USING ALTERNATIVE RETAINING WALLS in Rebuilding the Freeway System in Atlanta

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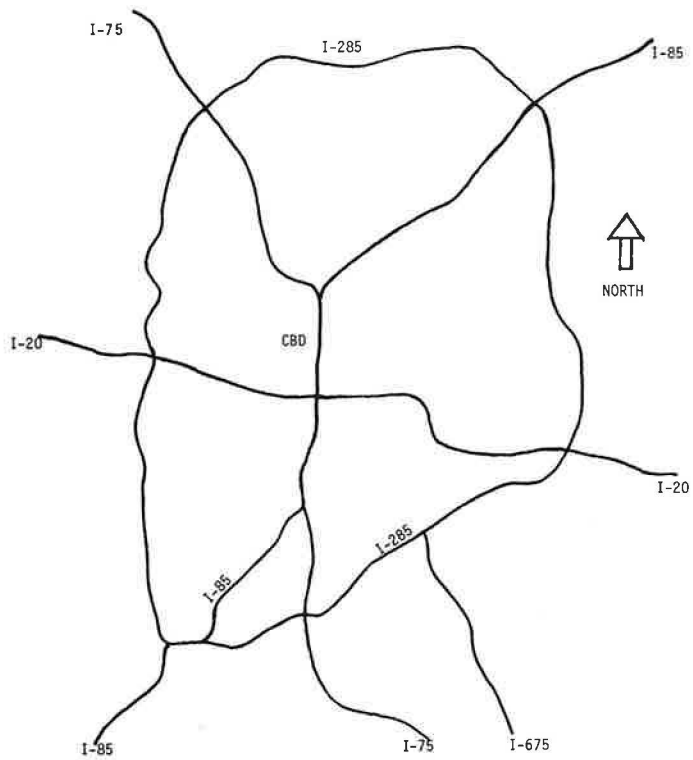
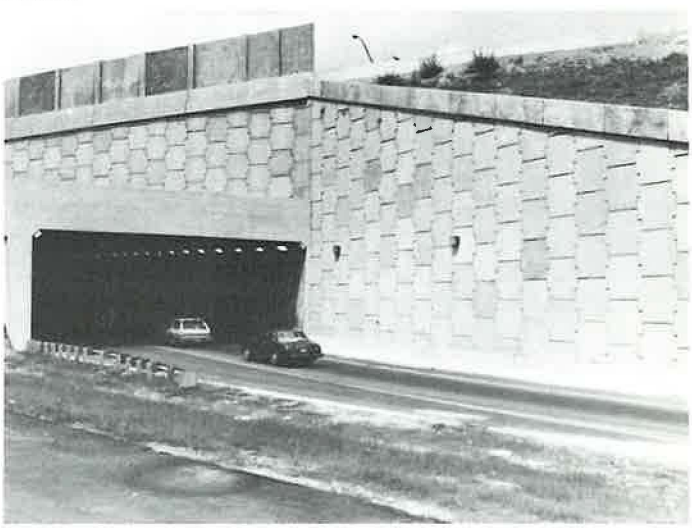


FIGURE 1 Atlanta freeway system.

FIGURE 2 RE wall detail supporting I-85, Atlanta.

FIGURE 3 RE wall and tunnel structure carrying ramp under I-85, Atlanta.



From 1974 to the present, the Georgia Department of Transportation (GDOT) has been involved in a major rebuilding of the freeway system in Atlanta. The freeway system consists of the circumferential Interstate route around the city: I-285, the existing portions of I-20, I-75, and I-85, and alignment for a new route I-675 (Figure 1). The rebuilding task began on the northeastern quadrant of I-285 and the northern portions of I-85.

As the preliminary engineering for projects proceeded inward toward the central business district (CBD), it became apparent that new approaches to the selection and construction of retaining walls would have to be considered if the GDOT was to meet its construction schedules and its other goals: (a) reduction of adverse project impacts and costs associated with right-of-way acquisition; (b) reduction of wall construction costs; (c) increasing the speed of plan preparation; and (d) increasing the speed of project construction.

