CONCRETE FINISHES FOR HIGHWAY STRUCTURES

by

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SUMMARY

The site conditions just about always dictate the basic layout of a structure. The choices of materials and appearance are usually made by the engineer. The materials going into the structure get a great deal of attention, but unfortunately the appearance too frequently does not. It is not unusual then to find a very few structures with deficiencies stemming from the materials used, but many with deficiencies in appearance.

This report is intended to acquaint the designer of highway structures with the more popular and presently used architectural concrete finishes to help him enhance the appearance of his structures. The various architectural concrete finishes obtainable from cast-in-place and precast processes are presented. General considerations such as appearance, weathering, and specifications for these finishes are discussed. A discussion is presented of the costs and practical considerations that need to be taken into account in selecting architectural concrete finishes for highway structures.

The report does not deal with concrete paints or other superficial coatings.

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INTRODUCTION

The architectural use of concrete has progressed rapidly in recent years as engineers and architects have seen the possibility in using it as a decorative as well as a structural material. Engineers probably have been slower than architects to adopt recent developments in concrete finishes since the mass and form of their structures usually provide sufficient impact without enriched surfaces. Their position appears to be changing now and they are trying harder to make their structures more interesting, not only through changing forms but also by enhancing the exposed concrete surfaces.

Since concrete exists in both the unhardened and hardened states, it provides opportunities for producing a wide variety of surface textures depending upon whether one chooses to treat the concrete by molding it while in the unhardened state or by altering its surface as it sets or after it hardens. In either case, it can usually be said that shaping or texturing the surface, i.e., applying an architectural finish, aids in camouflaging surface defects. Conventional structural concrete contains surface imperfections such as shrinkage cracks, air pockets and bugholes, and blotching caused by variations in the water-cement ratio, form release agents, and other factors. If these blemishes are unacceptable to the specifier, then what he is really seeking is an architectural finish that will diguise them. Architectural concrete finishes can be said to be those concrete surfaces exhibiting a nearly uniform surface appearance with minor imperfections that are not readily noticeable and that do not reveal the normal surface variations of untreated structural concrete. One architect has gone so far as to say that, "If the owner will not accept any variation in his concrete surface, he should not use concrete in any form."

In this day of emphasis on the aesthetics of the environment, and in particular on highways, it behooves the highway designer to enhance the appearance of his structures by changing their form, color, surface texture, etc., by whatever means available to him. In years past, highway and bridge budgets were more limited and aesthetic considerations were frequently not considered affordable. But today that situation has changed somewhat and aesthetics should be one of the prime design requirements along with sufficient load carrying capacity and safe geometrics. Some uses of aesthetically treated concrete surfaces have been made by the Virginia Department of Highways & Transportation. Some examples of instances where treated surfaces have been used in Virginia's highway structures include the retaining

walls at the entrance to the Hampton Roads Tunnel (textured surface) wingwalls of structures over Interstate Route 64 west of Charlottesville (textured surface), the bridge on Route 647 over the Rappahannock River at the Faquier - Rappahannock County line (tinted concrete, timber rail, and weathering steel stringers), and the piers of the Leigh Street viaduct in Richmond (textured surface).

The foregoing discussion provides sufficient reasons to justify a cursory examination of some of the architectural concrete finishes that are available to today's designers of bridges and other structures, and as an aid to such an examination this report is directed to a discussion of the various popular types of architectural finishes that are being applied to cast-in-place and precast concrete. No attempt is made to provide a complete "how-to" manual, however some discussion of how the various finishes are obtained is presented. Neither does the report deal with explanations of why certain imperfections, such as bugholes for instance, occur in concrete surfaces. The purpose is only to acquaint designers of highway structures with the more popular concrete finishes available as viewed from the standpoint of aesthetics.

The report touches on such general considerations as costs of the finishes generally available for cast-in-place and precast concrete surfaces, appearance, weathering and specifications. It does not deal with concrete paints or other superficial treatments, but comments on the use of pigments to color concrete are included.

CONCRETE FINISHES AND PROCESSES

Concrete finishes can be divided into two large groups: form finishes, and exposed aggregate finishes. Form finishes can be divided into two categories: smooth finishes and textured and patterned finishes. Exposed aggregate finishes can be divided into four major categories: acid washed, sandblasted, retarded, and bushhammered. In many instances, these finishes or combinations of several finishing processes are applied to both cast-in-place and precast concrete. Therefore, one should not assume from this report that any one particular finish is applied exclusively to either cast-in-place or precast concrete items.

Types of Form Finishes

Smooth

Form work for smooth-surfaced concrete is very critical and difficult to control. Any imperfection in the surface or any forming misalignment is immediately evident and tends to become the focus of one's attention.

Textured and Patterned

Designs can be created in the concrete surface by using high and low relief in the forming material. Designs of practically any form can be achieved. Both straightline geometric patterns and free form shapes are possible. Board marked surfaces, revealing the texture of the forming lumber on the concrete face (or simulated with plastic forms), fall into this category.

Types of Exposed Aggregate Finishes

Acid Washed

Acid washed finishes yield only a light exposure of aggregate and are intended to bring out the tone of the concrete materials. This type of finish readily exposes construction and form deficiencies to a high degree.

Sandblasted

A sandblasted finish is called for when it is desired to reveal the character of the stone. Sandblasting is done with extremely fine sand and can be done lightly enough so that only the cement paste film will be removed from the surface. Again, variations in construction practices and forming will be readily revealed, but not as much as with the acid washed finishes. But if the sandblasting is continued, the coarse aggregate will become the dominate feature, which constitutes the most common sandblasted finish sought.

Retarded

Retarded finishes are achieved by applying a retarding chemical to the surface to delay the set of the surface mortar in order that the aggregate can be exposed early by washing. These finishes provide a range from light to deep exposure of aggregates and are relatively little affected by deficiencies in the forming material.

Bushhammered

Bushhammered surfaces are produced by pneumatic tools fitted with a bushhammer, chisel, or multiple pointed attachments. The type of tool will be determined by the surface effect desired. Form or construction deficiencies are seldom revealed with this type of surface finish.

Cast-In-Place Processes

The finishes generally obtainable from cast-in-place processes include those received directly from the form work and by exposing the aggregate.

From the Form Work

The finishes that can be obtained directly from the form work are smooth finishes, board marked finishes, and those produced from special form linings.

Where it is desirable to obtain a smooth final finish it is generally necessary to line the form work with sheets of either plywood or fiberboard. Surface coatings applied to the plywood at the site or plywood with factory applied plastic facings are generally used when a good quality smooth surface is desired. Special attention should be given to the quality of forming to minimize objectionable surface variations and discolorations that result from form leakage and surface absorption. To obtain a uniform color, it is important that the form surface be either impervious or of uniform absorption. Examples of smooth finishes from plastic faced plywood forms are shown in Figures 1 and 2 (all figures are appended).

The uniformity of surface appearance is enhanced considerably by texturing. The use of board marked finishes offering variable texture is particularly popular. A wide variety of board marked patterns and textures is obtainable depending on the type and quality of timber and the way in which it is used. Sound, straight, softwoods, free from large, loose knots are normally used for practically all kinds of form work, and the impression of the grain in the concrete will depend upon the species of the wood and the manner in which it is sawed. The boards must be uniform in width and thickness so that there will be no offset at the joints unless these are desired. Widely used now are fiberglass forms that duplicate all the various wood textures that are usually available (see Figures 3-6).

Fiberglass, reinforced plastics and expanded polyurethane are commonly used to provide a variety of textured finishes (see Figures 7-16). Form joinery is critical because whenever a joint occurs it will be reflected in the finished surface. As a general rule, rustications should be provided at all construction joints and should be included as a feature of the structure.

Exposed Aggregate

The exposed aggregate finish reveals the nature of concrete as a material and can give varying degrees of color and texture, depending upon the aggregate and cement used. However, surprisingly an exposed aggregate finish will not be applicable to every type of structure and any imperfections in the concrete such as honeycombing or poorly made construction joints will become more noticeable when

the aggregate is exposed. One of the simplest and most economical means of achieving an exposed aggregate finish is by stripping the form work at an early age and washing and brushing the surface. The period up to which this method is effective depends considerably on the time of the year and the ambient temperature; the upper limit is about 16-18 hours. When the form work is to be left in position for periods longer than 18 hours, the set of concrete can be retarded by treating the form work with a retarding agent. Steel bristle brushes are normally used to remove the surface mortar. Work starts at the bottom because this is the oldest concrete and it establishes the depth to which the mortar can be removed. A fine spray of water is used throughout this scrubbing operation. Examples of washed surfaces exposing the aggregate are shown in Figures 17-20. Subsequent curing, after washing, is generally necessary.

Another method of exposing the aggregate in concrete is by tooling the surface. Bushhammering, point-tooling and chiselling are methods widely used. The tools used for this work are generally electrically or pneumatically powered. Aggregates which tool without shattering, such as granites and other igneous and sedimentary rock, are much preferred to, say, natural gravels. The color and texture are governed essentially by the type of aggregate, but the overall surface effect is most affected by the type tool used (see Figures 21-26 for examples of tooled surfaces).

