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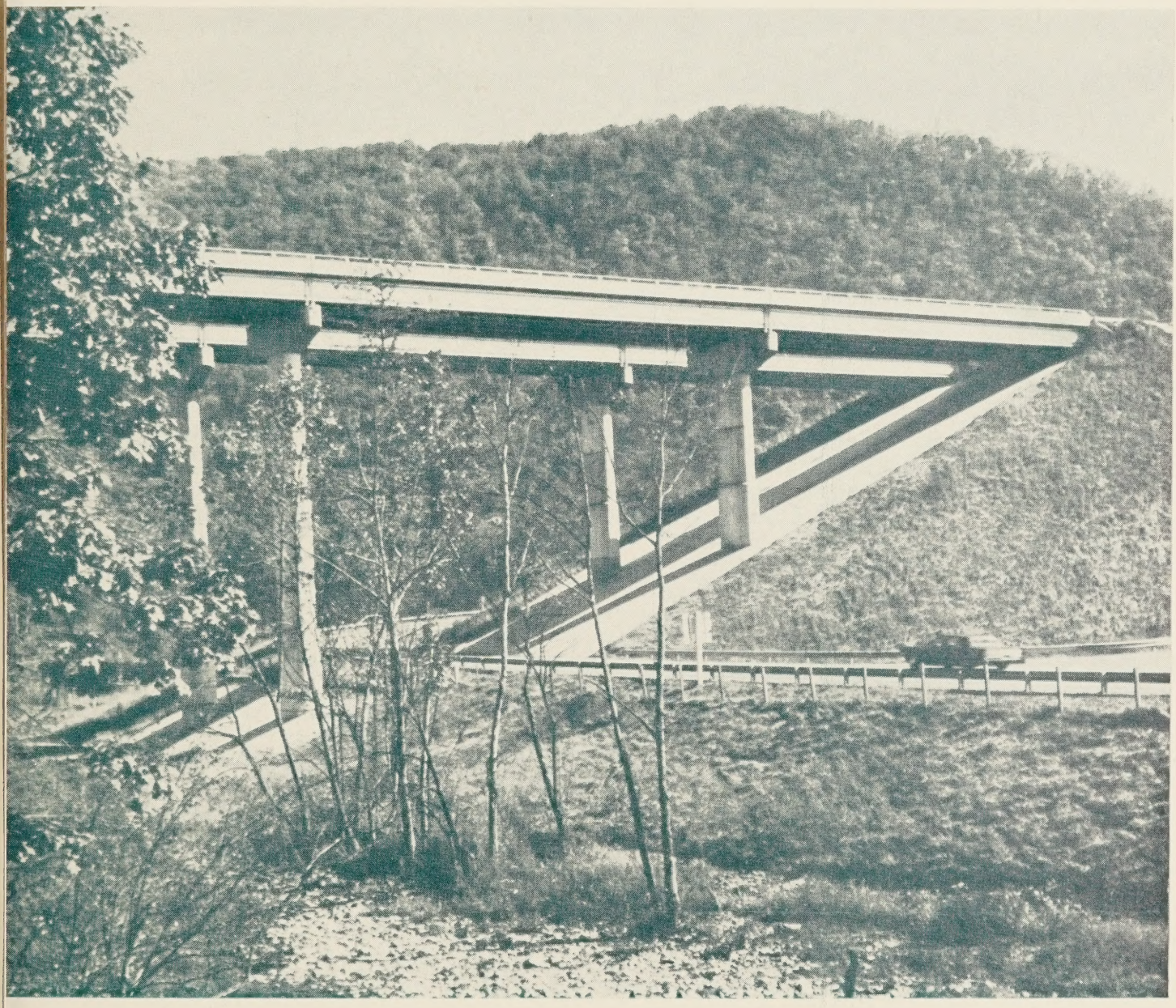
Public Roads

A JOURNAL OF HIGHWAY RESEARCH



U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
BUREAU OF PUBLIC ROADS

Public Roads

A JOURNAL OF HIGHWAY RESEARCH

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BUREAU OF PUBLIC ROADS
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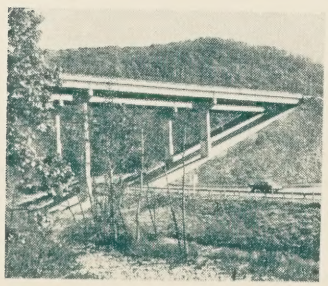
ERRATA

In the article *How Drivers Locate Unfamiliar Addresses—an Experiment in Route Finding* in the June 1970 issue of PUBLIC ROADS, A JOURNAL OF HIGHWAY RESEARCH, volume 36, No. 2, page 44, column 3, line 3, change the following statement:

"The local route in Annandale has three traffic lights on Old Georgetown Road. The Bethesda local route has three lights on Route 236 and on Columbia Pike." to read as follows:

"The local route in Bethesda has three traffic lights on Old Georgetown Road. The Annandale local route has three lights on Route 236 and on Columbia Pike."



COVER

Rural setting in Allegheny Mountains where Interstate Highway 64 crosses over U.S. Highway 60, approximately one-quarter mile east of Callaghand, Va. (Photo courtesy of Virginia Highway Commission.)

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FEDERAL HIGHWAY ADMINISTRATION
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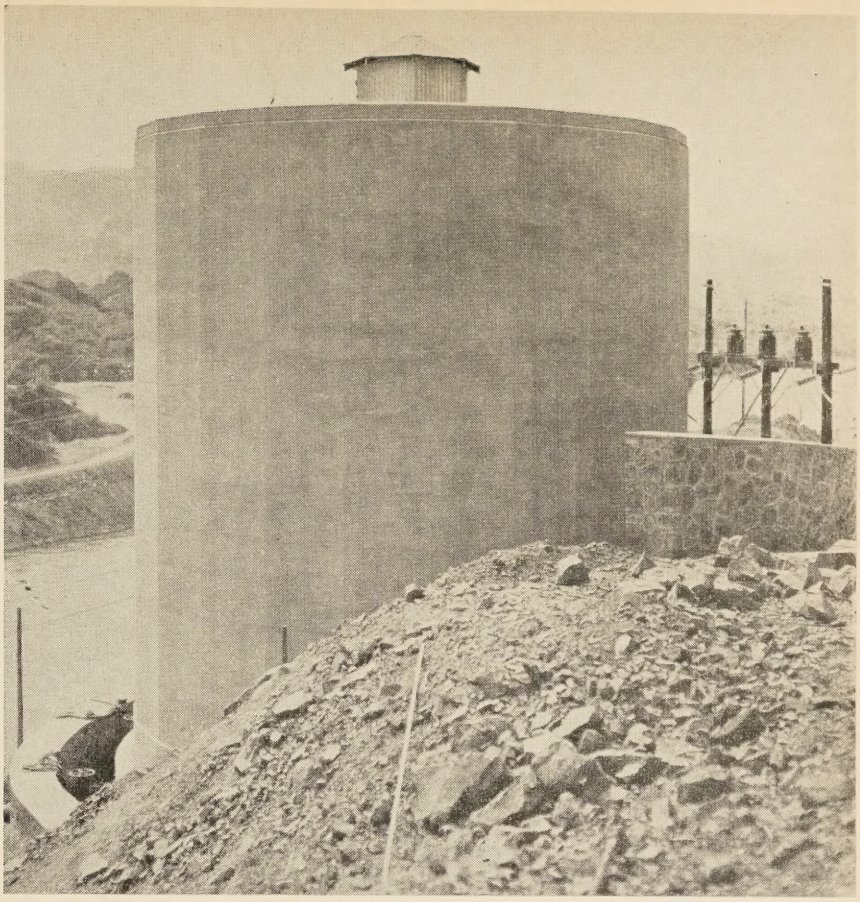

This 100,000-gallon water tank at Parker Dam, Calif., was formed against absorptive form liner in 1942.