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By the fall of 1984, the GDOT had let to contract approximately 2.8 million square feet (vertical wall face area) of alternative retaining wall types. This does not include walls built as conventional cast-in-place (CIP) construction. A conservative estimate of the savings associated with the use of alternative wall types in lieu of CIP construction is $34.7 million. These savings occurred during a period from spring 1979 to fall 1984.

AVAILABLE WALL TYPES

In the past few years, alternative retaining wall types have proliferated to the point that the GDOT has had difficulty in allotting the time to perform adequate technical evaluation for all walls offered by private vendors. This was not the case in the 1974-1979 period. Then, alternatives were limited to conventional CIP concrete wall construction and the Reinforced Earth (RE) wall, which is a proprietary product marketed by the Reinforced Earth Company of Arlington, Virginia. At that time, the RE wall was the only proprietary wall with a successful record of use.

Figures 2-4 show RE walls under construction in Atlanta. The RE wall consists of concrete facing panels, ribbed-strip earth reinforcing, and select backfill placed around the reinforcing strips. Other wall types available were rejected because they did not meet department goals and needs. From a technical standpoint, the department was required to select retaining wall types that have proven loading and design models and were constructed of proven materials.

When the offered wall type did not meet appropriate technical criteria, extensive evaluations were necessary. These evaluations were a laborious but profitable venture. With the introduction of the RE wall as an alternative to CIP construction, the average unit price of retaining walls dropped approximately $15 per square foot; average prices for walls bid in direct competition, based on contract bid prices, were approximately $60 per square foot for CIP construction and approximately $45 per square foot for the RE walls. These prices were for walls in moderate to very complicated urban settings. Additional significant price reduction accompanied the introduction of other alternative retaining walls.

FIGURE 4 RE walls and bridge abutments at Chamblee-Tucker Road and I-285, Atlanta.

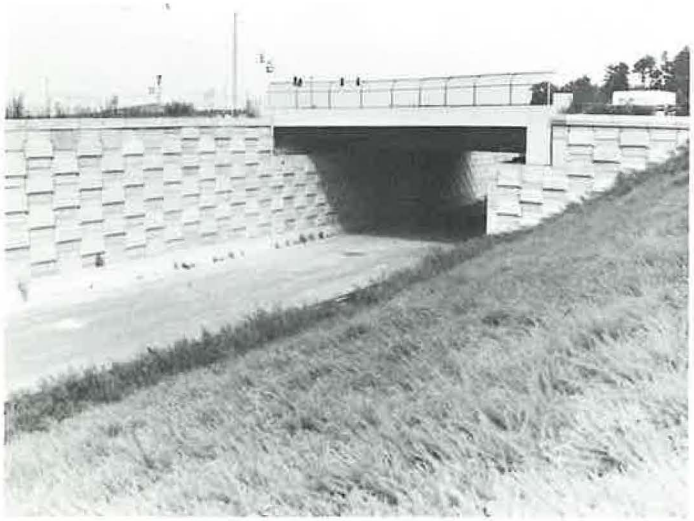


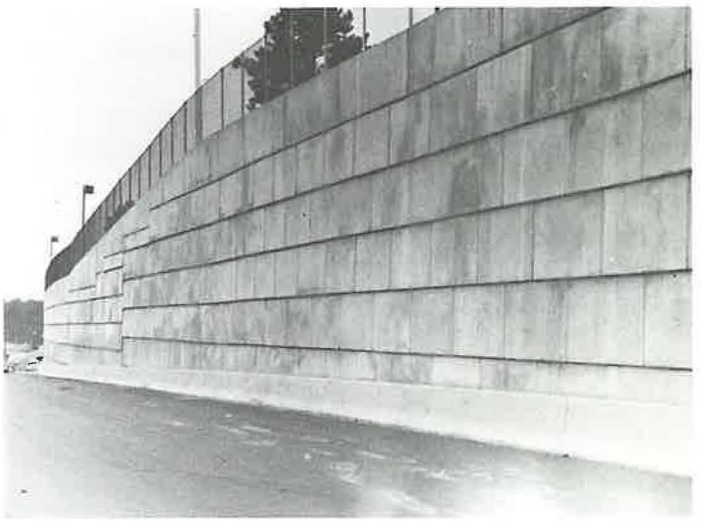
FIGURE 5 VSL wall supporting MARTA rail line over Piedmont Avenue, Atlanta.

