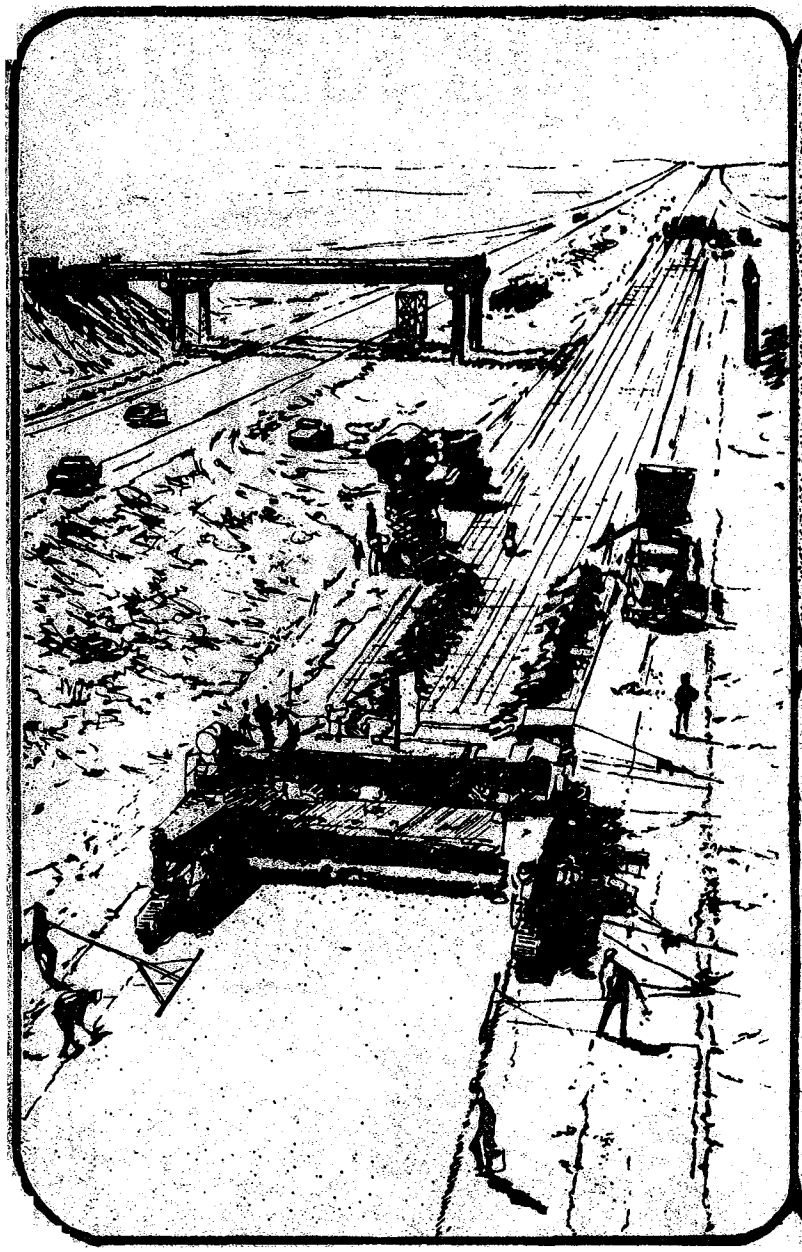
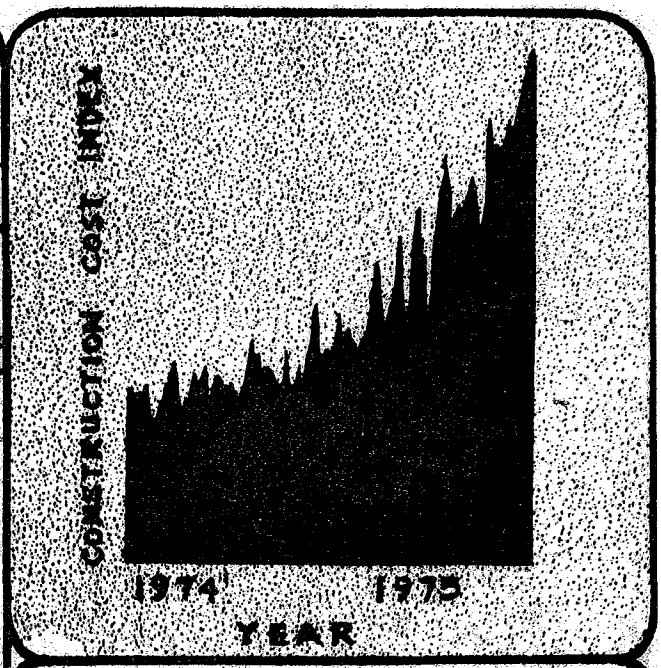
ENGINEERING ECONOMY AND ENERGY CONSIDERATIONS

INCIDENTAL COSTS DURING CONSTRUCTION

RESEARCH REPORT 214-5

DECEMBER, 1975





COOPERATIVE RESEARCH PROJECT
2-9-74-214

"ENGINEERING, ECONOMY AND ENERGY CONSIDERATIONS IN DESIGN, CONSTRUCTION AND MATERIALS"