Sand, grit and shotblasting are frequently used to expose the aggregate on the face of the concrete. Various decorative effects can be obtained by varying the depth of blasting or by leaving some parts untouched in regular or irregular patterns. The timing of this process is not nearly so critical as that of exposing the aggregate by the wire brush and water spray method. Examples of sandblasted finishes are shown in Figures 27-30.

Precast Processes

The use of precast concrete with architectural finishes has the advantage over treating cast-in-place surfaces of a greater variety of finishes, and if the work is not satisfactory it can be readily rejected at the plant rather than at the site where repairs are difficult to administer. The design aspects of precasting concrete units must be implemented right from the start and they should not be an afterthought of a proposed cast-in-place installation. Only in this way can the attributes of precasting such as standardization, repetitive processes, and a minimum of variation be acheived. The processes by which most surface finishes are obtained on precast concrete are in many cases quite similar to the processes used on cast-in-place concrete and there is little difference in appearance to the casual observer. The types of finishes most generally employed in precast work are discussed below.

Colored Cements and Coloring Admixtures

Various colors of cement are now available for use in place of ordinary portland cement, with or without special sands. Strong, uniform colors can be used in large areas, but the surface should be patterned or profiled so that any unevenness in the color will appear minimal. Colored cements and coloring admixtures can also be used in cast-in-place work but the problems with job site quality control make the possibilities of unacceptable color variations very large.

Coloring admixtures (pigments) are often used to obtain colored concrete in lieu of using colored cements. Requirements for pigments include: (1) color fastness when exposed to sunlight, (2) chemical stability when in contact with the alkalies of the concrete mixture, and (3) setting and strength characteristics of the concrete mixture that are unaffected by the pigment. Trial mixtures are strongly recommended. Color variations may occur from changes in concrete materials and their proportions, the tools and procedures used in the finishing operations, and the curing procedures used.

Pigments frequently used are shown in Table I (ACI Manual of Concrete Practice, 1974).

TABLE I

Colors of Various Pigments

Shades of Color	Pigment
Gray to black	Black iron oxide Mineral black Carbon black
Blue	Ultramarine blue Phthalocyanine blue
Bright red to deep red	Red iron oxide
Brown	Brown iron oxide Raw and burnt amber
Ivory, cream, or buff	Yellow iron oxide
Green	Chronium oxide Phthalocyanine green
White	Titanium dioxide

The additional charge for concrete containing pigments is reportedly $7 to $15 per cubic yard ($9 to $20 per cubic meter).

Form Linings

Form liners such as rough timber, rubber, fiberglass, reinforced plastic, expanded polyurethane and other thermoplastic materials are used to impart a pattern or texture to the surface.

Thermoplastic materials have the advantage of requiring no release agent; however they do produce an extremely smooth surface that tends to craze more than one formed against a more absorbent material. Timber liners which have been specially sawn, say across the grain, provide interesting surfaces and help in reducing the look of massiveness of large surface areas. The effect obtained by precasting against textured liners is essentially like that obtained in using them with cast-in-place methods.

Casting Face Up

The casting face up technique can be used to apply a pattern or texture to the surface of unhardened or hardened concrete. This can be done by scraping the concrete, rolling it with an indented roller, by screeding, or by the use of bush-hammers, etc. When scraping, rolling or screeding, one difficulty is the control of the plasticity of the mix. If the mix is too soft, the relief flows out and the pattern is lost; if the mix is too stiff, no impression can be made. Advantages of horizontal casting include ease of positioning the reinforcement and generally greater control over finishing treatments.

Treating the Face

In treating the face the aggregate is exposed by washing, brushing, acid etching, tooling, sandblasting or shotblasting. Slabs can be produced either by using special facing mixes incorporating the coarse aggregate it is designed to expose applied monolithically with the backing concrete, or by spreading a layer of stone over the concrete and tapping it into the surface. The aggregate is exposed by washing and brushing about three or so hours after casting, wire brushing when the concrete is about 16 hours old, or mechanically treating when the concrete is older. Again, the processes cited are very similar to those used in cast-in-place work.

APPEARANCE

Obviously, an important consideration in choosing a finish is that of the uniformity of color required of the surface. Variations in the color can occur by a number of means. Principal among these means are the variation in the color of the constituents (cement and fine aggregate are most significant), variations in mix proportions (cement content and water/cement ratio are the most critical), moisture movement

(absorption of the concrete moisture into the form work or leakage of it at the joints), contamination (usually caused by impurities within the concrete), nonuniform curing (generally caused when form work is removed at different rates), and weathering (most frequently caused by streaking of dirt, rain, rust stains, and efflorescence).

The relative importance of cement and aggregate in determining the final color of the concrete depends very largely upon the treatment given to the exposed face. On plain, textured patterns and other nonexposed aggregate surfaces that are untouched after removal of the form, the cement is the dominating factor in color considerations. For exposed aggregate finishes, it is in most cases the color of the aggregate that dictates the color, since the proportion of cement to aggregate visible is relatively small. Nevertheless, the cement has an effect on the general tone value of the concrete and for that reason it should always be considered when choosing the aggregate to be exposed.

Texture is another factor that influences the appearance. The further the distance from which the surface is viewed, the coarser or more "brutal" the texture must be in order for the surface to yield maximum appreciation to the viewer. Too, the more textured and profiled the concrete surface is, the better it will look after exposure to weathering. Minor defects and blemishes are readily hidden by proficient texturing.

WEATHERING

The surface of concrete as it comes from the form is usually a smooth, hardened skin of cement paste. This surface is relatively hard, but has a tendency to craze and weather unevenly. Rough textured surfaces have certain advantages in weathering. When rain runs down the face of smooth surfaced concrete, its path is determined by random irregularities in the surface and the result is usually light colored streaks on a discolored background. With rough textured surfaces the rain running down the surface is broken up and more evenly distributed over the whole surface so that streaking is practically eliminated. In the cases of some of the more pronounced exposed aggregate finishes, the aggregates serve as drip-points and thus prevent a substantial portion of the rain from reaching the mortar surface.

A successful concrete finish should be able to withstand the environment that it's exposed to, for its specified life. The capacity to do this is generally dependent upon both external and internal factors. The factors discussed below appear to be the most important weathering characteristics affecting the durability and appearance of concrete surfaces.

Permeability and Absorptive Capacity

The permeability and absorptive capacity of concrete affect its life and weathering ability and therefore, for durable surface finishes, these two properties are very important. Important too is the fact that these properties also influence a concrete's resistance to reinforcement corrosion. The more impervious the surface, the less internal and surface deterioration in the concrete. Excessive voids in concrete generally result from excess water in the mix, incomplete curing, or entrapped air resulting from mixing and placing. It is well-known that for concrete to have a low permeability, the water cement ratio should be as low as possible, consistent with sufficient workability for full compaction. The curing procedure should also be as complete as possible.

Freeze-Thaw Resistance

One of the most serious forms of concrete weathering involves the freezing of moisture that has penetrated the exposed surfaces, and the end effect is generally a type of scaling. When the temperature of saturated concrete is lowered, the absorbed water begins to freeze and to exert immense pressure. The pressure results from the increased volume of the water as it freezes and the resistance to flow encountered by the freezing water.

The effects of freezing and thawing can be reduced by using low water/cement ratios. This practice permits only as much water as is needed to be used in hydrating the cement and also permits the concrete to gain high strength to resist the stresses brought on by the above mentioned pressures. Of course, air entrainment in the proper amounts is highly beneficial in rendering concrete resistant to freeze and thaw action also.

In exposed aggregate finishes, the aggregates also must be of good quality in order to obtain an enduring surface.

Since most highway applications of treated concrete surfaces will be in a vertical plane and, therefore, drainage and drying will be enhanced, the consequences of reduced attention to the above mentioned factors should not be as severe as they would be if the surfaces were in a horizontal plane, except where splash and runoff containing chlorides come into contact with concrete surfaces such as those on curbs, sidewalks, and parapets.

Efflorescence

The white deposit of efflorescence frequently seen on concrete surfaces is caused by the movement of calcium hydroxide, freed by the hydration of the cement and carried in solution to the surface of the concrete where carbonation and evaporation take place. The occurrence of efflorescence is largely dependent upon the permeability of the concrete surface.

If brushing does not remove the efflorescence, then washing the affected area with a 5 to 10 percent solution of hydrochloric acid should be tried. The area should first be wetted with clean water and the acid solution applied with a soft brush. When the chemical reaction has stopped, the surface should be thoroughly flushed with clean water.

SELECTING A SURFACE FINISH

Regardless of the concrete finish designed and specified, the quality of the result will be dependent upon the capability of the contractors. Practical specifications that permit the contractor to fit the requirements to his method of operation and experience are more likely to achieve a desirable end result than overly complicated and restrictive specifications.