BY THE
BUREAU OF PUBLIC ROADS

Effect of Absorptive Form Liner on Surface Durability of Concrete

Reported by[1] **FREDERICK W. CRON**
Engineer Manager
Office of
Engineering and Operations

At one time it was believed that research had established absorptive form liner (AFL) as the technique needed to produce architecturally-pleasing, dense, hard concrete surfaces that are more resistant to freezing and thawing and to mechanical abrasion than surfaces formed otherwise. Even though much research data supported the practicality of AFL and specifications were developed for its application by industry, this promising advance in concrete technology was never fully implemented.

The state-of-the-art summary presented here reviews much of the research that established AFL as a worthwhile method of concrete casting and restates the physical properties of concrete cast against absorptive form liners that were presented in reports from both research and construction projects. The author presents a case for further research on AFL, particularly to determine absorptive performance of form liners used on highway pavement and bridge deck surfaces.

Introduction

THIRTY years ago absorptive form liner (AFL) was hailed as the greatest advance in concrete since vibration, and yet today it would be difficult to find an engineer or concrete technologist under 45 who had ever heard of it. Like a new star AFL appeared on the horizon of concrete technology in the late 1930's, glowed brilliantly for a few years, and then faded into oblivion—an incredible eclipse when it is considered that the benefits of AFL were solidly supported by a successful research program that not only proved the practicality of the AFL concept, but also developed product specifications and methods of testing for full-scale application by industry.

In May 1938 the U.S. Bureau of Reclamation (USBR) began an investigation of surface durability of concrete, hoping to find a way to improve resistance both to weathering and to the erosion and cavitation that occurs when concrete is in contact with high velocity water. Concrete cast against ordinary vertical wood or metal forms exhibits numerous surface voids, or *bugholes;* sand streaks; channels; and other surface imperfections. If the forms overhang, as they do for sloping spillway surfaces, the pits are larger and more prevalent. By casting concrete against a sloping, transparent pyralin form, the USBR researchers proved that the pits were caused by bubbles of air trapped against the form. By drilling small holes through the pyralin form, the air was allowed to escape whereupon the bubbles collapsed. Shortly afterward clear water began bleeding from the holes and continued for some time in surprising amount.

The researchers then looked for a porous form lining material that would be strong enough to resist the pressure of the wet con-

[1] The paper on which this article is based was prepared by Mr. Cron while he was serving Region 9, Federal Highway Administration, as Chief, Design Division. He retired in February 1969 and since has again become active to serve in his present position.

crete, yet allow trapped air to escape into its interstices, and also absorb some or all of the free water adjacent to the form. Burlap, muslin, fabric-covered fly screen, blotters, and other materials were tried with limited success. Good results were obtained with vacuum mats, but forming complications obviated their use. All commercially available wallboards were tested; most of these had good absorption performance but stuck to the concrete and were difficult to remove.

Properties of AFL-Cast Concrete

The USBR Laboratory then made a series of tests to determine the physical properties of concrete cast against AFL. These tests are described in Laboratory Report C–114 (*1*),[2] and the results are briefly summarized, as follows:

- Concrete surfaces formed against AFL's have superior quality owing to the decrease in water-cement ratio resulting from direct removal of free water at the form surface. Good linings remove water from a concrete depth of almost 1 inch.
- The rate at which the lining removes water is important. Too rapid removal in the first few minutes causes a cleavage plane to form between the surface and the body of the concrete. A sustained rapid rate of removal causes *channeling*.
- Most of the water flows through the interstices of the liner and not in the fibers themselves. A satisfactory liner absorbs 0.433 lbs. of water per sq. ft. of surface.
- The volume of pits, or air voids, on a concrete surface cast against a sloping, 0.8 to 1, nonabsorptive wood form was measured at 17.85 cc. per sq. ft. of surface. A satisfactory absorptive liner has at least this much available pore space.
- The absorptive action of the liner substitutes mortar for air and water voids. If the liner is too thin or not sufficiently absorptive, not all of the voids will be eliminated. The surface will appear smooth, but grinding will expose pits just below the surface (fig. 1).
- Coarse aggregate particles lie more closely to the surface when AFL is used (fig. 2).
- X-ray photographs of slices cut from cubes formed against AFL distinctly show a surface densification that is absent from surfaces cast against nonabsorbent linings (fig. 3).
- A 90-p.s.i. airblast carrying No. 50 steel filings for grit was directed for 1 minute against test surfaces 2½ inches from the air nozzle. Surfaces cast against AFL were unaffected by the blast; those cast against plywood were badly eroded (fig. 4).
- Once a day for 35 days, test specimens were oven heated to 120° F. and then dunked in Denver tapwater, which is always about 40° F. No crazing was evident on AFL-formed specimens but specimens cast against plywood were badly crazed (fig. 5).

[2] Italic numbers in parentheses identify the bibliographical references listed on page 68.

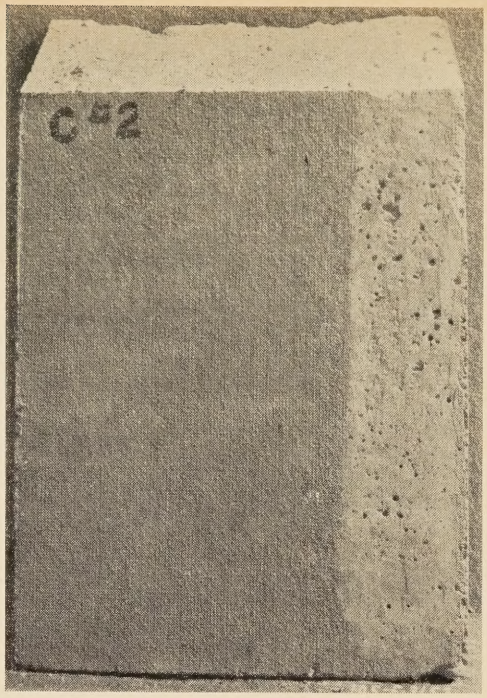

Figure 1.—Block formed against AFL of insufficient absorptive capacity has smooth-appearing surface, but stoning on right side has revealed pits below surface.

- Test beams with 3- by 3-inch cross sections and 9-inch lengths were broken under 2-point loading. Those formed against AFL, of all ages, from 7 to 28 days, had 35–40 percent higher flexural strength than those cast against ordinary liners. This increase was attributable to the better tensile and compressive strengths of the densified concrete at the beam surfaces resulting from the lower water-cement (w/c) ratio of the surface concrete.
- Compressive strengths of 3-inch cubes were increased 40 percent by casting against AFL.
- Test specimens, consisting of 9- by 9- by 3-inch blocks, were alternately frozen for 17 hours at 5° F., and thawed at 70° F. After a 60-cycle period, the plywood-formed blocks failed with 38 percent loss, whereas the AFL-formed blocks had only 0.3 percent loss at 100 cycles. In another test at 120 cycles, plywood-formed samples had 45 percent loss, and the AFL-formed specimens, zero loss (fig. 6).