TEXAS STATE DEPARTMENT
OF HIGHWAYS
AND PUBLIC TRANSPORTATION

AND

TEXAS TRANSPORTATION INSTITUTE
TEXAS A&M UNIVERSITY

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

TASK FORCE ON ENGINEERING, ECONOMY AND ENERGY CONSIDERATIONS

Larry G. Walker, Task Force Chairman and Materials and Tests Engineer

Charles H. Hughes, Sr., Study Contact Representative and Assistant Materials and Tests Engineer

H.L. Arno, Engineer, Secondary Roads

Paul H. Coleman, District Engineer

Wayne Henneberger, Bridge Engineer

Robert L. Lewis, Chief Engineer, Highway Design

Archie J. Sherrod, Chief Engineer, Maintenance and Operations

J.R. Stone, District Engineer

William V. Ward, Urban Project Engineer-Manager

Phillip L. Wilson, State Planning Engineer

Franklin C. Young, District Engineer

Theodore E. Ziller, Construction Engineer

TEXAS TRANSPORTATION INSTITUTE

W. Frank McFarland, Study Supervisor and Transportation Economics and Sociology Program Manager

Jon Epps, Natural Materials Program Manager

Ronald Holder, Transportation Operations Program Manager

INCIDENTAL COSTS DURING CONSTRUCTION

By
Jack Lamkin
and
W. F. McFarland

Introduction

Incidental costs during construction, including costs of job cleanup and aesthetic treatments, range from two to four percent of total construction costs on many highway projects. Even though this percentage is relatively small, present money restraints necessitate careful study of the benefits and costs of such incidental activities, especially those that give only temporary or minimally-observed benefits. By minimizing temporary treatments, but continuing to allocate some funds to permanent aesthetics, it should be possible to reduce costs without severely reducing permanent aesthetics. Even though the cost savings on any specific job will be small, total statewide savings could be meaningful.

Job Cleanup

The principal incidental costs occuring during construction are those related to "cleaning up the job." Some of this activity is temporary and some is permanent, and it is often difficult to make a distinction. Nevertheless, costs can be lowered by reducing temporary maintenance during construction. Judgment is extremely critical in separating those items that are temporary from those that are permanent, since it is often a matter of degree, but general guidelines can be given.

Contractors sometimes are required to clean tire and skid marks from curbs, from concrete median barriers, and from concrete pavements. Often this is required only if the marks are made by the contractors' equipment. This

is temporary maintenance, in the sense that other tire marks are made after the facility is opened. Project costs can be reduced by eliminating or reducing this as a requirement.

Contractors are required to pick up trash and clean up the job site several times on many projects. In addition, contractors sometimes are required to mow the right-of-way during construction. These operations are costly, and to the extent possible, should be done only at the end of the job. Required job cleanup is especially costly if it disrupts the main construction effort. A certain amount of "housekeeping" and neatness probably increases worker morale and efficiency and also may help public relations. Also, some cleanup activities are required by the contractor's insurance carrier and by OSHA inspectors. Especially at structure sites, there is no alternative but to require periodic cleanup--even if on a daily basis. OSHA requirements do not leave this to the contractor's discretion; it must be done to insure job safety. An attractive job site is most important for facilities near populated areas of that are highly visible to the traveling public. Therefore, judgements pertaining to job cleanup are especially critical.

Another area where judgment is critical is in controlling erosion, cleaning eroded areas, and cleaning drains. The best rule again is to require those activities that affect permanent aesthetics and maintenance and minimize those activities that provide only temporary maintenance. Frequently, culverts and outfalls become inoperative due to eroded material and it is necessary to insist that the contractor immediately clean out these areas to avoid damage to adjacent property. Unless there is such danger to adjacent property, it

is not necessary to clean out these structures or outfalls until just prior to final inspection. Drains should be cleaned to the point where water will run to natural conditions, but requiring that drains be cleaned perfectly (which will be "ruined" by the first rain after job acceptance) is costly and often of dubious value.

Probably the most costly of all cleanup procedures in some areas is the correcting of "washes" and ruts created by erosion; particularly in the past few years with the frequent heavy rains. Often, the same area may be corrected several times prior to final inspection. An alternative to this type of clean-up is to place retards and silting basins at frequent intervals, but these are also quite expensive. Another cleanup item is draining water from low places. This activity should be held to a minimum if only minor temporary benefits are gained.

Contractors indicate that from two to four percent of the cost of many projects is for incidental items, including cleanup. One contractor roughly estimates cleanup cost at 10¢ per square yard of right of way. Some of this activity gives permanent results and some is temporary. If temporary maintenance and cleanups can be reduced, it may be possible to save significant amounts of money on many jobs (See Table 1).

Finishing Structures

Contractors indicate that it costs about 15¢ per square foot to prepare a structure for Tex-cote and about 25¢ per square foot for the Tex-cote, for a total cost per square foot of about 40¢. Double rubbing probably costs more than Tex-cote with minimal pre-rubbing. Double rubbing probably costs more than 50¢ per square foot, and some contractors estimate costs of up to $1.25 per square foot. There are some indications that Tex-cote finishes abnormally