Among the factors that should be considered in selecting the finish are: (1) The setting of the structure; i.e. is it rural, suburban, urban, mountainous, tidewater, etc.; (2) the severity of the environment with respect to weatherability aspects; (3) the "brashness" of the surface finish and the distance from which the surface will normally be viewed (subtle finishes for short site distances are acceptable, but for vehicular bridges and similar structures to be viewed by the traveling public more harsh or brutal finishes will be necessary to reveal the intended impact); (4) the possibility (in exposed aggregate finishes) of using local aggregates to create some affinity to the local landscape, and (5) the cost of these factors. Only the last of these factors, cost, appears to need discussion here.

There are important cost considerations in designing architecturally treated concrete surfaces. The costs of structural and architectural concrete should not be compared directly. The proper comparison should be between architectural concrete and structural concrete that is subsequently given an architectural treatment. Any finish over and above that which is expected for a cast-in-place surface, including rubbing, will be an item of cost. The cost of rubbing concrete generally ranges from \$.50 - \$.75 per ft^2 (\$5.50 - \$8.00 per m^2).

Reasonable budgets for architectural concrete finishes are in the following ranges:

Type of Budget	Cost, per ft^2 (m^2) of finished concrete
Rubbing	$0.50 - 0.75 ($ 5.50 - 8.00)
Low Budget	$0.75 - 1.25 ($ 8.00 - 13.50)
Medium Budget	$1.75 - 2.50 ($19.00 - 27.00)
High Budget	$3.00 and up ($32.00 and up)

A discussion with a representative of a state concreting firm supplied the following price ranges and comments for the more conventional types of architectural concrete finishes available in today's (1974) market.

(I) Cast-in-place with Rubbing Only:

The costs for this type finish is $0.50 - $0.60/$ft^2$ ($5.50 - 6.50/$m^2$). This is a relatively economical finish but it tends to become nonuniform as the surface paste weathers away.

(II) Cast-in-place against Textured Forms:

The cost for approximately five conventional grade separation types bridges is $0.50 - $1.00/$ft^2$ ($5.50 - 11.00/$m^2$). If the forms are used and handled properly, the cost could be reduced by $0.20/$ft^2$ ($2.00/$m^2$). Textured surfaces can provide a pleasing appearance and will help to disguise surface variation.

(III) Exposed Aggregate Finishes:

Acid washed

Acid washed finishes provide a very light finish, and are relatively expensive at about $2.00/$ft^2$ ($21.50/$m^2$). This type finish is probably too subtle and too costly to be recommended for highway structures.

Sandblasted

Sandblasted finishes could be used in highway structures and their cost ranges from \$0.25 - \$1.00 ft^2 (\$2.50 - 11.00/m^2). At \$0.25/ft^2 (\$2.50/m^2) the paste is removed to expose sand, at \$0.50/ft^2 (\$5.00/m^2) coarse aggregate is exposed (this is the most common form of sandblasted finish) and at \$1.00 ft^2 (\$11.00/m^2), a very brutal texture on a very hard granite-like stone is obtained. With the sandblasting process, one can try to customize the depth of removed mortar (that is, relief) to obtain improved uniformity throughout the work. This remedial measure is not possible when a surface retarder is used to expose the aggregate. The curing and mortar removal cycle in the exposed aggregate process is not nearly so critical with the sandblasting process as it is with the surface retarding process as seen from the following discussion of retarded surfaces.

Cast-in-place retarded surfaces

The cost for cast-in-place retarded surfaces ranges from \$0.25 - \$0.50 ft^2 (\$2.50 - 5.00/m^2). The process is difficult to administer in the field in that uniformity in surface appearance is not easy to obtain. This process is also difficult to use on vertical surfaces because the depth of the retarding action varies with the height of the work. Between the bottom and top of the form the distribution of coarse aggregate is different, the consolidation of the concrete is less at the top, and the age of the concrete and therefore its strength is greater at the bottom. These factors contribute to a lack of uniformity in surface appearance when the retarding process is used on vertically cast surfaces.

Cast-in-place broken-face ribbed finish (see Figures 24-26)

The cost of this finish type ranges from \$0.75 - \$1.00/ft^2 (\$8.00 - 11.00/m^2). This effect is achieved by casting against forms which have vertical ribs attached. Upon form removal, the projections of concrete are broken off with a hammer. A consistent treatment with the hammer is essential. This bold finish has been used frequently in Great Britian on highway structures.

Cast-in-place, bushhammered surfaces

Bushhammered surface costs range from $1.00 to $2.00/ft^2 ($11.00 - 22.00/m^2). Bushhammering covers mistakes better than the process of exposing aggregates by the use of surface retarders, but it is relatively expensive.

It was also felt by the representative of the concreting firm that when CIP abutments, wingwalls, and other large vertically placed concrete elements are to have their surfaces treated, the most feasible type of treatment would be that received from textured or patterned forms. The broken-face ribbed finish could well be used in these applications to provide a bold and unique surface appearance. Exposed aggregate finishes (not including the above mentioned broken rib) definitely should not be used on large vertical CIP placements because of the previously mentioned great variability in the aggregate distribution, consolidation and other characteristics of the concrete from the bottom to the top of the placement. These characteristics would, of course, tend to destroy the uniform surface appearance being sought.

The more feasible means of enhancing the appearance of beams might be through the use of colored cements or coloring admixtures, or by exposing the aggregate by sandblasting or the use of surface retarders. Exposing the aggregate by either of these methods is not as easily accomplished as coloring the concrete or treating the surface with textured or patterned forms, but it can be accomplished with moderate care.

SPECIFICATIONS

With traditional specification methods in construction, the specification writer accepts responsibility for prescribing methods and performance in material and production, and the contractor, who has to follow the specification, usually cannot be held responsible if the building or unit does not perform as the specification writer intended. This type of specification is frequently called a prescription specification. With a performance specification, the writer does not generally specify all the materials to be used or the methods of production, but does attempt to spell out precisely the end result required. However, it is very difficult if not almost impossible to describe aesthetic qualities that one might require in a concrete finish.

To overcome the deficiencies of both the above mentioned specification methods in achieving the desired surface finish, a useful technique is to specify an exposed concrete finish that has already been achieved elsewhere. Another technique is to provide a prototype sample for viewing by the prospective bidders. However, the appearance of concrete in a small sample may be considerably different from that of larger areas. In whatever way possible, the purpose is to provide the bidder with as accurate a guide as possible for bidding purposes.

The terms of the contract probably should require the contractor to produce trial panels using experimental mixes in order to decide if the desired effect will be achieved. The trial panels should be reasonably large and should include at least one horizontal and one vertical construction joint so that a minimum standard of quality can be settled upon.

RECOMMENDATIONS

It is well-known that the public's role in highway matters is ever increasing. This movement, if it does not already do so, will certainly sooner or later involve the appearance of bridges and other structures. Thus, it is recommended that the Department select a modest number of the finishes mentioned in the report (from those mentioned as probably most appropriate for its needs) for field trial in appropriate locations or settings. As mentioned previously, the Department does have some experience with architectural concrete finishes, having used them in a limited number of instances in the past. Not only will the Department obtain the public's reaction in these field trials, but also, importantly, it will gain additional experience with the engineering aspects and costs of specifying treated concrete.

The writer has a strong interest in and a limited amount of field experience with architectural concrete finishes, and will happily accept the assignment of working with the Department in any capacity in field trials of selected finishes on whatever concrete surfaces are chosen.

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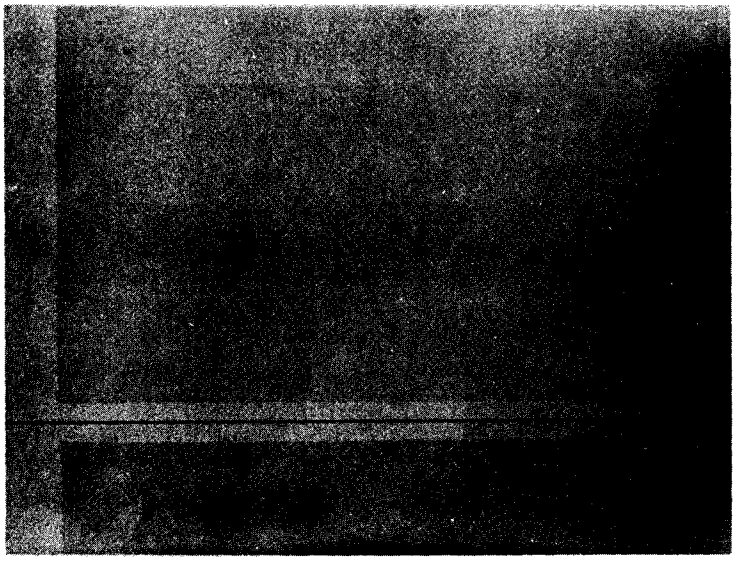

Figure 1. Finish from plastic faced plywood form.

