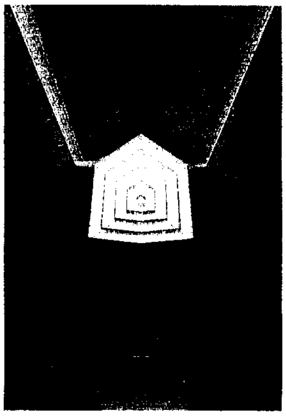

fig. 26

fig. 27

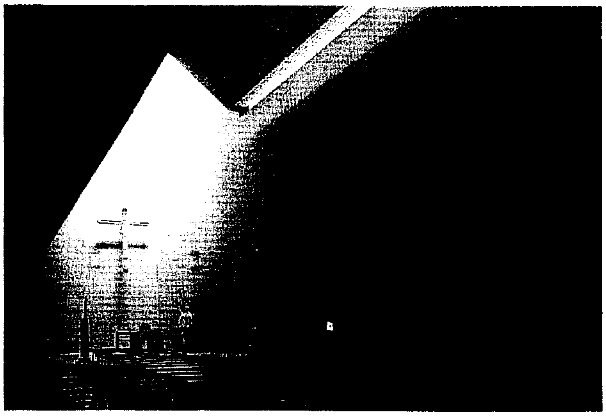

fig. 28

the nave and side aisles is a secondary phenomenon but still vitally important to creating a sense of oneness between the congregants and the religious celebrants, in accord with Dieste's religious convictions.

A final surprise remains. Turning to leave, we see the third, and only other, source of light through an opening that is a tour de force in brick masonry (fig. 26). The old façade facing the square contains large lancet windows that give generous light into the high narthex. In Dieste's new inner wall of the narthex (the back wall of the nave), he suspends on tiny steel rods five concentric "rings" of brick in an irregular hexagon, creating a rose window that borrows light from the façade. Here too the beauty of the light and the improbability of the material phenomenon challenge our comprehension (fig. 27).

The folded plate construction used in Dieste's church at Durazno is all but unique in the engineer's work; indeed, it is unique among the great buildings of the world. The side walls of the nave are over 100 feet in length. How can it be that there are no columns to support them? How can it be that there is a continuous source of light between the walls and roof of the nave? The answer is that the side walls of the nave and the folded planes of the roof are beams spanning the length of the church! They are supported on the reinforced inner wall of the narthex and a reinforced concrete portal frame at the sanctuary.

Placing structural members in the long direction of the space is itself counterintuitive, but if you would stretch your intuition, examine the transverse section of St. Peter. In taking the apparently difficult path of spanning the church in the long direction, Dieste did not solve the problem with brute force. Observe the thinness of these wall/beams and roof plates! The nave wall—a slightly inclined beam—is a composite of brick and concrete, about 26 feet high and only about 10 inches thick, a ratio of 1:30. The principal roof plates, resting only 34 degrees off the horizontal, are even more amazing: little more than 3 inches thick, they too span over 100 feet. The ratio of thickness to span is approximately 1:400. The structural adequacy of these members is due to their form (the 26-foot height of the beam and the effective depth of the folded roof plates), but the actual and conceptual thinness of the structural elements remains striking. While the impressive span of the nave walls and the virtual independence of the roof from the nave walls are visible to the viewer, it is true that the extraordinary thinness of wall and roof is not directly given to view. Yet the taut brick surfaces in this building convey a clear sense of an economy of means that is much more than a mere material matter (fig. 28). Here again, Dieste has performed a "dance without effort or fatigue." He explains:

> The resistant virtues of the structures that we are searching for depend on their form. It is through their form that they are stable, not because of an awkward accumulation of matter. . . . there is nothing more noble and elegant from an intellectual viewpoint than this resistance through form.[12]

Dieste's resistance through form was a matter of spanning space. The centrality of this evident fact entails an important and less obvious aspect of his work. Virtually all of his buildings have the simplest of rectangular plans—in the greatest of his buildings, the Church of Saint Peter, even an obtuse, unpromising rectangle. Where the walls are curving, ruled surfaces, they are bounded by a real or implied rectangle. With the exception of his house, it is not the plan that sets his buildings apart. Nor are their exteriors elaborated. It is the section that is the telling feature of Dieste's buildings

12 Dieste, "Architecture and Construction," 187 of this volume.

and, through the section, that his innovations of space, light, and structure are achieved. Despite the excellence and centrality of structure and construction, with Dieste, a building offers little as an object and much as a space articulated for life.