TABLE 1: JOB CLEAN-UP

	TYPE OF JOB CLEAN-UP ACTIVITY	COST	COMMENTS	SUGGESTED ACTION
1.	CONTROLLING EROSION.	IN CONTRACTOR BEST INTEREST TO CONTROL EROSION AT JOB SITE.	MAJOR BENEFIT TO CONTRACTOR FROM EROSION CONTROL.	LEGAL REQUIREMENT AND JUDGMENT MUST BE USED TO DETERMINE EXTENT OF THIS ACTIVITY. LONG-RUN EFFECTS ARE THE PRIMARY CONCERN, SO LONG AS THERE IS NO ADVERSE ENVIRONMENTAL EFFECT.
2.	CLEARING ERODED MATERIALS AND CLEARING WATER FROM LOW AREAS.	EXPENSIVE FOR CONTRACTOR, CAN MINIMIZE ACTIVITY BY CONTROLLING EROSION.	CONTRACTORS REPORTED CLEANING CURBS AND GUTTERS SEVERAL TIMES BEFORE FINAL ACCEPTANCE. ONE CLEAN-UP AFTER JOB COMPLETION SHOULD BE SUFFICIENT.	SIMILAR TO ABOVE. MINIMIZE TEMPORARY MAINTENANCE AND PROMOTE THAT WITH LONG-TERM BENEFITS. FOR THIS AND PRECEDING ITEM, TO THE EXTENT POSSIBLE, CONTRACT PLANS, SPECIFICATION AND SPECIAL PROVISIONS SHOULD CONTAIN DETAIL DESIGN SHEETS FOR ALL TEMPORARY AND PERMANENT POLLUTION AND EROSION CONTROL MEASURES AND BID ITEMS PROVIDED FOR EACH. ALTHOUGH MANY ITEMS MAY NOT BE NEEDED, BIDDERS SHOULD BE MADE AWARE OF WHAT WILL BE REQUIRED AND WHAT THEY WILL BE PAID FOR EACH.
3.	CLEANING DRAINS.	1½¢ PER INCH OF DIAMETER PER FOOT (NORMAL CLEANING). MAY BE REPETITIVE FUNCTION.	THIS ACTIVITY MAY BECOME A REPETITIVE TYPE FUNCTION WITH LITTLE IF ANY LONG TERM BENEFITS PROVIDED JOB SPECIFICATIONS FOLLOWED. CONTRACTORS REPORT CLEANING DRAINS SEVERAL TIMES PRIOR TO FINAL ACCEPTANCE BY STATE.	SHOULD BE PERFORMED ONCE AT THE END OF JOB UNLESS CIRCUMSTANCES WARRANT AND/OR NECESSITATE DRAIN CLEANING DUE TO CLOGGED CONDITION. AFTER SECTION OPEN TO TRAFFIC THIS ACTIVITY SHOULD NOT BE CONTRACTOR FUNCTION.
4.	CLEARING BRUSH.	PAY ITEM IN BID.	EXPENSIVE ITEM, ESPECIALLY IN URBAN AREAS, WHERE BURNING IS PROHIBITED AND MUST BE HAULED TO DUMP.	MAY BE PERFORMED AT LEAST PARTIALLY IN ADVANCE OF CONTRACT WORK BY STATE FORCES TO REDUCE CONTRACT TIME (REDUCING LENGTH OF CONTRACT REDUCES UNCERTAINTY) AND TO ALLOW BETTER PRE-CONTRACT INSPECTION OF JOB SITE BY DEPARTMENT AND CONTRACTORS. SOME CLEARING OF BRUSH MAY BE ENTIRELY OMITTED ON WIDE RIGHTS-OF-WAY, AWAY FROM TRAFFIC LANES (REDUCES COST, IMPROVES AESTHETICS, PROMOTES WILDLIFE).
5.	MAINTAINING ORDERLY JOB SITE.	IN CONTRACTORS BEST INTEREST.	CONTRACTOR SHOULD HAVE AN ORDERLY, WELL-MANAGED JOB SITE. SAFETY ASPECTS INVOLVED IN MAINTAINING ORDERLY JOB SITE.	MAINTAINING AN ORDERLY JOB SITE MAINLY SHOULD BE LEFT UP TO THE CONTRACTOR EXCEPT AS IT AFFECTS MOTORIST SAFETY OR PROMOTES AESTHETIC APPEARANCE TO NEARBY POPULATION AND MOTORISTS.
6.	CLEANING TIRE AND SKID MARKS FROM CURBS, CONCRETE MEDIAN BARRIERS, AND CONCRETE PAVEMENT SURFACES.	5-20¢ PER LINEAR FOOT.	CONTRACTOR SHOULD NOT BE HELD ACCOUNTABLE FOR REMOVING TIRE AND SKID MARKS FROM CURBS, CONCRETE MEDIANS, ETC. AFTER JOB IS OPEN TO TRAFFIC BUT BEFORE ACCEPTANCE BY STATE.	THIS ACTIVITY SHOULD BE HELD TO A MINIMUM CONSISTENT WITH SAFETY AND LONG-TERM BENEFITS.
7.	PICKING UP TRASH.	CONTRACTORS BEST INTEREST TO MAINTAIN ATTRACTIVE JOB SITE BUT SHOULD NOT BE "DAILY" ACTIVITY EXPERIENCE.	CONTRACTOR SHOULD HAVE AN ORDERLY, WELL-MANAGED JOB SITE. AREA OF EXPERIENCE AND JUDGMENT FOR INSPECTORS.	EXCEPT NEAR POPULATED AREAS AND FOR FACILITIES NEAR TRAVELED WAYS, THIS ACTIVITY SHOULD BE REQUIRED ONLY ONCE PRIOR TO JOB ACCEPTANCE.
8.	FILLING IN RUTS IN SIDE SLOPES.	7-10¢ PER SQUARE YARD TO HAND RAKE AFTER FINISH BUT PRIOR TO ACCEPTANCE.	MAY BE DONE SEVERAL TIMES.	EARLIER ACCEPTANCE OF COMPLETED WORK AND MAINTAINANCE WITH STATE FORCES SHOULD SPEED UP WORK AND MIGHT REDUCE OVERALL COST. JUDGEMENT SHOULD BE GEARED TOWARD REASONABLE COMPLIANCE.

increase the maintenance cost of structures, if there is an attempt to maintain the initial appearance over time. Nevertheless, if a good finish is necessary, the Tex-cote finish probably is less expensive if pre-rubbing is held to a minimum. Also, this cost can be reduced by specifying thin coatings.