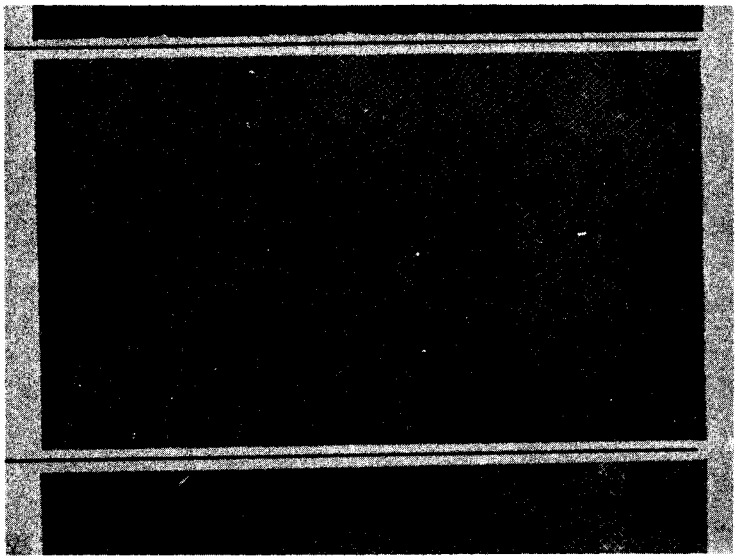

Figure 2. Same general type finish as shown in Figure 1.

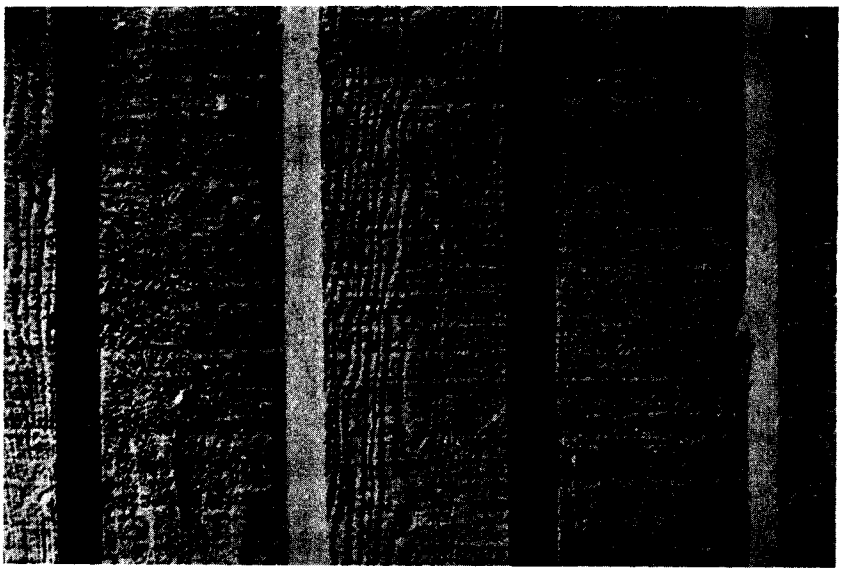

Figure 3. Wood textured finish duplicated from fiberglass forms.

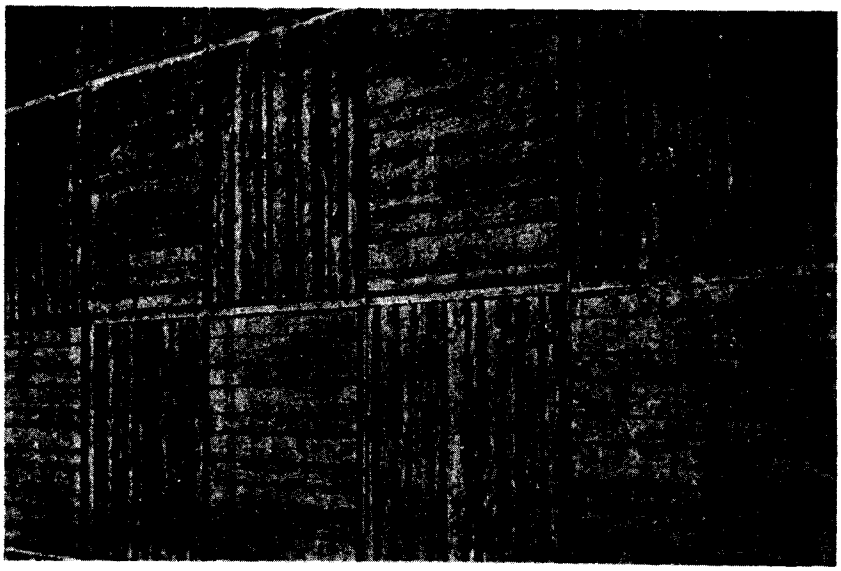

Figure 4. Same general type finish as shown in Figure 3.

Figure 5. Same general type finish as shown in Figure 3.

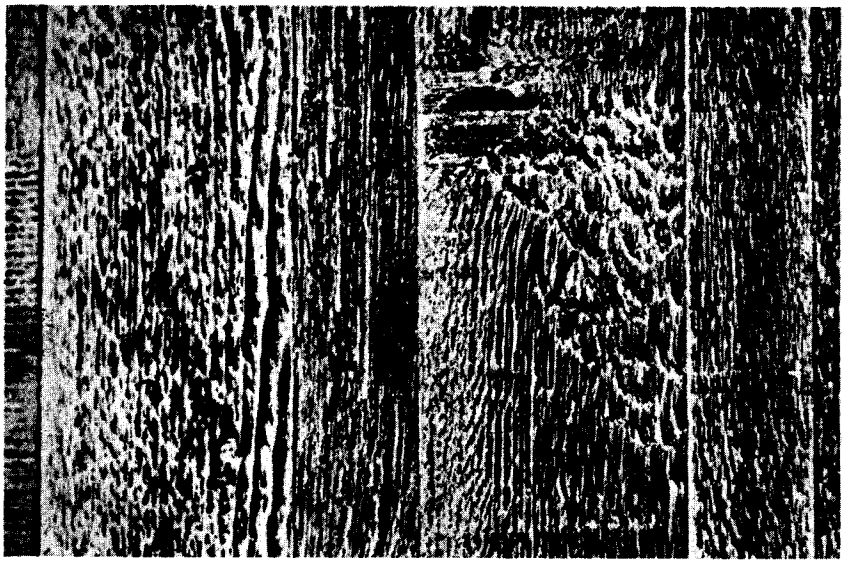

Figure 6. Same general type finish as shown in Figure 3.

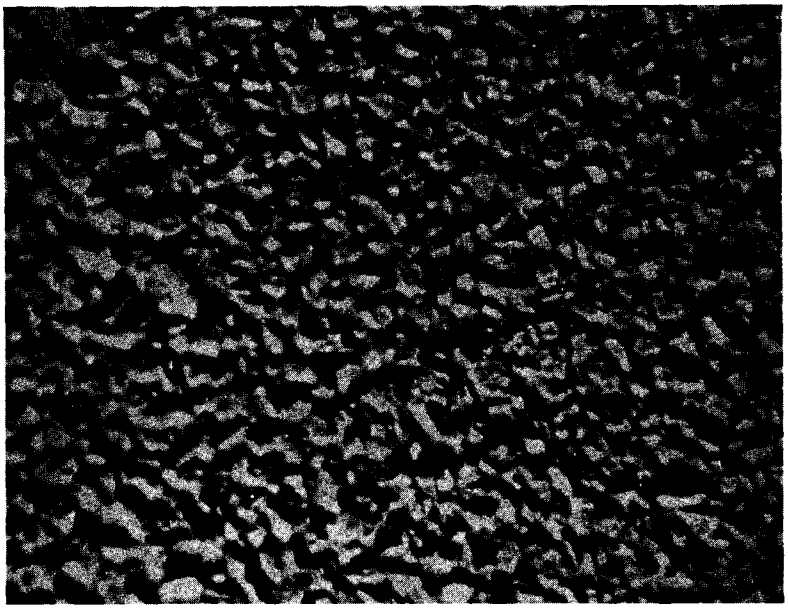

Figure 7. Textured surface from plastic forms.

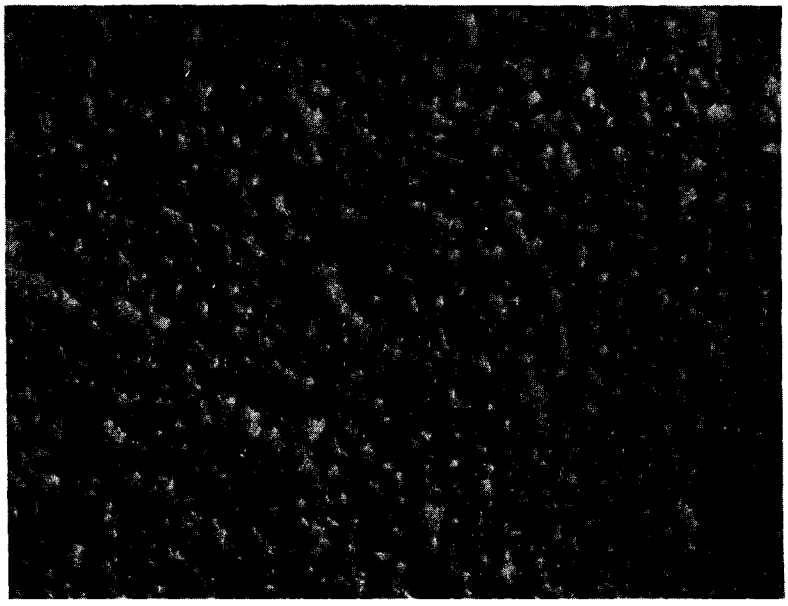

Figure 8. Dimpled surface from plastic forms.