Dieste's innovations in structure also entailed quite exceptional innovations in construction: movable formwork, simple pre-stressing techniques, rapidity of construction, and the like. What is so evident in the Church of St. Peter is the exquisite brickwork. The overall impression is of such perfection that one is convinced of the precision and economy of the thinking and performance that must lie behind such a work. This precision can be pursued down to details. At the junction of the nave, side aisle, and sanctuary, no two of these surfaces are at right angles to one another, yet the bonding here, as elsewhere, is perfect in its transitions.[13] To achieve such perfection requires deeply informed planning on the part of the designer, but it will never be achieved without excellent collaborators during the design and construction process and, needless to say, skilled and devoted craftsmen.[14]

Early in his career, Dieste courageously disciplined himself, his client, and his collaborators to achieve in the church at Atlántida a challenging work that went far beyond the initial program and established Dieste as an architectural force. The church at Durazno, with its intellectual as well as spiritual power, its refinement in both thought and execution, make it, I would argue, one of the major architectural achievements of the last half of the twentieth century. Dieste knew this and was willing to recognize that he had achieved architectural works, even if he was loath to title himself an architect.

Dieste was still more than an engineer and architect; he was a man with deep ethical concerns and broad intellectual interests. In his two churches he sought to unify the congregation and the priest and liturgy for the well-being of people, especially those who labored or were dispossessed. At Atlántida, Dieste had fulfilled this ideal prior to the dictates handed down by the Second Vatican Council. He was a religious man; you will find a crucifix on the wall of his study. But his concerns were not framed by the Church or even by religion more generally. His was a concern for humanity, expressed in both political and humanistic terms. He wrote, "I think that we would reach a wide consensus if we proposed as a common aim the fulfillment and happiness of mankind. This is an aim that would certainly produce different principles in accordance with each individual's philosophy of life and his religion."[15] After noting that "what we see around us is not acceptable," he continued, "The industrial revolution took place with such great injustice that the repercussions from the fierce indignation that its inequities produced in mankind are the reason for the destructive madness that has spread throughout the world."[16]

Deeply concerned for the inequities suffered by the majority of the world population, and committed to the maintenance of well-being in countries like his own that were buffeted both by local constraints and the harms of international development activities, Dieste did not lose sight of the higher goals of humankind. In his essay "Technology and Underdevelopment," he maintained:

> Efforts that are put to good use are efforts that help man to be happier, to be more himself. Efforts dedicated to science, art, health care, and efforts to make the earth, our countryside and cities, the true home of mankind, are efforts that are put to good use. If we understand development in this way, then it is both good and desirable.[17]

13 In Remo Pedreschi and Gonzalo Larrambebere's essay in this volume, the authors make this point. See page 148.

14 Gonzalo Larrambebere, a longtime key member of the Dieste y Montañez office, confirms that the architect Alberto Castro Oyola and the engineer Antonio Raúl Romero Riveiro collaborated with Dieste both in the design and the direction of the construction of St. Peter. Gonzalo Larrambebere to Stanford Anderson, electronic communication, 28 May 2002.

Castro explains that both he and Romero were "immediate collaborators," working independently but from an initial idea that Dieste had, as usual, given in a small (now lost) sketch. He states:

> My initial participation was the architectural elaboration of the preliminary design based on Dieste's original idea. When this phase was completed, the engineer Romero worked

Embracing this general position, Dieste's own efforts were conducted as both science and art, and were directed not only to the home of mankind but to our edification.

Recognizing that calls for simplicity usually entail unjustified simplification and that those for economy address merely money and its movement, Dieste advanced a much larger cause: "The things that we build must have something that we could call a cosmic economy, that is, to be in accord with the profound order of the world. Only then can our work have the authority that so surprises us in the great works of the past."[18] While here Dieste refers to structures, we should see his notion of "cosmic economy" in terms of that "profound order of the world." The inexplicable harmonies of the Church of St. Peter are the fundamentals of his cosmic economy, but so too are his understandings of how his country should operate within a world of disparate opportunities, and how genuine goods must reach equitable distribution.

Dieste's thought and work are undeniably metaphysical. Yet he rejects any teleology and his ambitions are always grounded:

> It is not easy to have a clear image of the goal. On the other hand, it is much easier to have a clear image of the foundations and principles that will shape that goal. This is why the idea that "the ends justify the means" is a drastic mistake. We do not know what the end will be. We have an image of our goals, but these will never be realized if in our actions we betray the principles that will shape and form these goals. We cannot postpone for the future city the beauty and dignity that we need so badly to endure the severities of life. We cannot postpone them as principles even though we might have to compromise in practice. When we have no other choice, we will have to compromise, but we should always continue to try to achieve the principles that will shape the goal, our future.[19]

With this confrontation of principles and reality, it is tempting to recall Dieste's story of one of his professors, who, hearing the word "theoretical" used with disdain, retorted, "Theoretical, theoretical, the theoretical that fails in reality, fails because it isn't theoretical enough!"[20] Dieste's thought, his search for "cosmic economy," takes him readily to large and small issues in quite different domains, but there remains a selective and rational mind behind these ambitions.