In urban areas, it would appear that cost savings can be made by requiring minimal rubbing, together with thin coatings of concrete finishes such as Tex-coat, on outside surfaces of structures. Also, there does not appear to be any meaningful benefit (other than aesthetics) from filling air bubbles on beams before final spray finishing. On surfaces that are not normally exposed to direct view, finishing should be limited to plugging tie holes and honeycombed areas and removing fins or other protrusions. Rubbing the surface with a wet sponge soaked in thin, watery cement grout should provide enough "finish," if a finish is desired.

In rural areas, any surfaces not in direct view of the driving public can be finished sufficiently by:

(1) plugging tie holes and honeycombed areas and removing fins and protrusions, and

(2) rubbing the surface one time with a sponge soaked in watery cement grout.

An even less expensive finish can be provided by only plugging tie holes and honeycombed areas. Some buildings and concrete walls in urban areas now use prestressed concrete slabs with form marks and fins as aesthetic features. There does not appear to be any significant disadvantage to doing the same for highway structure surfaces in rural areas that are not viewed by the driving public, so long as the contractor is fully aware that use of such a "finish" does not imply that sloppy forming and construction techniques are allowed.

The cost of finishing concrete median barriers with organic finishes is around $1.50 to $2.00 per linear foot. Most of this cost can be saved by spot

TABLE 2: FINISHING CONCRETE SURFACES

	TYPE OF FINISH	ESTIMATED COST	COMMENT	SUGGESTED USE
1.	PLUGGING TIE HOLES AND HONEYCOMBING.	UP TO 3¢ PER SQUARE FOOT OF TOTAL AREA.	USUALLY CONSIDERED TO BE NECESSARY ACTIVITY.	ABSOLUTE MINIMUM FOR ALL STRUCTURES.
2.	REMOVING FINS AND PROTRUSIONS	UP TO 5¢ PER SQUARE FOOT OF TOTAL AREA.	USUALLY CONSIDERED TO BE ESSENTIAL STEP PRIOR TO FURTHER FINISH WORK. ALSO MAY PROMOTE SAFETY IF AREA MAY BE HIT BY VEHICLE.	RECOMMENDED FOR ALL EXPOSED, HIGHLY VISIBLE SURFACES. MAY BE LEFT ON "UNSEEN" SURFACES WHERE IF RUSTIC APPEARANCE IS ACCEPTABLE, ESPECIALLY ON LOW-VOLUME RURAL ROADS.
3.	RUBBING OF FORM MARKS AND OTHER ROUGH AREAS.	10-20¢ PER SQUARE FOOT.	STEP PRECEDING 5 OR 6 BELOW. ALSO CAN BE PRIOR TO STEP 4 BELOW. GIVES SMOOTH UNIFORM APPEARANCE TO AREAS THAT MIGHT OTHERWISE DISTRACT MOTORISTS.	MINIMAL TREATMENT FOR VISIBLE AREAS WHERE UNIFORM APPEARANCE IS CONSIDERED NECESSARY. MAY BE OMITTED, HOWEVER, PRIOR TO USE OF ORGANIC FINISHES, IF SURFACES ARE FAIRLY UNIFORM - SUCH AS WITH PRECAST ITEMS AND SLIP FORM CONCRETE MEDIAN BARRIERS.
4.	RUBBING SURFACES WITH SPONGE SOAKED IN CEMENT GROUT (ONE TIME).	UP TO 5¢ PER SQUARE FOOT (AFTER STEP 3).	HELPS GIVE A MORE UNIFORM INITIAL APPEARANCE.	ACCEPTABLE FOR EXPOSED, VISIBLE AREAS AFTER STEP 3. OPTIONAL FOR NON-EXPOSED AREAS AFTER STEP 2. ACCEPTABLE FOR GIVING UNIFORM APPEARANCE TO CONCRETE MEDIAN BARRIERS.
5.	APPLICATION OF CONCRETE COATING WITH ORGANIC FINISH.	20-30¢ PER SQUARE FOOT (AFTER STEP 3).	HIGHLY ADHESIVE, RELATIVELY LONG LASTING. GIVES UNIFORMITY OF APPEARANCE, VARIED COLOR SCHEMES AVAILABLE, REFLECTIVENESS MAY PROMOTE SAFETY. LESS EXPENSIVE THAN FINE, DETAILED DOUBLE RUBBING. HAVE SHOWN RESISTANCE TO WATER PENETRATION. REQUIRES COSTLY FUTURE MAINTENANCE TO MAINTAIN INITIAL APPEARANCE.	GOOD FOR EXPOSED, HIGHLY VISIBLE SURFACES IN URBAN AREAS AND HIGH-VOLUME RURAL ROADWAYS. THINNER COATINGS THAN CURRENTLY USED MAY BE ACCEPTABLE. MAY PROMOTE SAFETY IF VISIBILITY OF STRUCTURES, AND ESPECIALLY MEDIAN BARRIERS IS INCREASED.
6.	FINE, DETAILED RUBBING.	35¢ PER SQUARE FOOT (AFTER STEP 3 ABOVE).	LIKE CONCRETE COATINGS, THE APPEARANCE DETERIORATES OVER TIME. GIVES STRUCTURE A GOOD, UNIFORM FINISHED APPEARANCE. PROBABLY MORE COSTLY THAN COATINGS. LABOR REQUIREMENT IS A PROBLEM FOR CONTRACTORS USING THIS FINISH.	GOOD FOR EXPOSED, HIGHLY VISIBLE SURFACES IN URBAN AREAS AND HIGH-VOLUME RURAL ROADWAYS. MAY PROMOTE SAFETY IF VISIBILITY OF STRUCTURES, AND ESPECIALLY MEDIAN BARRIERS IS INCREASED.