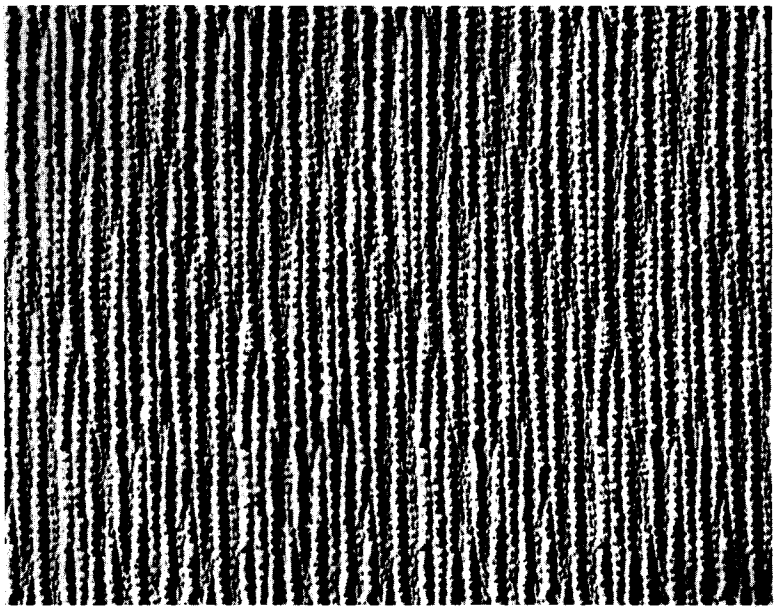

Figure 9. Textured surface.

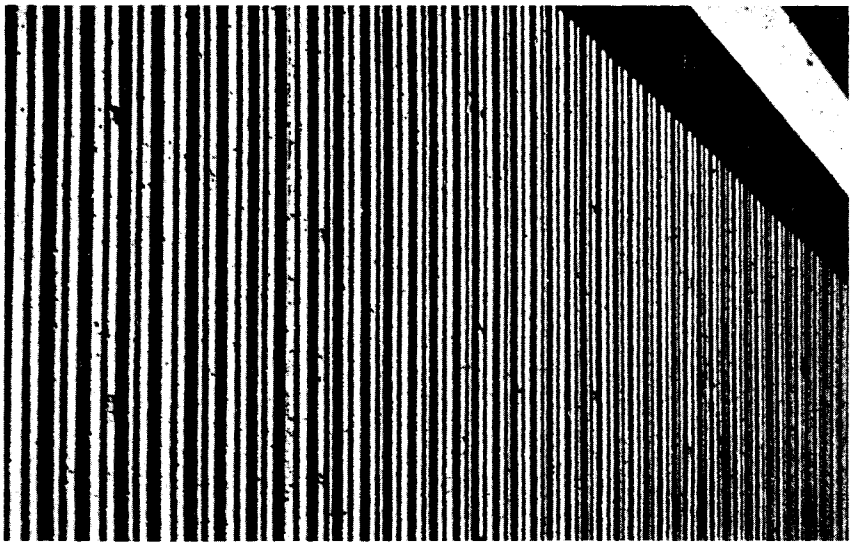

Figure 10. Corrugated surface.

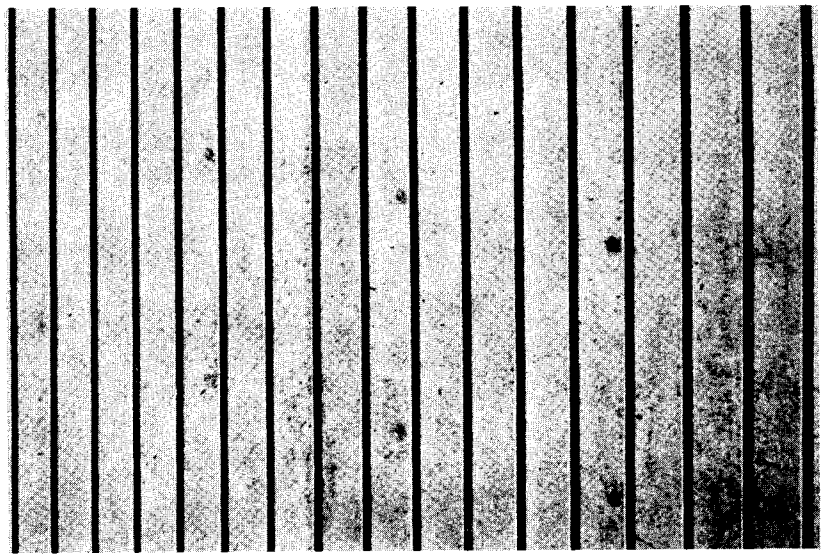

Figure 11. Same general type finish as shown in Figure 10.

Figure 12. Same general type finish as shown in Figure 10.

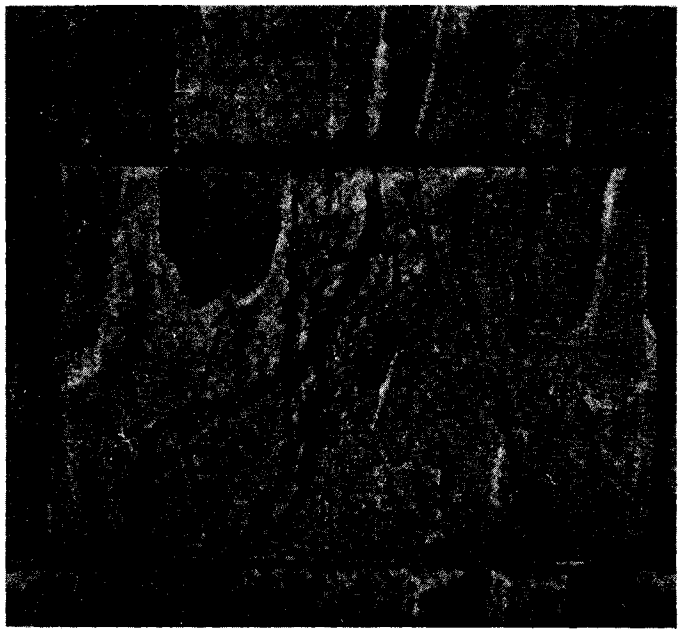

Figure 13. Original finish using glass-reinforced plastic forms.

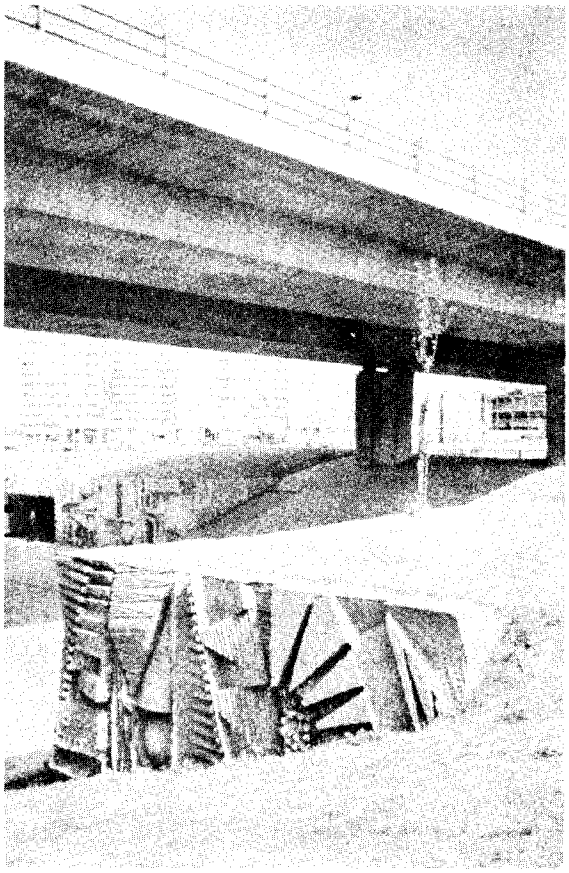

Figure 14. Original finish on a retaining wall.