Use of AFL in Field Projects

The laboratory results, particularly the resistance to abrasion and to freezing and thawing were so encouraging that the USBR ordered a full-scale field test at Grand Coulee Dam, then under construction. AFL was used for the downstream faces of 22 block lifts, each of which had a 50-foot length, a 5-foot height, and a front slope of 0.8 to 1—a total area of 5,962 square feet. Thirteen different liners furnished by four manufacturers were used to form the block lifts, and the work was done in October and November 1939 by experienced workmen under close field laboratory inspection. Although some of the liners stuck excessively to the concrete, the results were generally encouraging. In November 1939, the board of consulting engineers that evaluated this test stated that none of the boards used was fully satisfactory in removing excess water and surface pits, and suggested that research be continued.

During the Grand Coulee tests and in subsequent projects, the USBR invited the major wallboard companies to participate in a program to develop a form liner that would combine absorptivity with strength but not stick to the concrete. The Denver laboratory developed specifications and acceptance tests that were used to purchase form liners for the Parker Dam Powerhouse, the Shasta Dam, the Friant Dam, and for other USBR structures.

At Parker Dam Powerhouse in California, AFL was specified for both interior and exterior surfaces. A total of 240,000 square feet of *Firtex* AFL, meeting the USBR's specification, was purchased for this job and installed by USBR forces. Architectural results were very satisfactory, but special precautions were needed to avoid accidental wetting of the form liner before the concrete was placed against it (*2*). As this was one of the first structures on which AFL was used extensively, many of the forming details and construction procedures had to be developed specifically for AFL. The Parker Dam Powerhouse structure is now 28 years old. (See illustration at beginning of article.)

In 1941, the USBR used 1.5 million square feet of *Celotex* AFL on the Friant Dam in California. The lining was purchased under the USBR's AFL specification by open bidding and furnished to the contractor. All per-

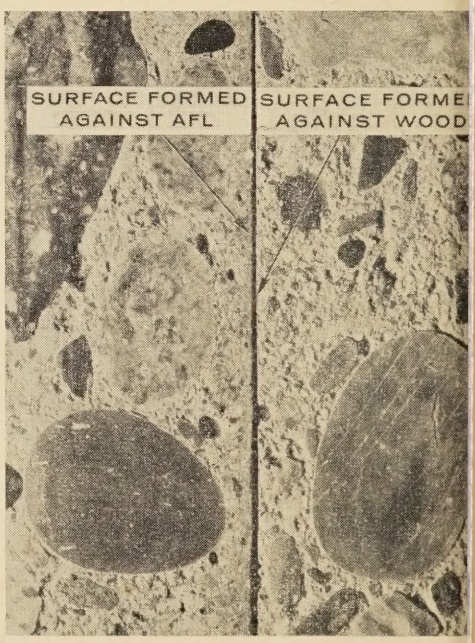

Figure 2.—On specimen formed against AFL, surface has superior density, and coarse aggregate tends to lie more close to surface.

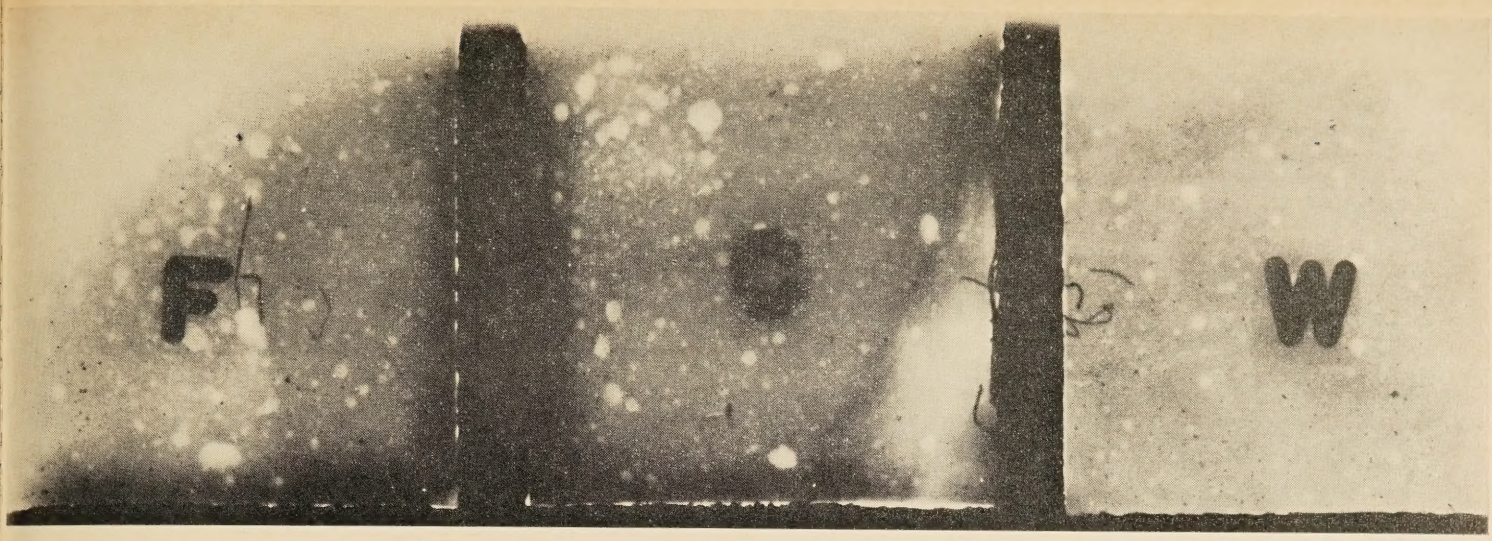

Figure 3.—In these X-ray views of slices cut from test blocks, case hardening effect of AFL is shown by darker appearance of denser surface concrete on specimens F *and* C. *Specimen* W *was cast against wood form.*

manently exposed surfaces of the dam, including the sloping overflow sections and the stilling basin, were poured against AFL. As at Parker Dam Powerhouse, special techniques were developed to keep the AFL dry prior to concreting and to patch honeycomb, vibrator bruises, and other surface blemishes (*3*, *4*, *5*).

Other dam-building agencies became interested in AFL after USBR had shown the way. In 1941, after an extensive program of testing, which confirmed the USBR findings in all essential respects, the Tennessee Valley Authority (TVA) used AFL for all exposed surfaces of the Kentucky Dam project, including the dam itself, the powerhouse, and the lock. No particular difficulty was experienced by TVA in the use of AFL on this project, and superior results, particularly in surface finish, were reported (*6*).

The Corps of Engineers used nearly a million square feet of *Hydron*—a thin fabric facing bonded to an absorptive cardboard backing—on the Norfork Dam in Arkansas, during 1944–45 (*7*). This AFL was also used for parts of the John Martin Dam in Caddoa, Colo., and of the Nimrod and Clearwater Dams in Arkansas. Previous to these applications extensive tests by the Corps' Little Rock and Caddoa district offices established the superior performance of *Firtex* as an AFL (*8*). However, when actual construction began on the Norfork Dam, *Firtex* was unavailable owing to wartime restrictions, and the fabric-faced flexible *Hydron* was used instead.

The Wyoming Highway Department was the first State highway department to use AFL. Form liner conforming to USBR specifications was specified for a railroad underpass in Casper and for three concrete structures in Rock Springs. The total cost of these structures was about $800,000. The kind of forming required for these rather complicated structures was much different from that used on dam faces, and yet, by exercising great care in all forming and concrete placing operations, a first-class job was obtained. These structures were completed in 1941 (*9*). (See figs. 7 and 8.)