rubbing with watery cement grout. So long as the "finish" is uniform, there does not appear to be any particular long-term advantage to the use of organic or hand-rubbed finishes (as opposed to being able to construct more median barriers with the money saved by not applying expensive finishes to existing barriers). An exception to this is that a good finish, especially organic coatings on median barriers, may temporarily make structures more visible, less tiring to the eye, and thus more safe--especially if they are near the traveled lanes.

The alternative of using exposed aggregate on retaining walls and other structure surfaces costs approximately $150 per cubic yard as compared to approximately $90 per cubic yard for conventional finishing of such structures. Alternatively, the extra cost of exposed aggregate can be estimated at 15¢ to 20¢ per square foot of surface.

Corrugated concrete riprap is very expensive to finish and the Department probably should continue the current practice of not using it. Also, construction of retaining walls with sandblasted plywood panels, to produce a herring-bone-surface finish, is "very expensive" and the benefits of such a finish should be carefully weighed against the increased cost.

Summary

Between two and four percent of the cost of many projects is for incidental items, including finishing structures and job cleanup, mostly the latter. Part of this cost provides long-term benefits but part is for temporary and minimally observed aesthetics. By emphasizing aesthetics that are permanent and highly visible and by minimizing temporary maintenance and minimally observed aesthetics, project costs can be reduced. Suggestions to consider are:

- Reduce requirements for cleaning tire and skid marks from concrete curbs, median barriers, and pavements.

- Reduce requirements for picking up trash to one time at end of construction except on "highly visible" projects.
- Use reasonable requirements in controlling erosion, cleaning away eroded material, and cleaning drains, with emphasis on permanent conditions.
- Minimize requirements for cleaning water from low places.
- Use reasonable requirements for filling ruts, especially those not caused by the contractor and occurring on completed sections of roadway.
- In urban areas, the cost of finishing of concrete structures can be reduced by only finishing surfaces that are exposed to direct view. Use of thin coatings, such as Tex-cote after minimal rubbing is probably the least expensive way to achieve a good finish. Nonexposed surfaces in urban and rural areas are low priority for finishing, and consideration should be given to using minimal finish.