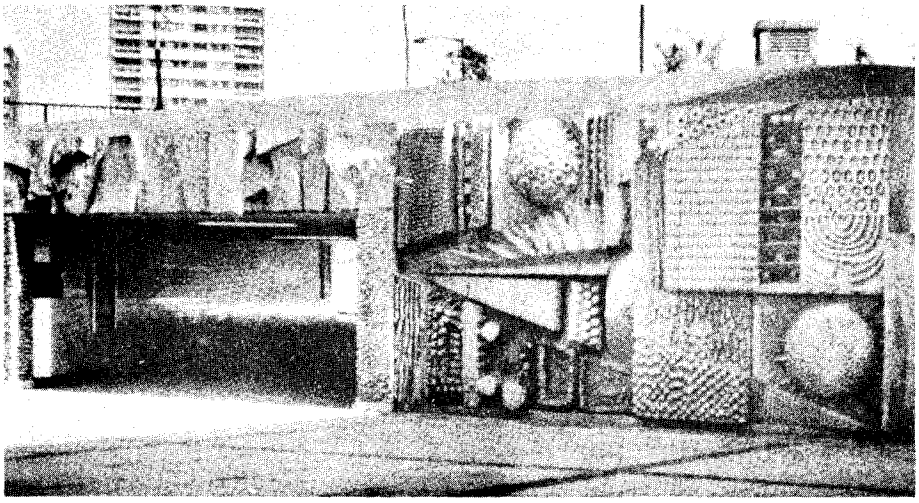

Figure 15. Same general type finish as shown in Figure 14.

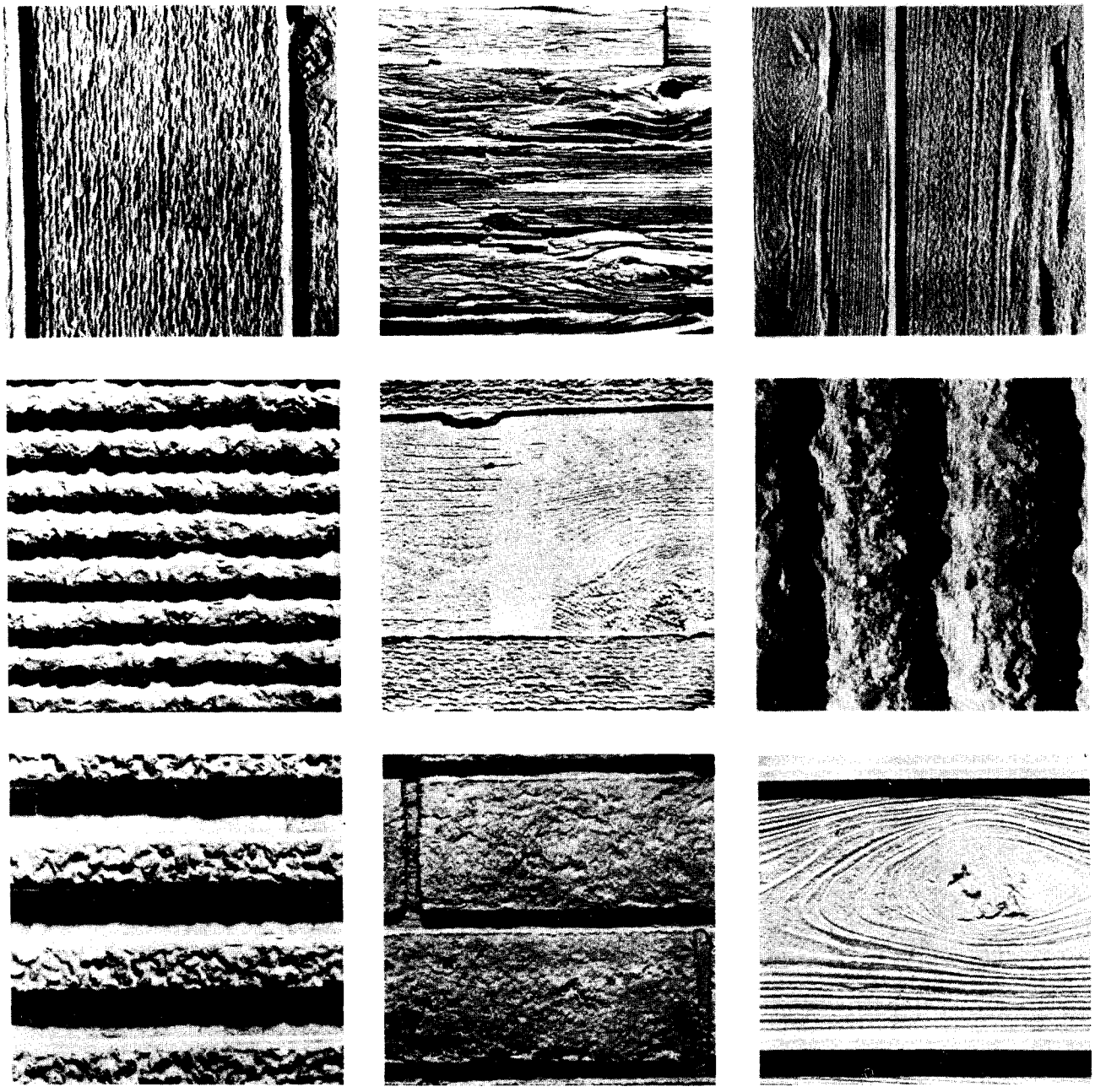

Figure 16. Examples of finishes obtainable from reinforced plastic forms.

Figure 17. Relatively coarse exposed aggregate finish.

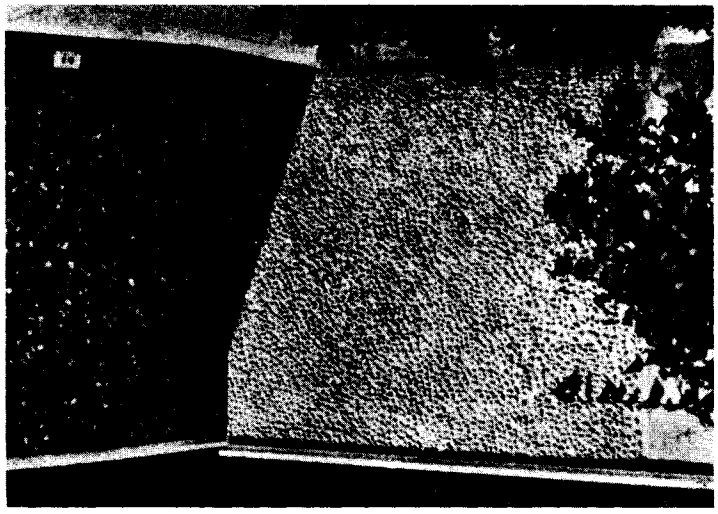

Figure 18. Exposed aggregate finish.

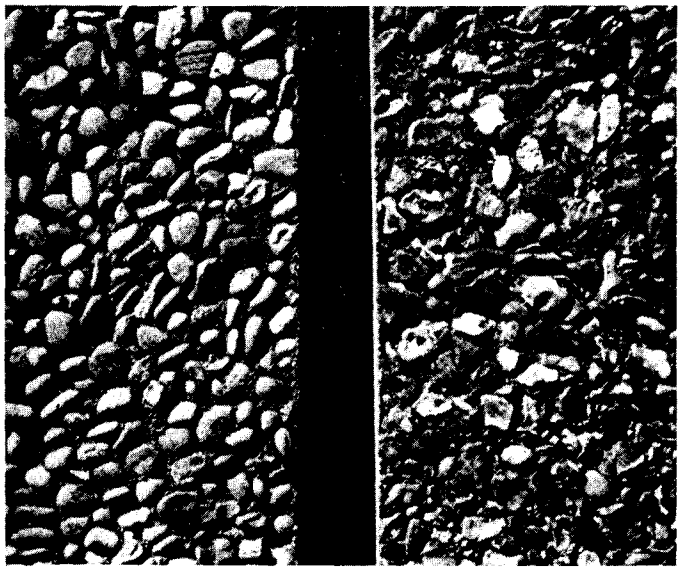

Figure 19. Exposed aggregate finishes — left photo is of a gap graded concrete mixture.

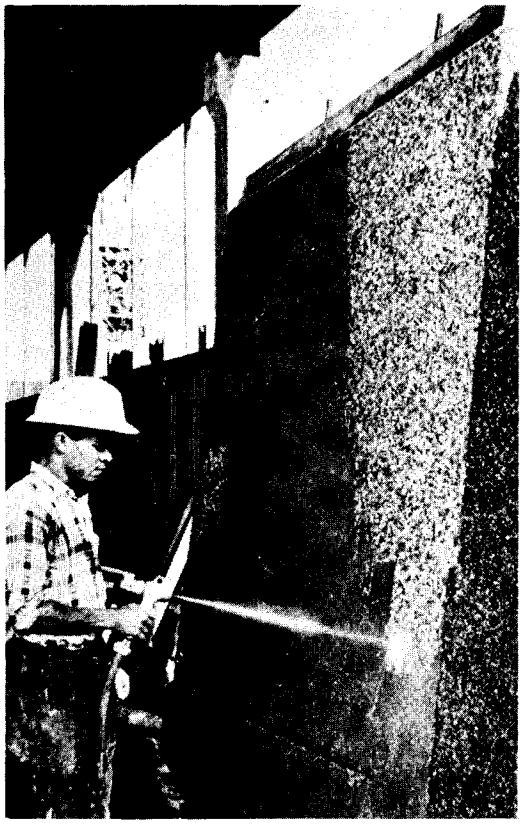

Figure 20. Exposing the aggregate by brushing and washing (Note: This is a precast slab raised from its horizontal casting position and thus washing may begin at any point since the concrete is of the same age and consolidation throughout.)