Dieste's achievement has a strong moral and intellectual basis. It offers fundamental lessons. Within a period marked by naïve modernist determinisms and conservative resistances, Dieste provided an unusual and strong counterexample. He was an engineer working rationally from first principles, but he was also a pragmatic humanist who chose his course in accord with both limiting conditions and social ideals. He knew how to make his situation work for him and others

> closely with Dieste to define the structure of the project.... Dieste directed the construction phase with Romero's support in structural issues and my support in architectural issues. At this point, the site superintendent Vittorio Vergalito was integrated in the team.

Castro also emphasized that this had been an exceptional team effort but (as with other projects in the office) under the natural leadership of an exceptional man, Dieste. Alberto Castro to Stanford Anderson, electronic communication, 5 June 2002. Dieste's recognition of Castro's and Romero's construction appears in Jiménez, ed., *Eladio Dieste*, 174. Vergalito was also a trusted collaborator, having long superintended the construction of Dieste's works.

15 Dieste, "Architecture and Construction," 188 of this volume.

16 Ibid.

17 Eladio Dieste, "Technology and Underdevelopment," in Jimenez, ed., *Eladio Dieste*, 261.

18 Dieste, "Architecture and Construction," 186 of this volume.

19 Dieste, "Art, People, Technocracy," 197 of this volume.

20 Eladio Dieste, quoted in Jiménez, ed., *Eladio Dieste*, 160.

without appeal to invented temporal imperatives. In the end, he was the author of innovations that are undeniably modern, socially responsible, and of high environmental quality.

Successively stepping down from these flights, consider a word that may still alarm the fastidious: form. Dieste introduced his essay "Architecture and Construction" with these words:

> [These] are reflections of an engineer who found in the process of building warehouses, he was creating architecture, even though that was not his object. He also found that he had an awareness of form and in confronting this awareness, he discovered that it helped him to solve problems that were strictly structural.[21]

Form is antecedent to Dieste's structural discoveries. I do not think he is referring to such knowledge as the structural efficiency of catenary curves; this is too well known in his discipline and too intimately related to structure to elucidate this passage. On the other hand, Dieste criticized the arbitrariness of architectural formalism, so his "awareness of form," though apparently susceptible to abstract exploration, is certainly part of a discipline. We are surely inserted once again in Dieste's "cosmic economy," but how can we understand this in a more concrete way?

A clue to answering this question appears in Dieste's comment, "If I had to synthesize what has driven our search, I would say that it is the perennial value of the surface itself."[22] "Surface" at first seems a dangerous word: "surface treatment," "surface coating," and the like suggest superficiality. We do not want to remain at the surface of a matter when it can be probed profoundly. Surely Dieste found something profound in the "perennial value of the surface," and it is here that he recognized a realm of formal exploration that could in turn solve structural problems.

Dieste rejected reliance on rectilinear frame systems.[23] He also resisted structural solutions that relied on two-dimensional curved forms such as arches and ribs.[24] Such approaches invited solutions based on additional material rather than on structural efficiency. To the contrary, Dieste's principal structural innovations relied on the efficacy of surfaces with particular formal properties. The simple curve of the self-supporting vaults allowed them to perform as beams. The S-shape 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 carefully detailed his buildings to facilitate the viewer's recognition of the literal and affective power of form. Simply examine again how the cantilever of a self-carrying vault terminates: so thin relative to the span that we think of line and surface rather than of mass.

The two vault systems that recur in Dieste's work deserve acclaim within his "awareness of form," but he had internalized these solutions so fully that he must have been thinking of still other formal explorations that helped him solve structural problems. I return to the planar beam and the folded roof plates of the Church of St. Peter. Planar forms can now be explored, but in assemblies where two or more planes work integrally to perform far beyond what they could achieve separately. The thickness of the walls and roofs is so slight relative to their extent that, again, we are inclined to think of them as surfaces. That reading is further motivated by the careful bonding and grouting of the bricks, turning the materiality of brick into elegant surfaces made evanescent by the effects of natural light.

21 Dieste, "Architecture and Construction," 182 of this volume.
22 Eladio Dieste, quoted in Jiménez, ed., *Eladio Dieste*, 218.
23 Dieste, "Architecture and Construction," 182 of this volume.
24 Eladio Dieste, in Jiménez, ed., *Eladio Dieste*, 218.
25 Alberto Petrina, "From the South," in Jiménez, ed., *Eladio Dieste*, 18.

Light, so effective in Dieste's most utilitarian buildings, is transcendent in St. Peter. The Argentinean architect Alberto Petrina gave a compelling appreciation of Dieste's use of light in the Church of Christ the Worker in Atlántida and, I would say most appropriately, of St. Peter:

> In these churches light is an irreplaceable ingredient without which the buildings would fall as if the structure had given way. Light is pulled toward the chosen points as if by a magnet; it is kneaded and mixed with the materials until it is part of them, it is exalted and transfigured. Light announces the Divine Presence, or at least simulates perfectly that presence.[25]

Ultimately, it is by the play of light on surfaces of material and structure, as well as by resisting through form, that Dieste achieves "a lightness, a mysterious ease, a concise simplicity, something like dance without effort or fatigue."