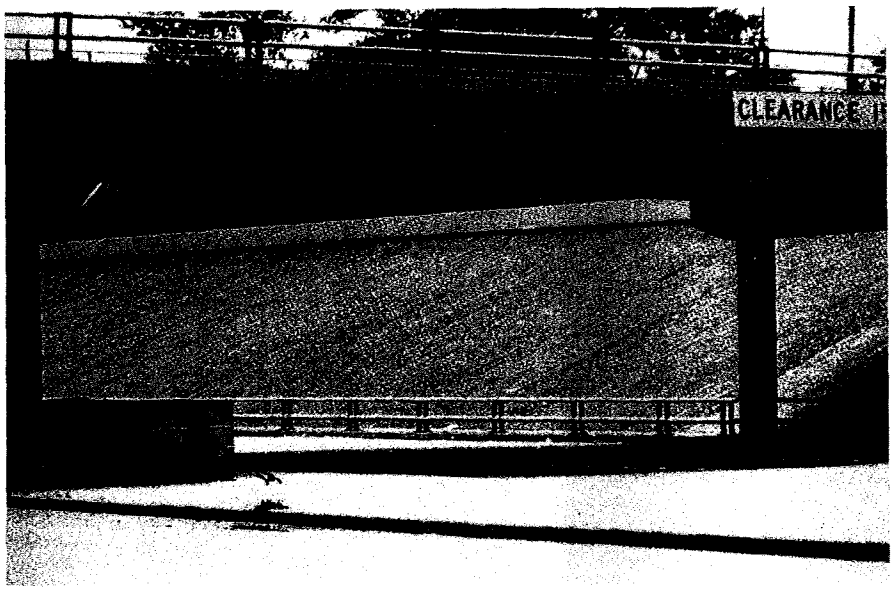


FIGURE 1

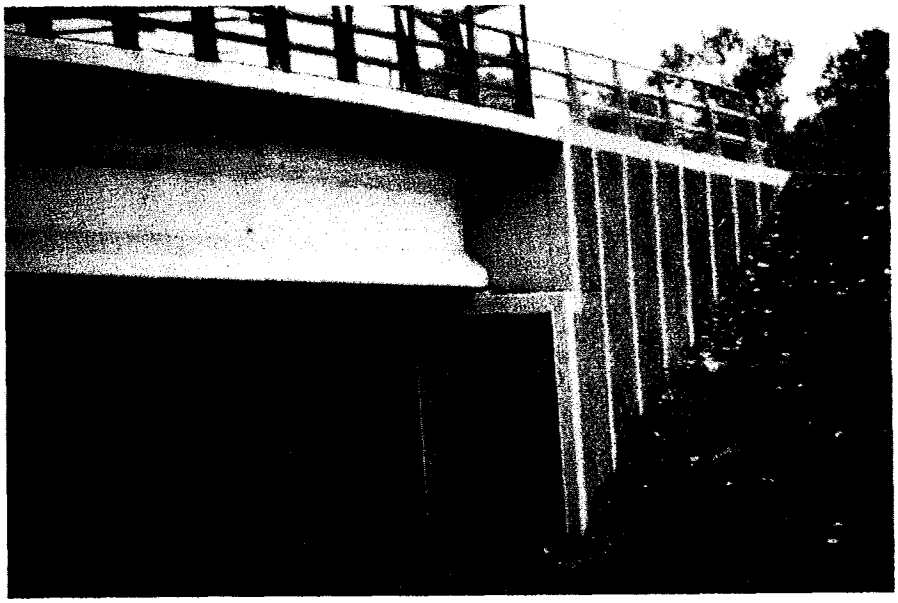


FIGURE 2

Figures 1 and 2 illustrate some long term aesthetic treatments used in highway construction. These tend to enhance the facility and increase public awareness and acceptance of urban freeway construction.

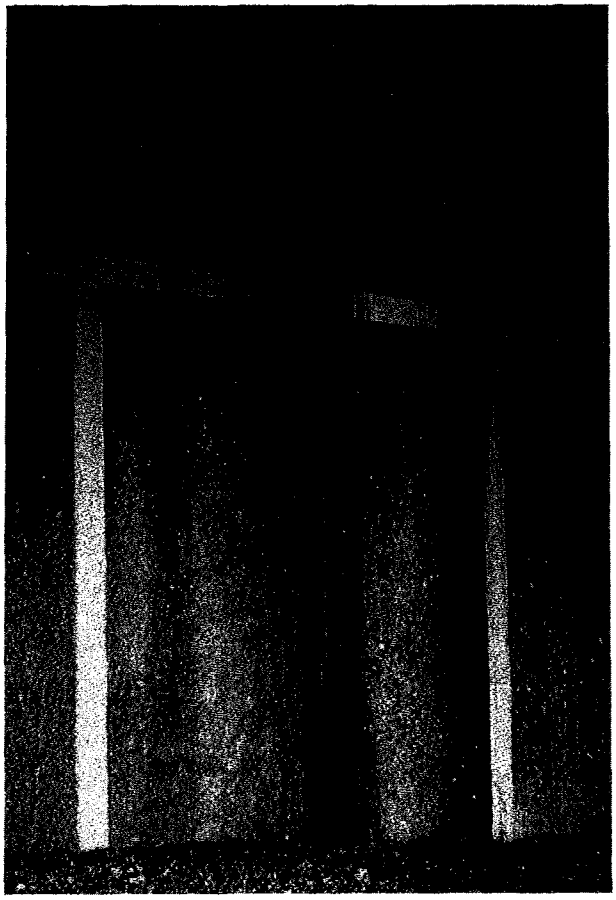


FIGURE 3

Investments in permanent aesthetics, however, should be maintained for positive public awareness. The exposed aggregate panel in Figure 3 has been stained by highway run off. Alternative construction design should be considered for those areas with limited public visibility. Exposed aggregate costs approximately two-thirds more than conventional methods.

Figure 4 shows a curb and gutter after clean up by contractor. This facility, open to the public for several months, was in the process of being sold. Clean up has been previously done on this segment. It is important from a cost reduction view to minimize clean up activities. However, public awareness and acceptance must be considered.