Two alternative types of walls, both proprietary, were offered: the Retained Earth wall marketed by the VSL Corporation of Springfield, Virginia, and the Doublewal marketed by the Doublewal Corporation of Plainville, Connecticut. Figure 5 shows details of a VSL (retained earth) wall supporting a rail transit project near Piedmont Avenue. Figures 6 and 7 show typical details of Doublewal construction. The VSL wall as used in Atlanta consisted of concrete facing panels, welded wire reinforcing mesh, and select backfill placed around the mesh. The Doublewal consisted of large precast modules that are placed like building blocks and then backfilled with select material. The availability of these two types of walls contributed an element of competition. For example, $762,000 was saved at one site when the Doublewal was bid against an earth-anchored wall.

A desire for additional savings on alternative walls led the department to seek a more competitive, perhaps nonproprietary, product. This search focused on the California Department of Transportation, which had developed a wire-mesh, stabilized earth wall system. Because this system had an acceptable design model and an acceptable loading model and was constructed of materials with which the GDOT was familiar, the department was able to rapidly devise its own system—the Georgia Stabilized Embankment (GASE) wall. This system consists of a concrete-faced wall, stabilized with welded wire mesh. A high-quality backfill is used around the wire mesh.

Figures 8-10 show details of GASE walls under construction. With the introduction of the GASE wall, the average unit price for walls fell from $45 per square foot to $25 per square foot. Prices have risen somewhat in 1984, with the unit price falling within the range of $20 to $35 per square foot. The GASE wall, the RE wall, the VSL wall, and the Doublewal are commonly used for general wall construction, both cuts and fills.

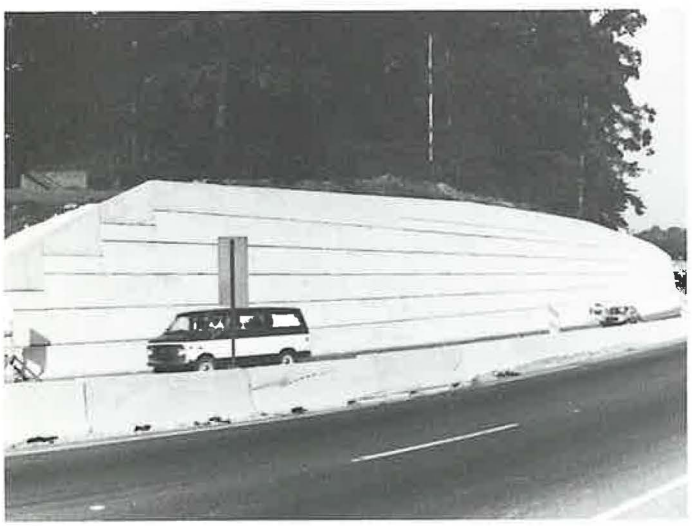
Two other nonproprietary types of walls have been used in Georgia for specialized purposes: the slurry wall and the earth-anchored wall. Technical ex-

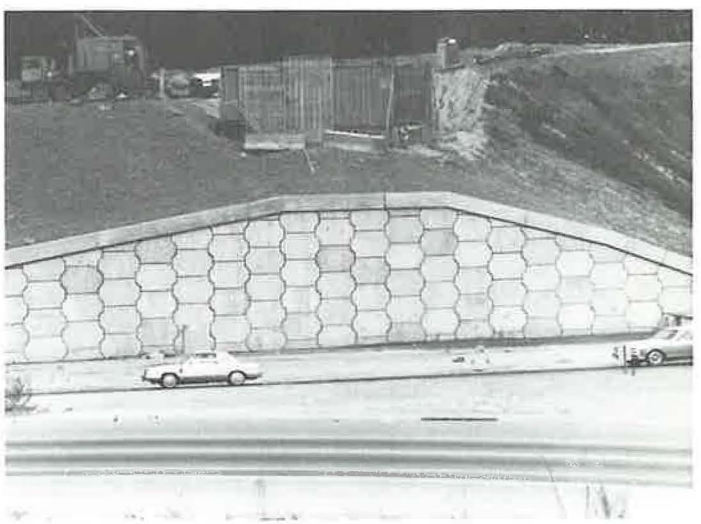


below
FIGURE 6 Doublewal construction near I-75 Northwest, Atlanta.