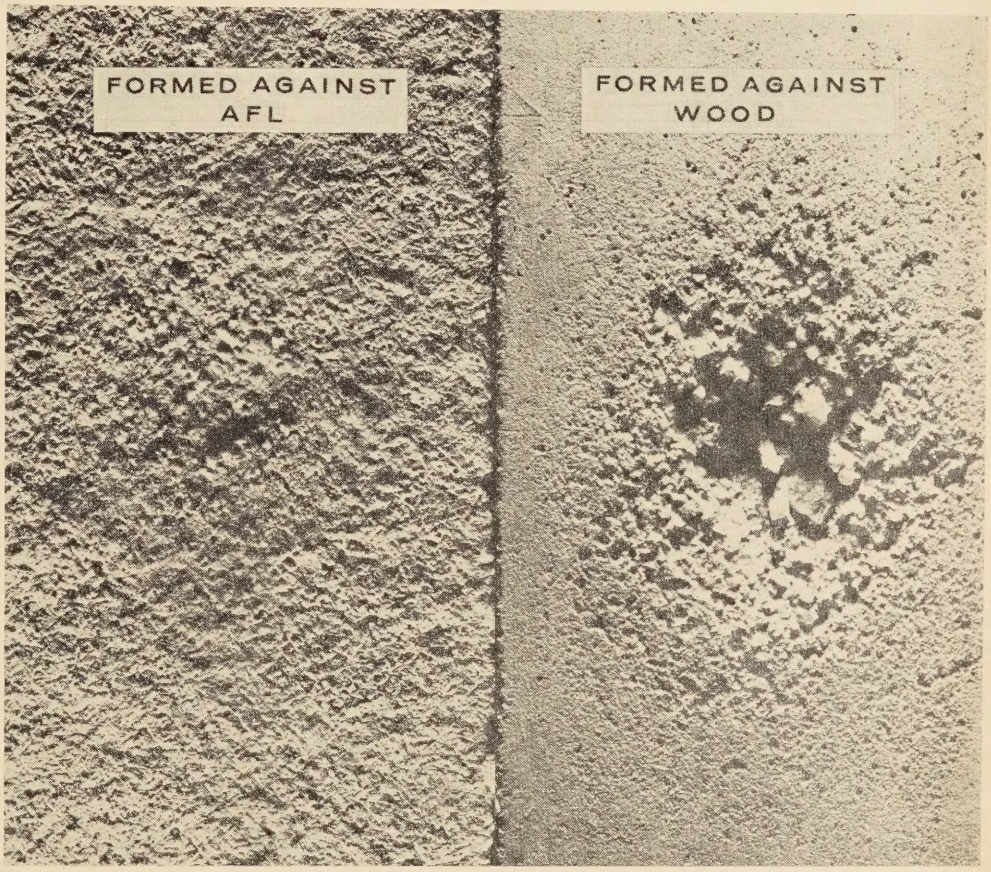

Figure 4.—Comparison of results of 1-minute abrasion test on AFL formed and wood-formed surfaces.

In 1940, AFL was used experimentally by the Bureau of Public Roads to form box culvert headwalls on the Natchez Trace Parkway in Mississippi.

The Bureau of Reclamation has in its outdoor weathering test area in Denver the acceptance panels cast against ordinary plywood, *Firtex* and *Celotex* for the Parker and the Friant Dams in 1941, and a set of test blocks cast against *Hydron* in 1944. These and the full-scale field applications mentioned above are now more than 26 years old. As no comprehensive service evaluation has ever been made, their superiority in resistance to weathering over concrete formed against plywood or boards is unknown.

Summary of AFL Field Evaluations

The full-scale field applications moved AFL from the laboratory out to the job where the construction engineers developed techniques for handling the new materials. Their evaluations, as expressed in the reports and articles cited at the end of this article are summarized below:

- None of the varieties of AFL is reusable.
- Use of AFL increases forming costs by the cost of the material and the labor to apply it to the backing forms. Also, when AFL is used, it is more difficult to clean out the forms preparatory to concreting because of possible bruising or premature wetting.
- Offsetting the above disadvantages, the form liner protects the backing forms from damage and permits their repeated use with negligible cost for rehabilitation. At the Norfork Dam, about 3½ cents per square foot of wooden forms was saved by form-liner protection.
- AFL is vulnerable to careless concrete placement. One blow from a vibrator spud or a shovel will bruise the liner and produce a raised blemish on the final concrete surface.
- When AFL is used, honeycomb, spreader holes, and raised blemishes are difficult to patch, although patching is possible. Patches are easily distinguishable from unpatched adjoining surfaces.
- Surfaces properly cast against AFL have a pleasing appearance and texture and do not need to be rubbed, ground, brushed, or otherwise treated for final finish. The cost of finishing, thus saved, can be credited against the increased cost of the liner.
- AFL has some value as a curing medium. At Los Angeles Union Terminal, one of the earliest jobs on which AFL was used, the *Celotex* AFL was left adhering slightly to the concrete surface after the backing forms were removed. The AFL was then shifted slightly, left against the concrete, and kept wet, giving effective curing. At Norfork Dam, *Hydron* AFL was left in place as a curing medium for the full 21-day curing period (*7*, *10*).

Development of absorption test for AFL

During 1941 and 1942 the Bureau of Reclamation continued its basic research on AFL specifically to develop a test to measure both the rate and amount of absorption of AFL materials. In the flotation test that evolved, 4- by 4-inch specimens of lining were floated in lime water, and capillary liquid uptake was obtained by weighing the specimen at intervals. It was determined that absorption could be expressed by the curve

$$W = C \log_e T$$

Where,

W = Grams of water absorbed per 16 square inches of AFL surface.

T = Time.

C = A constant varying with the particular AFL material, called the *absorption constant.*

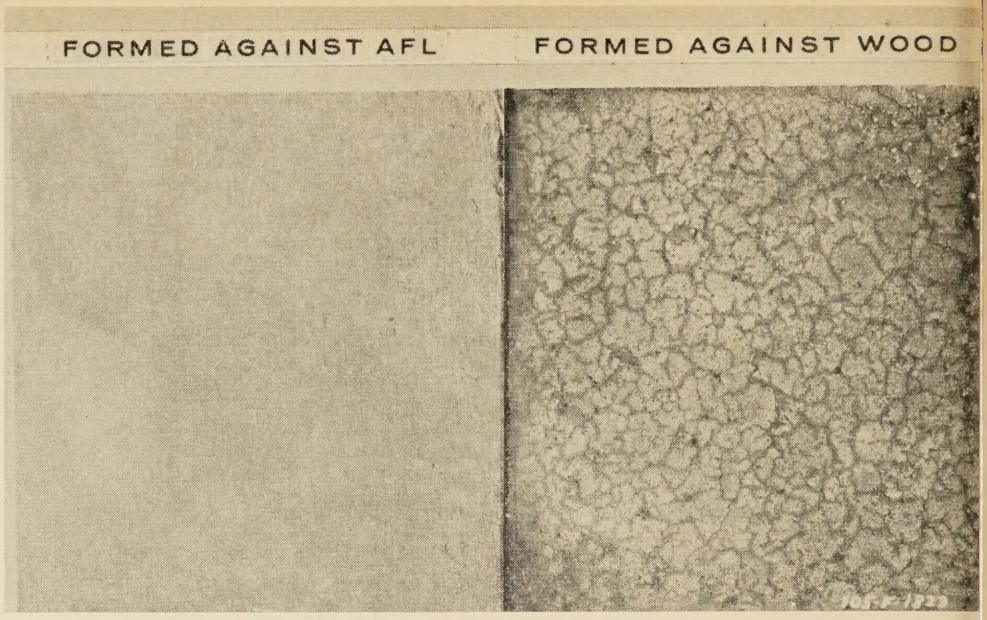

Figure 5.—Comparison of resistance to crazing of surfaces poured against AFL and wood forms.