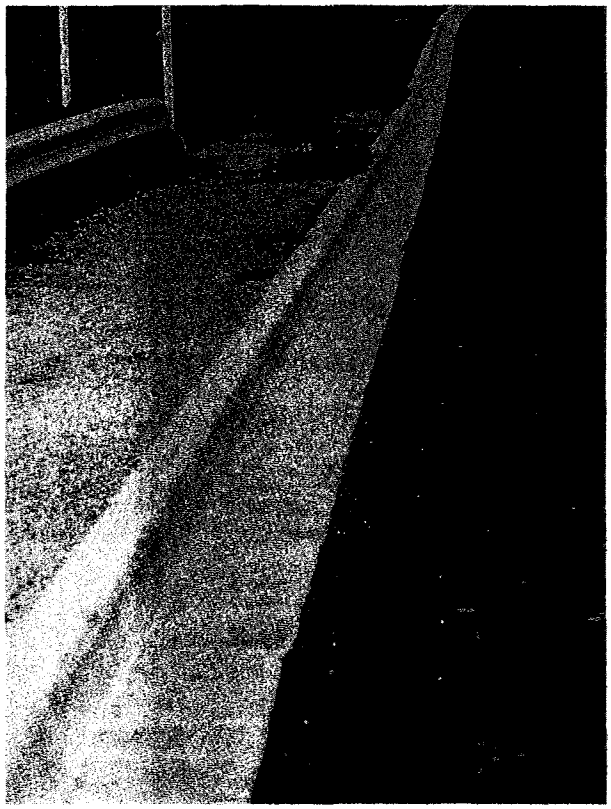


FIGURE 4

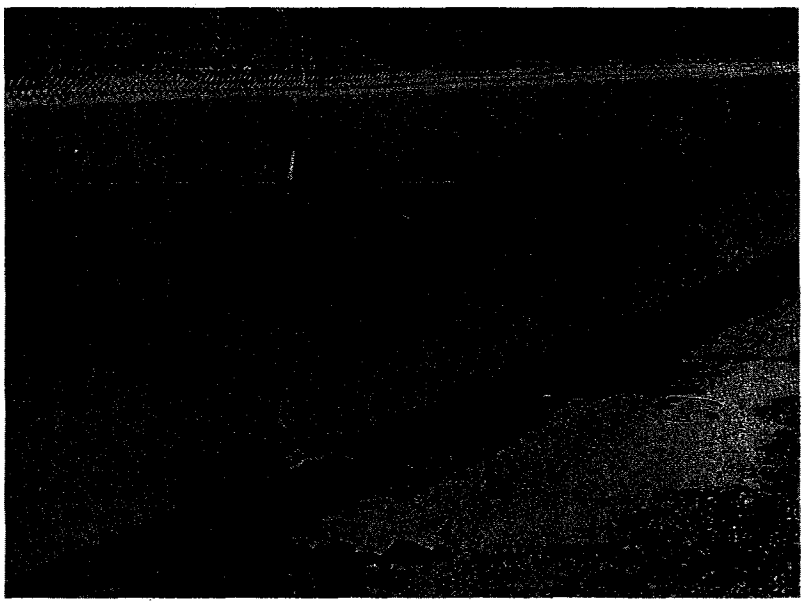


FIGURE 5

This facility, currently under traffic, has not been sold to the state. The area near the median barrier will be cleaned up; however, repetitive clean ups increase construction cost.

FIGURE 6

Funds spent in clean up activities on this facility will increase public acceptance. This facility is not currently open to the public. Judgement factors will determine when and how many times this facility will be cleaned prior to acceptance.

This drain grate will have to be cleaned often in order to function properly. This is an example of where alternative design selection might minimize repeated clean up activities.

FIGURE 7

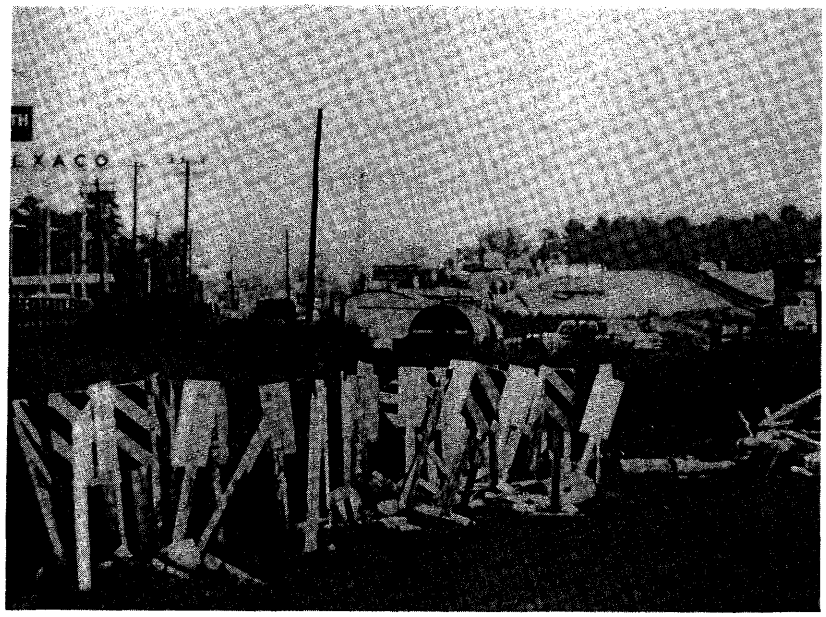


FIGURE 8

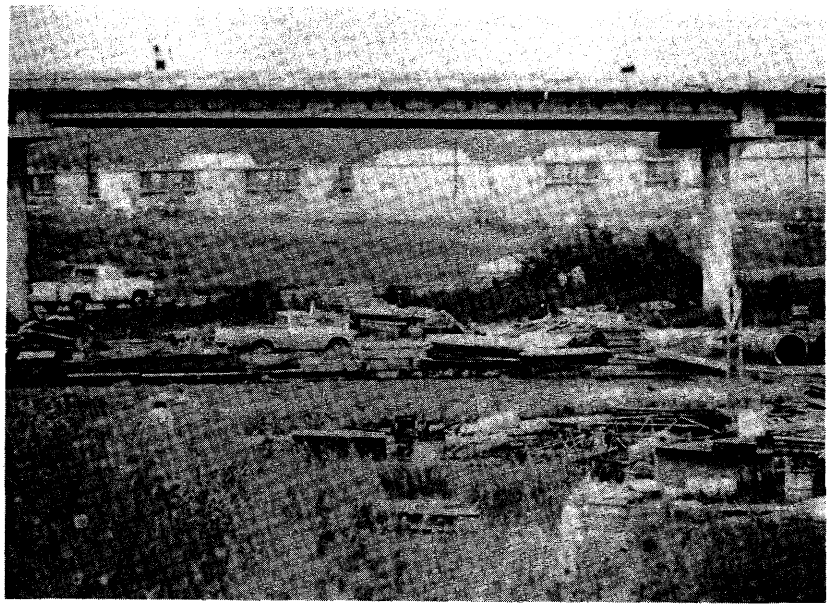


FIGURE 9

On-site job clean up on equipment and material is important in public acceptance of urban highway construction projects. Judgement is a critical factor in this area. (Figure 8). Nonpermanent clean up activities should be those which:

1) improve job site performance,

2) promote job site safety, and

3) increase public acceptance of urban construction.