right
FIGURE 7 Doublewal retain cut near ramp on I-85 Northeast, Atlanta.

below right
FIGURE 8 GASE wall at I-85/I-285 interchange Northeast, Atlanta.





pertise to design and construct these walls was obtained through the Federal Highway Administration's demonstration projects. The slurry wall was used in one situation in which the department desired to control the groundwater level to protect nearby buildings. Figures 11 and 12 show the details of the strutted, slurry wall. A savings of $1,492,000 was realized when the slurry wall was bid against conventional CIP construction.

Earth-anchored walls have generally been used when the right-of-way necessary to construct less expensive types of walls could not be obtained. Owing to the very competitive bidding situation in Georgia, the unit bid price of the earth-anchored walls has dropped from approximately $60 per square foot to $28 per square foot on recent projects. Figures 13 and 14 show details of earth-anchored walls. The results of recent bidding experience for alternative walls in Atlanta are presented in Table 1.

TABLE 1 1984 Bid Prices—Georgia Project I-75-2(128) Ct. 34, Let 06/15/84

No. Walls	Type Walls	$/Square Feet	Square Feet
18	RE	32.74	81,507
29	GASE	29.61	196,028
2	Earth-Anchored	27.08	67,321
49			344,856

SELECTION AND DESIGN PROCESS

In general, the GDOT selected wall types for a given site on the basis of site conditions and cost experience. There were differences in the manner in which plans for proprietary and nonproprietary walls were prepared. The department, or its consultant, prepared all plans and was responsible for the design of the internal and external stability of the GASE wall. The slurry and earth-anchored walls were usually bid as a contractor design and construct case. GDOT prepared conceptual plans, which consist of plan and profile sheets and a contract special provision that includes design criteria, materials specifications, and construction requirements.

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FIGURE 9 GASE wall abutment at I-85/I-285 interchange Southwest, Atlanta.

below left
FIGURE 10 GASE wall abutment with acute angle details, I-85/I-285 Southwest, Atlanta.

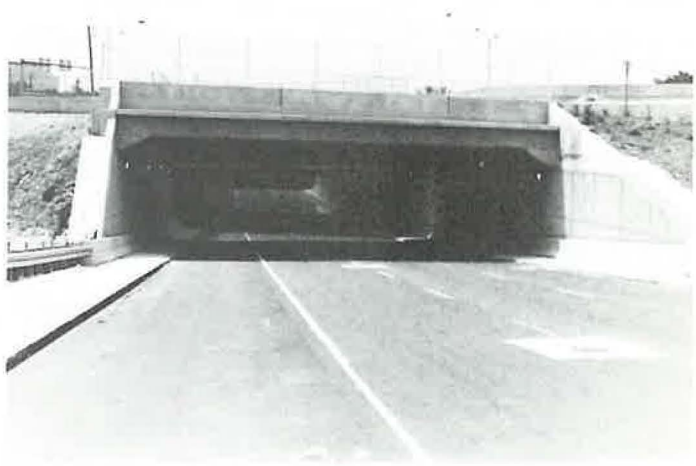

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FIGURE 11 Strutted, slurry wall, I-75, Atlanta.

In contrast, the contract special provision for the GASE wall contained only materials specifications and construction requirements. The department pays the Reinforced Earth Company a small royalty fee on GASE walls constructed in the Atlanta region.

Proprietary walls were selected, designed, and prepared in a different manner than the nonproprietary walls. The vendors of the three proprietary walls (VSL, RE, and Doublewal) were offered the opportunity to prepare detailed plans for inclusion in the department's contracts. The vendors had the choice of accepting or rejecting the offer. Acceptance by the vendor of the offer to participate in a given contract required the vendor to gather all site data, design the wall for internal stability, and prepare detailed plans for review by the department. The design model for internal stability was approved before offering the vendor an opportunity to participate. After review by the GDOT, the vendor-prepared plans and a special provision for materials and construction requirements were included in the contract documents. The department checked the external stability of all wall sites.