AFL's having absorption constants of 3.83 or less were not able to inhibit the formation of pits. Absorption constants of more than 5.50 were unnecessary, and often could be harmful. The working range of C-values for any AFL therefore was found to be between 3.83 and 5.50 (*11*).

It was further established that the depth to which AFL will remove free water and lower the water-cement ratio varies as the absorptive constant C of the material changes. The maximum depth observed was 0.9 inch. A lining having a moderate C value of about 4.28 will remove as much as 16 percent of the total mixing water in the concrete near the form, and 1 percent at a depth of three-fourths inch from the surface (*11*). For any given lining, the percentage of the water removed from the mix by the AFL remains constant regardless of the absolute amount in the mix. In one test of concrete formed against an AFL of $C = 3.83$ the water-cement ratio of the surface concrete was only 84 percent of the w/c ratio at a depth of 1 inch from the surface. The surface concrete was 23 percent stronger than the interior concrete (*11*).

Other properties of concrete cast against AFL

Other research by the USBR, TVA, and Corps of Engineers established the following additional properties of AFL-formed concrete surfaces:

- Surfaces of all ages from 1 to 50 days formed against an AFL have markedly better surface hardness than those formed against wood, as measured by the ball impact test. The ball-impact test measures the diameter of the impression made by a 1½-inch steel ball swung from a horizontal position at the end of a string 18 inches long. For example, at age 28 days, 0.21-inch-diameter impressions were made in AFL formed surfaces as compared with 0.34-inch impressions in wood-formed surfaces.
- Surfaces cast against oiled wood forms are more porous than those cast against AFL's. When specimens were soaked overnight and then allowed to dry, those cast against AFL's dried faster than those cast against wooden forms as the latter had absorbed more water (*6*).

Table 1.—Changes in characteristics of moist-cured and air-cured concrete specimens after 27-day curing period

Type of form lining	Method of curing concrete	Change after curing 27 days			
		Weight change, percent of mixing water		Compressive strength at 28 days	Ratio of air-cured strength to moist-cured strength
		Gain	Loss		
		Percent	*Percent*	*p.s.i.*	*Percent*
Oiled wood	Moist room	+16.4	------	4,410	66
	Air of laboratory	------	−34.1	2,910	
Absorptive form liners:					
A	Moist room	+10.1	------	6,040	81
	Air of laboratory	------	−24.4	4,900	
B	Moist room	+9.8	------	4,830	82
	Air of laboratory	------	−28.8	3,960	
C	Moist room	+9.1	------	4,930	80
	Air of laboratory	------	−29.5	3,940	

• Sandblasting exposed the coarse aggregate of 28-day-old concrete cast against oiled wood forms, but had little effect on surfaces cast against AFL's. Slabs cast against the most highly absorbent AFL's showed the least wear (*6*). This observation confirmed the USBR's findings (*1*) from the much more severe Ruemelin blast test using steel abrasives.

• Specimens cast against AFL were less affected by inadequate curing than those cast against wood forms. One set of 6-inch cubes was cast against AFL, and another set against oiled wood. Half of each type were cured in a moist room, and half were left in the air of the laboratory. The cubes were weighed immediately upon removal from the forms, 24 hours after removal, and at intervals thereafter up to 28 days. All the air-cured specimens cast against AFL's lost less weight than their counterparts cast in wood forms. The opposite effect was observed in the moist-cured specimens—the weight *increase* was less for the AFL-formed specimens than the wood-formed specimens (*6*). These results occurred, it was inferred, because the dense, case-hardened surfaces produced by the AFL inhibited moisture loss from the cube core in air-cured specimens, and checked moisture absorption in moist-cured specimens. All cubes cast in absorbent molds, both air cured and moist cured, had higher compressive strengths than those cast in oiled wood molds. In these tests AFL forming not only produced an appreciable increase in strength over wood forming, but also reduced the loss of strength that occurred when specimens were air cured rather than moist cured. The air-cured strength of the wood-formed cubes was only 66 percent of the moist-cured strength, whereas the air-cured strength of the AFL-formed cubes was 80 to 82 percent of moist-cured strength. The dense concrete at the face of the cubes allowed less water to escape from the concrete after the initial set, leaving more for hydration during the hardening process. This is the principle on which surface or membrane curing agents work, except that the dense surfaces obtained with AFL are more effective than the usual membrane agents in reducing moisture loss (*6*). These interesting results are shown in table 1.

• Two-inch mortar cubes formed against *Firtex* AFL absorbed only 89 percent as much water as similar plywood-formed cubes when both were subjected to the 5-hour boiling test, ASTM Designation C 67–39, for testing brick (*8*).

• AFL formed surfaces gave superior results in Swiss Hammer tests. Swiss Hammer rebound readings were taken and correlated with compressive strength; surfaces formed against oiled wood and those cast against *Firtex* were then tested with the Swiss Hammer and compared. Wood-formed surfaces 4 days old had a strength of 1,750 p.s.i., and AFL-formed surfaces of the same age had a strength of 3,100 p.s.i. After the specimens were 35 days old, the corresponding values were 3,750 p.s.i. and 6,000 p.s.i. (*12*).

When interest in AFL's was at its peak in the early 1940's, at least eight large companies had active programs underway to develop acceptable liners that could control the rate of absorption without adhesion to the concrete. Boards that met all requirements were developed by several companies, but the bright future for AFL, promised by the early investigations, failed to materialize. There was no widespread use of AFL's by construction agencies and the market failed to develop. One by one, producers of AFL discontinued the product. To the author's knowledge, only one absorptive form liner, *Firtex*, is still commercially available.