A job site which gives the appearance of misuse of equipment and supplies over an extended time period is not conducive to public support of construction projects (Figure 9). Contractors and Department Inspectors should recognize this and strive to improve this aspect of on-site appearance which the motoring public observes.

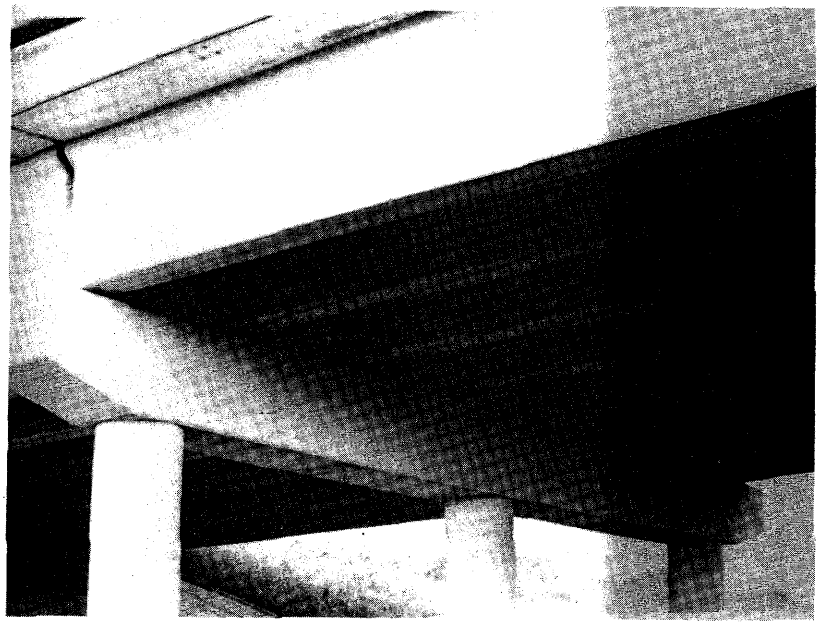


FIGURE 10

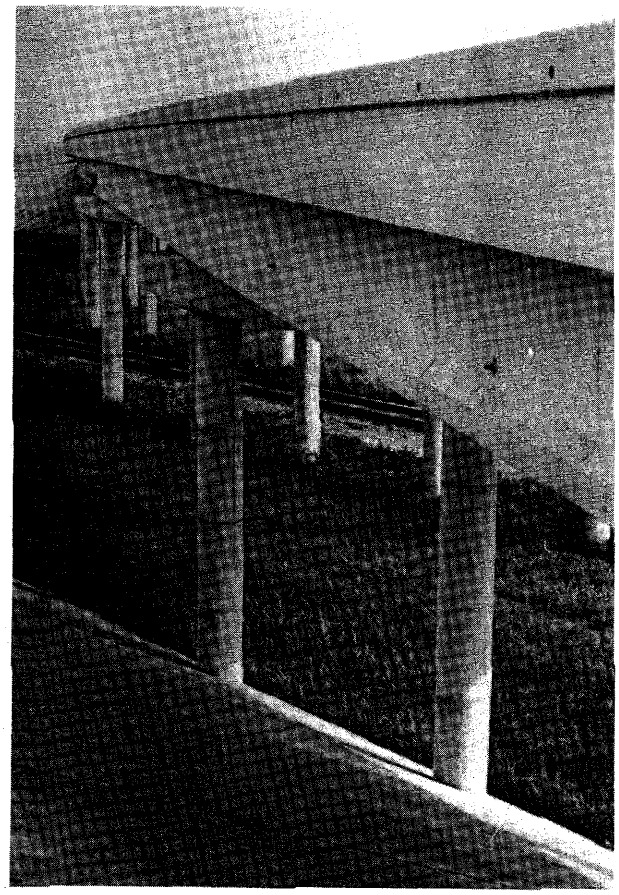


FIGURE 11

Figures 10 and 11 are structures located in rural areas. The area exposed to driver view in Figure 10 has been finished. The structure in Figure 11 is not exposed to driver view and has not been finished. At highway speeds driver perception of the degree of finish on a structure is limited. Unexposed areas as shown in Figure 11 should not receive costly finishes. The associated costs related to finishing the structures should be related to driver perception and public acceptance in rural areas.

FIGURE 12

FIGURE 13

Figures 12 and 13 illustrate that expensive finishing processes applied at the time of construction may be of relatively short duration. It is virtually impossible from both a physical and cost aspect to maintain these structures in original condition. Costly nonpermanent treatments, therefore, should be carefully evaluated from both the point of view of economy and public acceptance. A reordering of priorities may be necessary with the objective of increased investment in permanent asethetic features such as exposed aggregate.