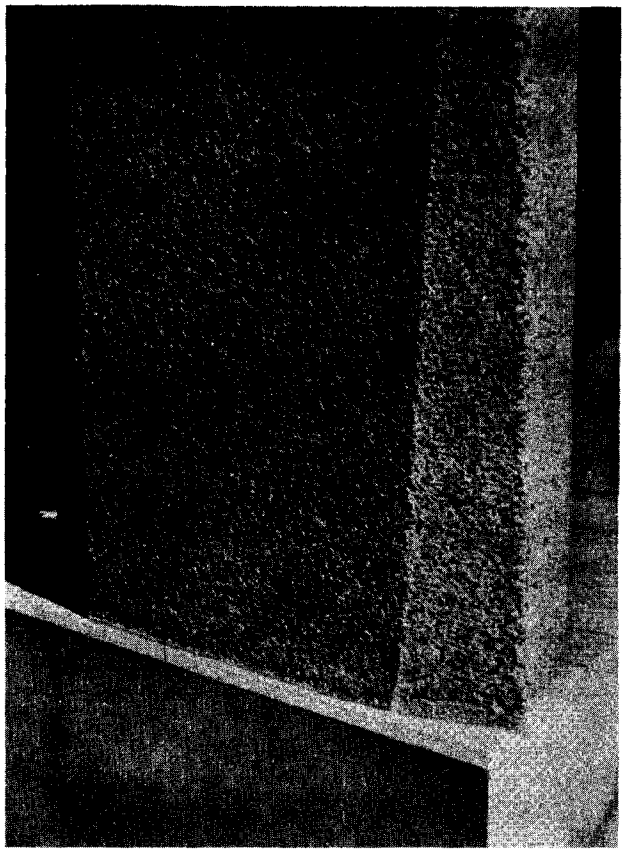

Figure 21. Bushhammered finish.

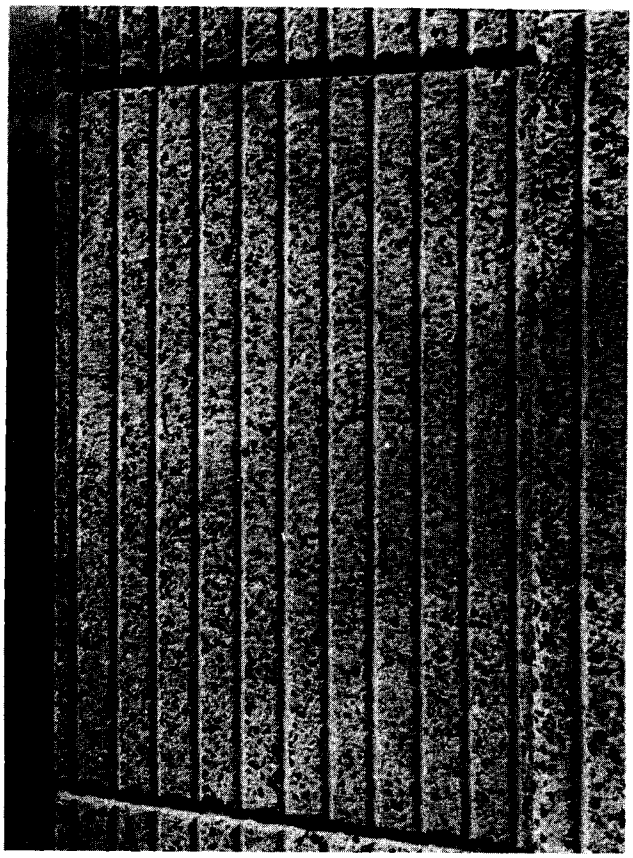

Figure 22. Same general type finish as shown in Figure 21.

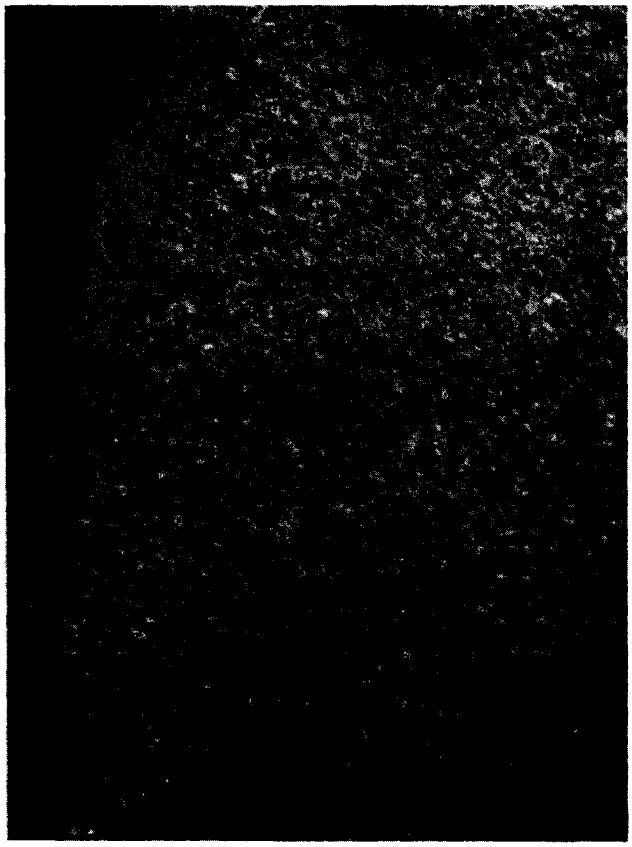

Figure 23. Point-tooled finish.

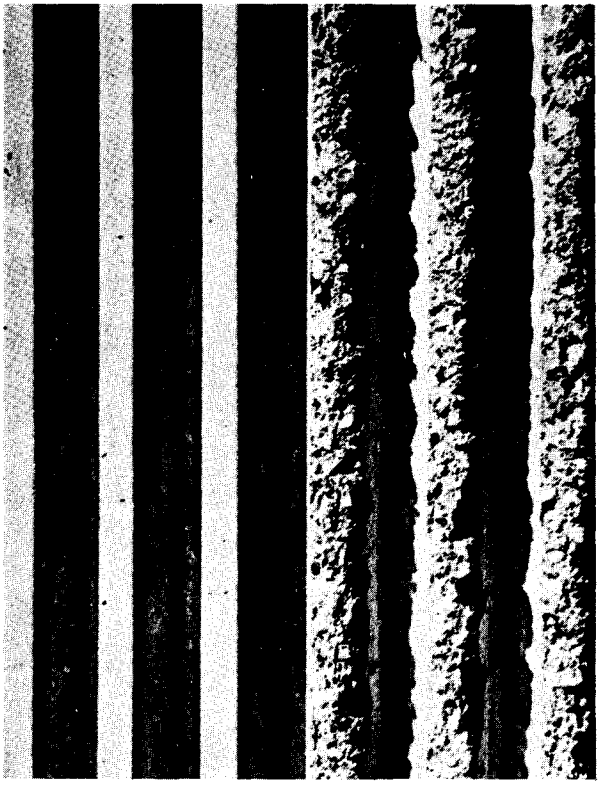

Figure 24. The above effect is achieved by casting against forms which have vertical ribs attached. Upon form removal, the projections of concrete are broken off with a hammer. A consistent treatment with the hammer is essential.

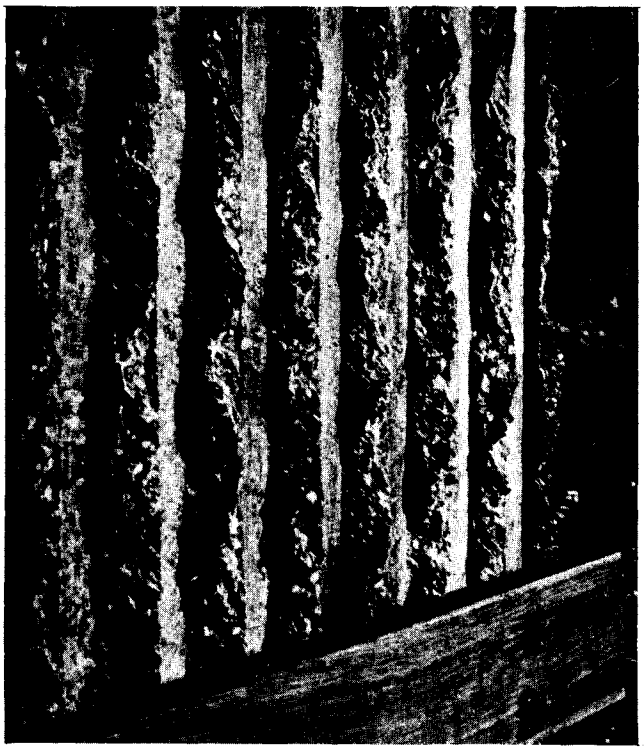

Figure 25. Same general type finish as shown in Figure 24.