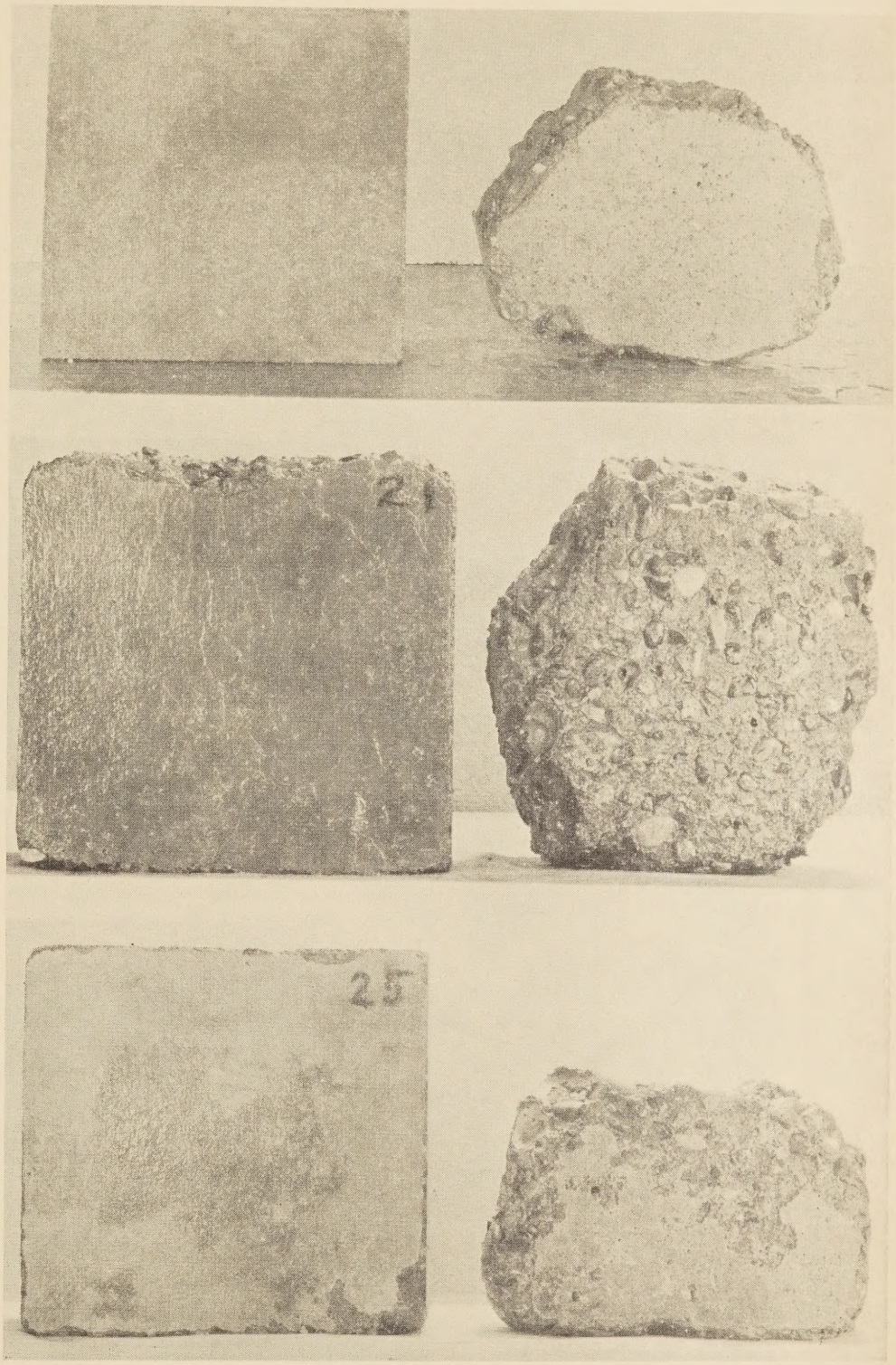

Figure 6.—Comparison of durability tests on 9- by 9- by 3-inch blocks cast against AFL (left) and wood forms (right). Upper pair—wood-formed block failed with 37 percent loss at 60 cycles of freezing and thawing; AFL-formed block lost only 0.5 percent. Middle pair—wood-formed block failed with 38 percent loss at 160 cycles; AFL-formed block lost only 3 percent. Lower pair—wood-formed block failed with 45 percent loss of 120 cycles; loss on AFL-formed block was zero.

Postwar Development

Two sequels to the USBR's research occurred in the postwar years. In 1945 a USBR employee made perforated forms by drilling 1/32-inch-diameter holes spaced on 1/4-inch centers through plywood or metal panels. The faces in contact with the concrete were covered with fabric to prevent loss of cement and plugging of the holes. The surfaces produced by casting against these perforated forms were equal in quality to those cast at the same time against absorptive form liner and superior to those cast against oiled wood forms. To facilitate the bleeding of air and water through the perforated forms and to inhibit hole plugging by cement, an ordinary household vacuum cleaner was applied to the back of the forms with excellent results. Grinding disclosed that there were fewer subsurface pits in the concrete placed against perforated forms than that placed against AFL (*13*).

Perforated forms would undoubtedly have a higher first-cost than ordinary forms lined with AFL. However, for certain types of work, like curbs and bridge parapets, reusability and simplification of form details would probably offset initial cost. Perforated forms are patented.

Erosion studies

The other postwar development in AFL's arose out of the USBR's interest in the cavitation erosion of concrete in contact with high-velocity water. Smooth-flowing, clear water, even at high velocities, will not damage ordinary concrete, but whenever the velocity or direction of high-velocity water is abruptly changed, or when conditions reduce the pressure of the water, pitting may result from cavitation. To measure cavitation erosion, the USBR developed a special machine and a standard procedure for its use. The results of each test were expressed by the symbol *H CI SI*, which represents the number of hours (*H*) of exposure required to erode 1 cubic inch (*CI*) per square inch (*SI*) of surface exposed to cavitation attack (*14*).

To measure resistance to mechanical abrasion the USBR developed a standard shot-blast test. Standard specimens identical to those used in the cavitation machine were exposed for approximately 3 minutes in a Ruemelin abrasion machine to an 80 p.s.i. airblast carrying 2,000 grams of No. 50 steel grit. The 3/16-inch air nozzle was held 4½ inches from the surface of the specimen. The test consisted of six separate exposures of the test specimen to 2,000 grams of steel grit, each exposure being applied at a different spot on the test surface. The results were expressed in *H CI SI* units (*14*).

In 1951 the USBR embarked on a comprehensive research program to ascertain the effect on resistance to erosion of varying the properties of the concrete used in test specimens. The more significant results of this program are given in the following summary:

- Resistance to erosion varies inversely with the water-cement ratio.
- With a given water-cement ratio, mixes of 3- to 4-inch slump are slightly more resistant than either very dry or very wet mixes.
- For concretes of the same water-cement ratio, resistance to erosion decreases slightly as the percentage of entrained air increases. However, within the range of nominal air contents, 0–4 percent, the resistance to erosion is not reduced by entrained air if the desired strength of concrete is maintained.
- Erosion resistance increases directly with compressive strength.
- Resistance to erosion increases with the age of the concrete. The increase is very rapid during the first 28 days, but diminishes to almost zero after 90 days.
- A vacuum of 20-in. Hg applied to fresh concrete test surfaces tripled resistance to erosion. Thus, vacuum-treated specimens 28-days old had an *H CI SI* of 18.1 whereas nontreated specimens of the same age ha an *H CI SI* of only 6.1. Comparable result were experienced with concrete cast agains AFL boards.
- Resistance of concrete to cavitatio erosion varies directly with the resistance t abrasion erosion.

In a later series of erosion tests by USBR it was shown that surfaces formed agains AFL's could have three times the abrasio resistance of surfaces given a steel trowe finish, 4½ times that of wood float finishes and 2½ times that of vacuum-treated surface (*15*). These concrete-erosion studies interes highway engineers because of their bearing o skid resistance. Pavement polishing is closel related to the resistance of the pavemen surface to mechanical abrasion. Extension o the skid-resistance qualities of a pavemen surface by 2 or 3 years, as might be expecte from use of AFL or vacuum treatment, ma be economically significant.

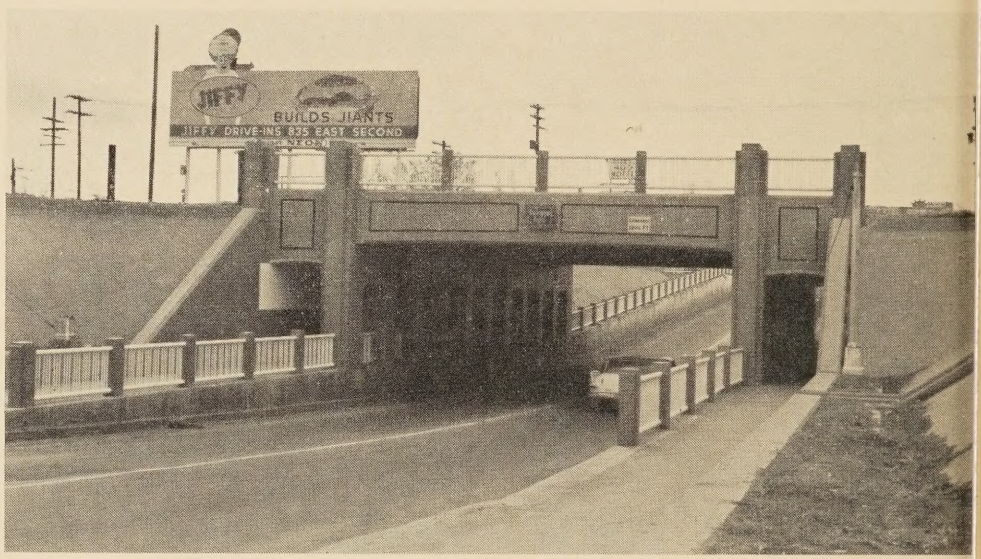

Figure 7.—In this C.B. & Q. Railroad underpass at Casper, Wyo., completed in 1941, an in other similar structures at Rock Springs, Wyo., AFL was used for the first time form bridge concrete surfaces.