By allowing the vendors to prepare the detailed site plans, the department saved a considerable amount of engineering manpower and time. Obviously, the cost of this service was included in the ultimate price of the product. However, in the existing competitive market for these retaining walls, the overall unit price remained at reasonable levels. This is not to say that developing the procedures to control the process of allowing vendor-prepared plans was without effort. The GDOT developed the procedures provided to each vendor. These procedures defined plan requirements and methods by which compatibility between wall plans and roadway plans was ensured.

All retaining walls were bid competitively on a site-by-site basis. Acceptance of walls was determined by the overall low bid for the project. When the GDOT first allowed proprietary walls as alternatives, conventional CIP construction was always offered as one of the options. Currently CIP construction is almost never offered. In 6 years of bidding experience, CIP construction has not been cost competitive in the fierce contest among the various proprietary and nonproprietary systems. The GASE wall is cost competitive with all the proprietary systems. The design and loading models are controlled by the GDOT. Marketing and manufacturing of the components is not restricted and is currently handled by several local companies. This competitive situation is being constantly reviewed by the department. If conditions change, then CIP construction would be used to ensure competition.

CONSTRUCTION

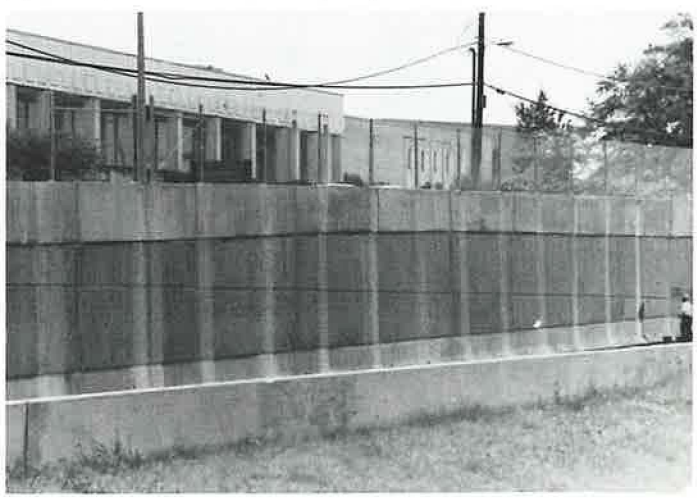
The GASE wall, the RE wall, the VSL wall, and the Doublewal were bid competitively on all cut-and-fill sites when right-of-way was available. The other systems were used in locations that required much more unusual construction methods.

The rate of construction, measured in square feet of wall-facing surface area, was approximately the same for the RE, VSL, GASE, and Doublewal systems. After the first course was leveled and in place, the rate of construction was rapid. Rates of construction vary among crews, ranging from 300 to 600 square feet per 8-hour day per crew, typically totaling 500 square feet per day. This rate is the equivalent of the construction of about 20 GASE wall panels, including the associated backfill and stabilizing materials. This far exceeds that which could be reasonably attained by means of CIP construction. In addition, the problems associated with forming, pouring, curing, and the related timing problems were eliminated from the construction cycle at the site.

The construction rates for the earth-

FIGURE 12 Strutted, slurry wall carrying depressed I-75 ramp, Atlanta.

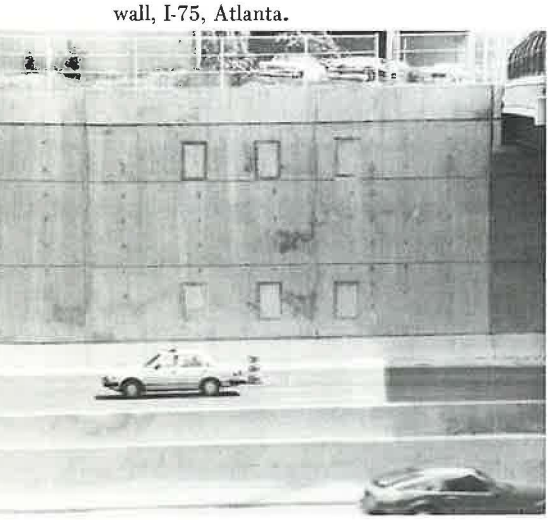
FIGURE 13 Earth-anchored wall, I-85, Atlanta.