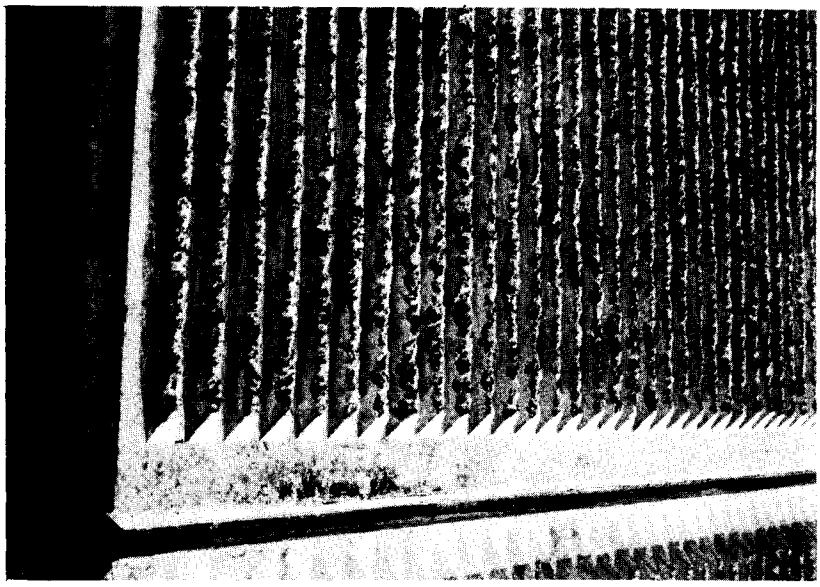

Figure 26. Same general type finish as shown in Figure 24.

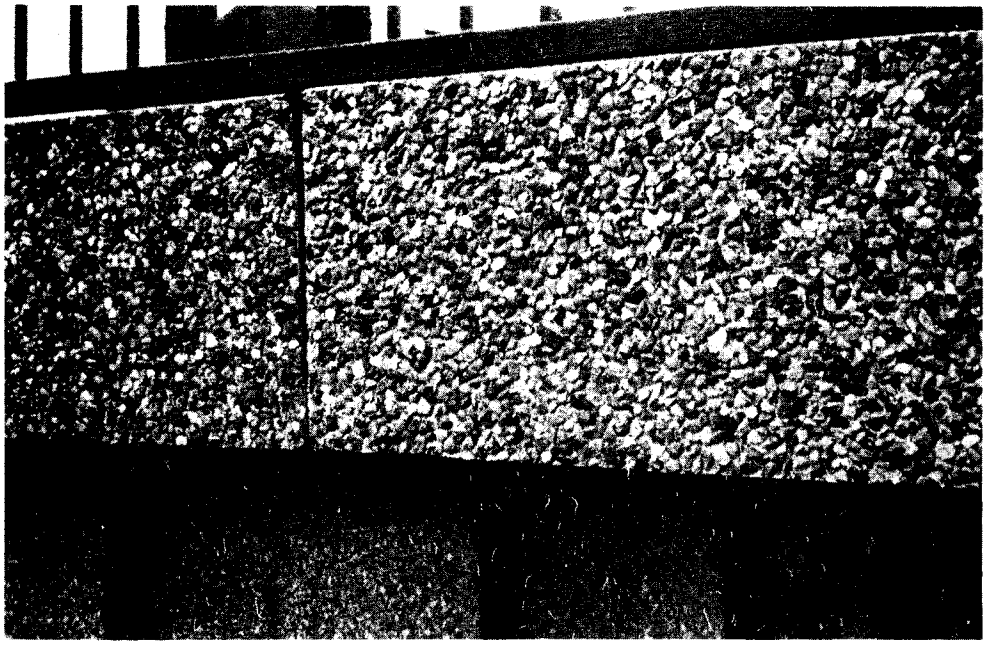

Figure 27. Heavy sandblasted finish.

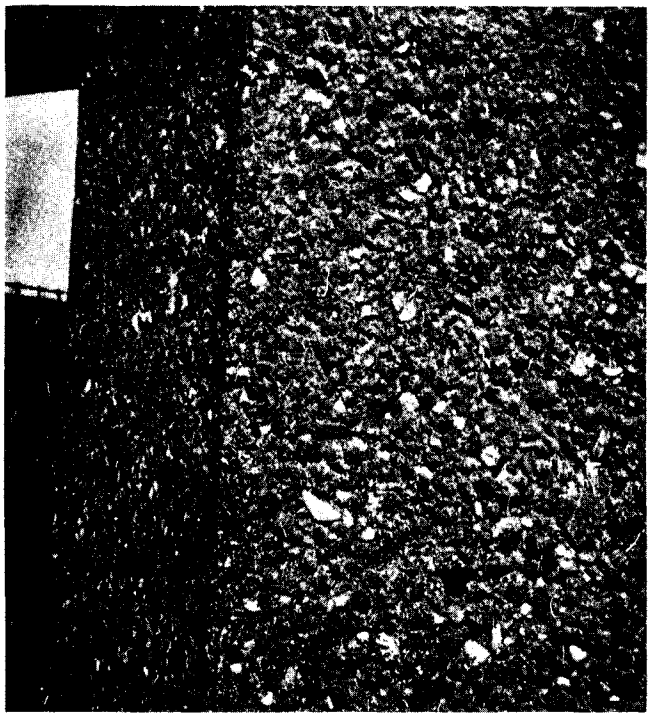

Figure 28. Medium to heavy sandblasted finish.

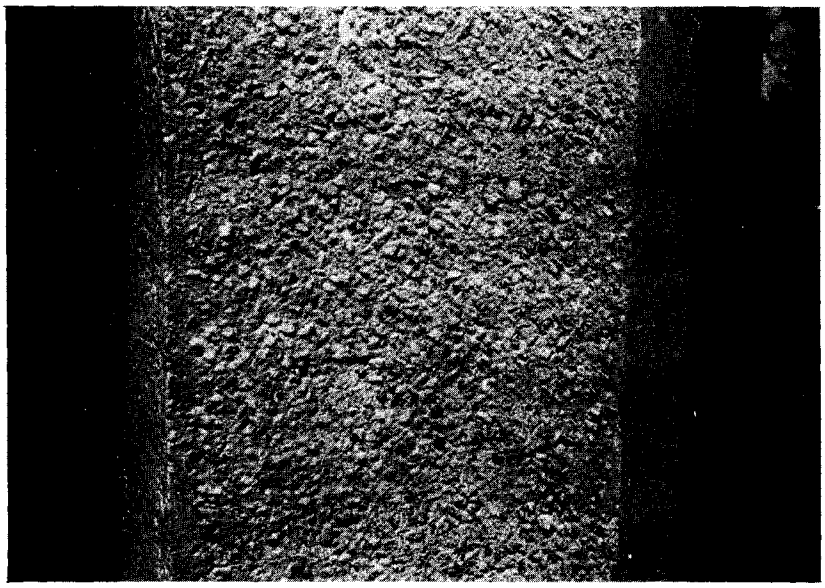

Figure 29. Medium sandblasted finish (white portland cement and white quartz aggregate).

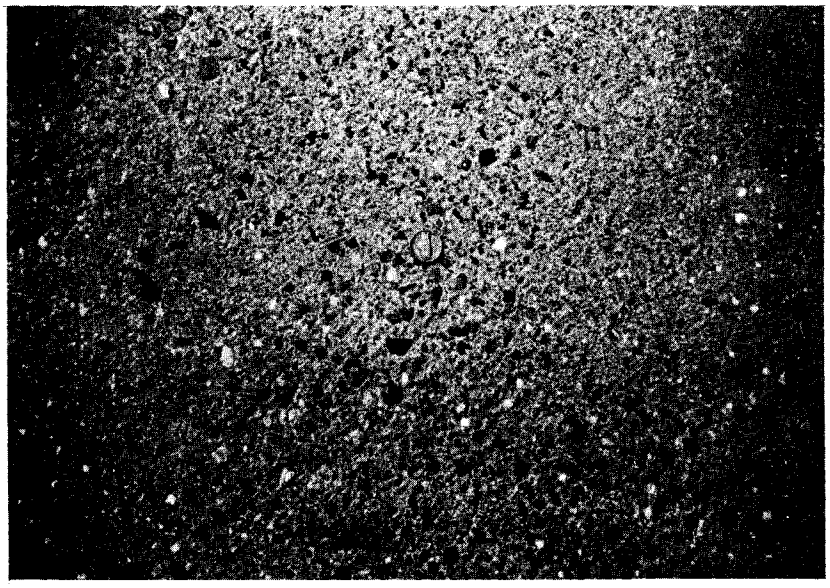

Figure 30. Light sandblasted finish.