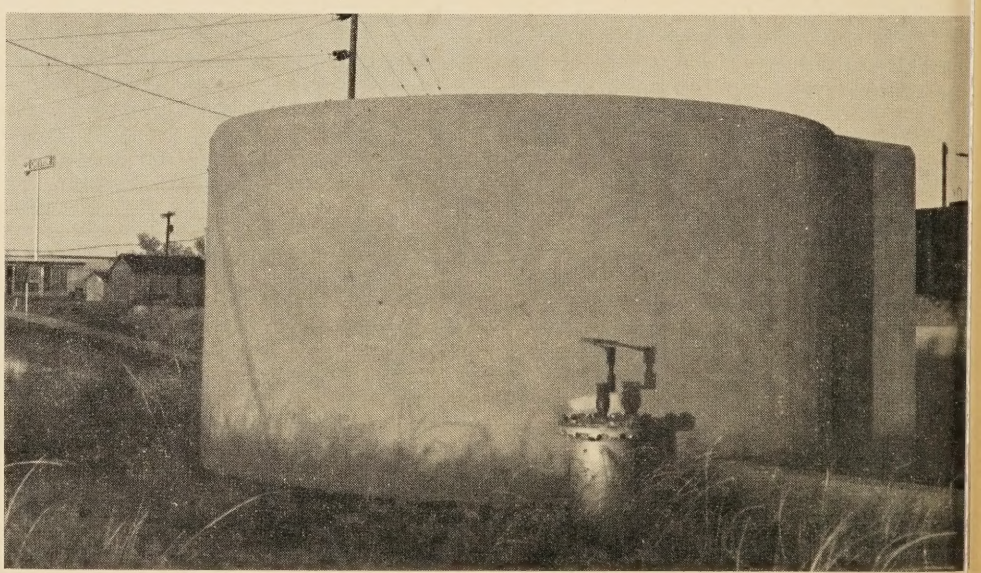

Figure 8.—Pumphouse of C.B. & Q. Railroad underpass poured against AFL in 1941

Public Roads Research

Beginning in 1951 the Bureau of Public Roads studied the effects of calcium chloride on the wearing surface of concrete. Tests made under outdoor weather conditions on concrete slabs on the ground evaluated the effects on surface durability of various mixes, cements, air-entraining admixtures, vacuum treatment of the surface concrete, and different methods of curing. The slabs were flooded with clear water in autumn and winter. When ice was frozen on the slabs, calcium chloride was applied, and after the ice was completely thawed they were washed and the surfaces rated for scaling. The ratings were based on visual observation of the extent and depth of scaling according to an 11-step table graduated from zero for *no scale* to 10 for *deep scale over the entire surface*. After 154 cycles of freezing and thawing the following results were reported (*12, 16*):

- A remarkable increase in surface durability resulted from air-entrainment. Specimens containing 5.2 percent entrained air were rated 2 after 154 cycles, whereas nonair-entrained specimens were rated 10 after only 51 cycles.
- Type of curing had little effect on the resistance of concretes to chloride attack.
- Application of a vacuum of 18–25 in. Hg to the surface of the plastic concrete for 30 minutes significantly increased the resistance to scaling of both nonair-entrained and air-entrained concretes.

This last result was unexpected, as it was believed that the vacuum treatment would not benefit air-entrained concrete because such concrete not only has inherent resistance but the vacuum treatment supposedly would lower the air content at the surface. It was postulated that this unpredicted behavior was probably due to reduction in water-cement ratio at the surface.

A new series of outdoor exposure tests and laboratory tests undertaken in 1956 pointed to the following additional conclusions concerning resistance to chloride attack:

- Even with air-entrainment the water content of concrete is of primary importance to its resistance to scaling caused by calcium chloride. Higher water-cement ratios result in more severe scaling. For example, mixes containing 7½, or even 6½, gallons per sack may show severe scaling after only 35 cycles of freezing and thawing—less exposure than may be expected in two average winters.
- The severity of scaling is influenced by the amount of water in the concrete when it is first frozen. Concrete subjected to freezing and thawing at an early age is likely to suffer serious scaling. Thus, for concrete placed when freezing is imminent, scaling can be minimized if wet curing is curtailed.

It is strongly suggested by the Public Roads research that the beneficial effect of air-entrainment in reducing scaling is greatly reinforced by removal of water by vacuum treatment or other means. Also significant is the observation that concrete that has a high-water content when first frozen is more susceptible to scaling damage. It follows, therefore, that any procedure, like vacuum treatment or AFL application, that will remove part of the mixing water before freezing takes place should reduce susceptibility to scaling.

Summary and Conclusions

From the research and practical experience presented here the following properties of concrete surfaces formed against AFL seem firmly established:

- Surfaces formed against AFL's are architecturally pleasing and require no rubbing, grinding, or other treatment after the forms are removed.
- Surfaces formed against good AFL's are denser, harder, and stronger and are more resistant to freezing and thawing and to mechanical abrasion and cavitation than surfaces formed against steel or wood forms.
- These properties derive from a *case-hardened* surface formed by removing air bubbles and excess water from the surface of the concrete, which in turn, lowers the water-cement ratio at the face and increases the strength of the surficial concrete to a depth of about 1 inch. This case-hardened skin forms a barrier to the escape of water needed to complete hydration of the cement and thus acts as a fairly effective curing agent.

The author believes that AFL can solve many of the pressing problems associated with concrete exposed to weathering, particularly in bridge decks, curbs, and parapets. Disintegration of exposed concrete surfaces in bridges, related in some degree to the use of chlorides for ice control, is a widespread and serious problem in this country. It seems logical that the dense, impervious surfaces imparted by AFL would reduce the penetration of water and brine into the concrete and mitigate damage by freezing and thawing.

Curing is perhaps the weakest aspect of modern concrete technology. AFL provides, directly, an effective mat for keeping surfaces moist, and, indirectly, a means of creating a dense impervious *skin* to retain moisture required to hydrate the cement. Such protection is especially important in extremely dry regions, as in our western States where low humidities and high winds combine to desiccate exposed concrete surfaces like bridge decks and pavements. According to recent research in South Africa, drying of the concrete during the first few hours after placement is detrimental to the rate and extent of cement hydration and should be avoided. Application of water after an intermediate period of drying promotes further hydration and is beneficial, but this hydration cannot repair damage caused by shrinkage (*17*).

Loss of skid resistance owing to wear and polishing is another problem connected with concrete surfaces. The remarkable increase in resistance to abrasion of AFL-formed surfaces should significantly extend the skid-resistance life of concrete pavements.