anchored walls are not directly comparable to the rates mentioned above. These walls are stage constructed. Starting at the existing ground elevation, soldier piles are driven, and the excavations are made down to the first anchor level. Anchors are installed and excavation continues as lagging is placed between the soldier piles. When the bottom of the wall is reached, a vertical reinforced concrete facing is cast as a permanent earth retainer between the soldier piles. However, before the CIP facing is placed, other construction at the site can take place, because the earth cut is stabilized when the lagging and anchor systems are complete. This phase of the construction can be accomplished rapidly. Therefore, this type of construction has proven to be effective in meeting the department's needs at sites where right-of-way could not be obtained at a reasonable price or without unacceptable disruption of existing development. Underground easements were required.

The Doublewal system has also proven to be effective at sites where right-of-way was difficult to obtain. In the past, this system has been less costly than the earth-anchored walls. The GDOT has built several urban projects that required a ramp to be placed under the spill-through end-span of a bridge.

FIGURE 14 Instrumented earth-anchored wall, I-75, Atlanta.



The sites were excavated and the large Doublewal modules were then placed and backfilled.

Only one slurry wall has been used in Atlanta. As previously noted, this application saved the department a considerable sum of money and also met the site requirement for providing a cut-off wall for the ground water table. This project used a strutted wall configuration to provide a depressed ramp near the CBD of Atlanta (Figure 12).

CURRENT RESEARCH

The GDOT has two research projects on wall types constructed in Atlanta: an earth-anchored wall project near Fifth Street at I-75, and a GASE wall project supporting a ramp off I-75 near Northside Drive.

The anchored wall project involved the first application of this technology in the state. The wall was fully instrumented; the anchors, the wall facing, and various points on the roadway surface above the wall were monitored for movement. The wall, and all its components, responded as expected. The design model and the contract special provisions were subsequently used on several other projects.

The instrumented GASE wall was 54 feet high, which is the highest wall of this type built to date. Instrumentation was placed on the stabilizing mesh and on the connection between the mesh and the concrete facing. Load cells were placed at the bottom of the wall and at the back of the wall between the select backfill and the natural foundation soil. The assumptions used for the design model proved to be quite conservative. The design model and the project special provisions are being used with increased confidence.

SUMMARY

The extensive use of alternative retaining walls met the four objectives of the GDOT. The first objective was the reduction of the adverse impact of right-of-way purchase in an urban area. The department has constructed approximately 2.8 million square feet of alternative retaining walls with an approximate cost of $96.8 million. The use of alternative wall types reduced construction time and hence the time during which adjacent property was affected. The selection of appropriate wall types, such as earth-anchored walls and the Doublewal, actually reduced the amount of right-of-way that needed to be purchased.

The second goal involved the reduction of the cost of the actual wall construction. The average unit cost of wall construction dropped from $60 per square foot to a current range of $20 to $35 per square foot. Estimates of cost savings are $34.7 million for a period from 1979 to fall 1984. In addition, preliminary engineering costs and time were reduced.

The third goal was to speed up plan preparation. Because the GDOT did not have to prepare the wall plans with its own personnel, plans for appropriate alternatives at reduced costs were obtained more rapidly. This allowed the department to obtain the plans for as many alternative retaining walls as deemed necessary and still stay on a fast-track schedule for the preliminary engineering.

The fourth and final goal involved the speed of project construction. A construction rate of 500 square feet of vertical surface area per 8-hour day per crew is a reasonable figure for the construction of the alternative wall types. This rate far exceeds the rate possible for conventional CIP wall construction.

Although not stated as a specific objective, technical adequacy of the design and loading models for the various wall types was absolutely essential. This objective was met owing to considerable diligence on the part of the GDOT personnel.