The value of AFL for forming surfaces in contact with high-velocity water has been amply demonstrated by research, but no evaluations of service behavior from actual installations are available at present. Use of AFL to provide leak-resistant walls for tanks, reservoirs, canals, and basements is logical, but as yet there is no record of such applications.

The architectural merit of AFL for both interior and exterior applications has been amply demonstrated in actual projects, notably the California Fruit Growers Exchange Building (*18*) and the Los Angeles Union Terminal. Aside from the pleasing texture achieved, the elimination of crazing is perhaps the most important contribution of AFL to architectural concrete. In 1939 it was reported that the exterior walls of the Los Angeles Terminal showed no evidence of crazing on 3-year-old *Celotex*-formed surfaces, whereas surfaces of the same age adjacent to the Terminal cast against plywood were badly crazed.

Despite the thorough research on AFL by the USBR, TVA, Corps of Engineers, and the wallboard companies, there are still areas in which additional research is desirable. The most important of these relates to absorptive performance when form liners are used on horizontal surfaces like pavements or bridge decks. Johnson theorized that the absorptive action would not occur in the absence of a head of concrete to squeeze out the air and water (*6*). However, this opinion is not backed up by any experimental evidence, and it seems reasonable that capillary action alone may be sufficient to remove excess water. (See flotation test previously described.)

During the past 10 years new products, such as the plastic foams, have been developed by industry. Some of these might possibly be effective absorptive form liners, and their potentialities should be investigated through research. Further research and development should be directed toward improving perforated forms and perfecting rapid and efficient applications of a vacuum to horizontal surfaces. The effect of absorptive liners and vacuum treatment on the entrained air-void system of air-entrained concrete surfaces also should be investigated, particularly to determine whether such treatment significantly reduces entrained air at the surface and whether removing water from the surface has a synergistic effect with air-entrainment to reduce surface scaling.

There is a need for full-scale experiments in which AFL is used on decks, curbs, and parapets of actual bridges exposed to normal maintenance, especially the use of deicing agents. These experiments should be conducted on pairs of bridges on divided highways, in which one structure is formed by AFL and the other by prevailing concrete-forming methods.

Finally, existing installations where AFL has been used to form concrete surfaces should be evaluated to determine service history, resistance to weathering, and present condition.

Concrete is the most widely used structural material in the world today; in fact, the 20th century could very well be called the *Age of Concrete*. Concrete has been the subject of intensive research and product development,

(*Continued on p. 68*)

BY THE OFFICE OF
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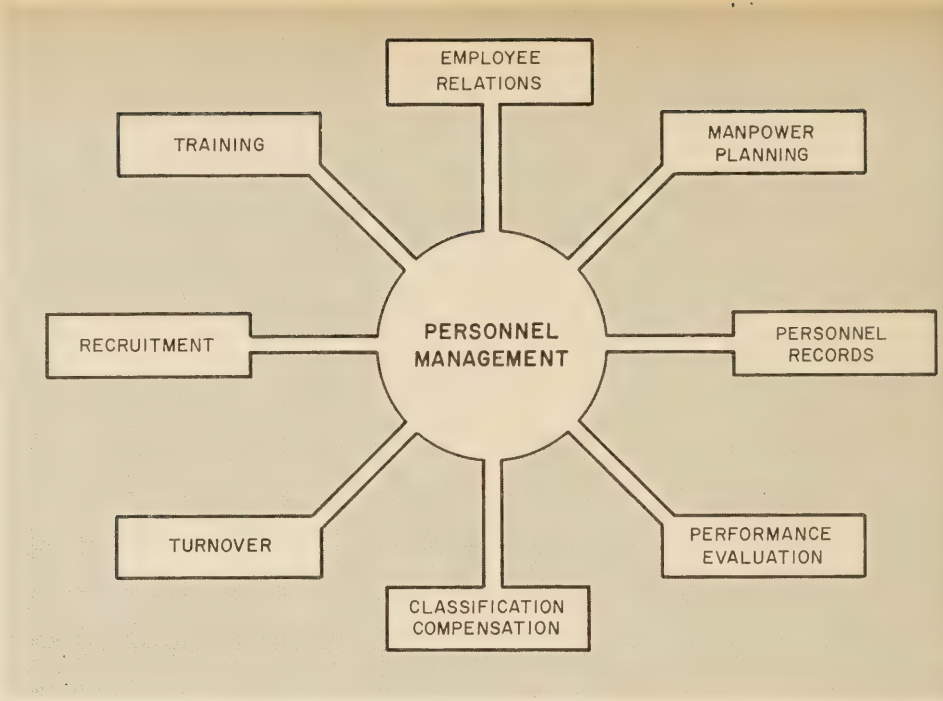

State Highway Department Management

Part 3.—Personnel Management

Reported by ALICE RANDILL
Management Analyst
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This is the third and final part of a report on management studies that were conducted in several States under the Highway Planning and Research program to upgrade the quality of highway administration. The findings related to highway department organization were reported in the February 1970 issue of PUBLIC ROADS, A JOURNAL OF HIGHWAY RESEARCH, vol. 35, No. 12, and those on training and manpower development in the April 1970 issue, vol. 36, No. 1.

This final part reports on the findings of the studies that relate to personnel management. The research consultants in the studies uncovered many deficiencies in highway personnel management, but the research was conducted several years ago, and many highway departments have since implemented the consultants' recommended improvements. Others currently are reorganizing their management functions or plan to do so in the future.

Introduction

As the highway function becomes more complex and sophisticated, the burden on highway managers to meet changing conditions and new demands becomes ever greater. One of the tools available to the manager is the personnel organization itself—personnel administration as it relates to all classes and types of employees. Effective administration of the personnel function enables managers to devote more time to other major responsibilities.

Because the source material for this report was obtained from 13 different State-conducted management studies and because each State study had specific objectives that were aimed at solving problems peculiar to the State conducting the study, it was difficult to extract related generalizations. The information presented is not intended as a comprehensive guide or manual for a model personnel management system. Instead, it is intended as a report of significant findings that may encourage highway managers to take an introspective look at their own personnel functions.

Organization of the personnel function differs from State to State. Usually in State highway organizations, the personnel director reports to the director of administration, although in some States he reports directly to the chief engineer or chief executive of the department. In a few States the highway organization has little influence over personnel policy and administration, because a State department of personnel provides services for all agencies of the State government.

The usual functions of a State personnel management system include the administration of a civil service merit system, classification and compensation standards, job evaluation program, recruitment program, manpower planning program, training and development program, safety, and maintenance of records and manuals. Additionally many systems recently have been expanded to include an equal opportunity program.

Merit Systems

A civil service merit system is intended t establish personnel policies and procedures based on merit principles and acceptabl standards, that govern the appointment promotion, transfer, layoff, removal, resig nation, discipline, and welfare of its em ployees. Appointments and promotions shoul be based on merit and fitness and determine by both competitive examination and pe

formance evaluation. Educational attainment and experience are other factors to be considered. A merit system should also provide dismissed, demoted, or suspended employees the right to appeal personnel actions within a specified period. The effectiveness of a merit system depends on the sympathetic support that the chief executive gives to its administration.

Personnel-management policy differs among State highway departments. Some departments have formal civil service merit systems; others have personnel policies or laws that provide for some features of a merit system.

Formal civil service merit systems

Consultants who conducted the management studies in four of the States reported that personnel functions were generally administered under a formal civil service merit system established by law. Although one of the requisites of a formal civil service system is that appointments and promotions be based on merit and fitness determined by competitive examination, it was noted that some promotions in these four States were based on seniority. It also was noted that not all highway employees were covered by the existing merit systems—in one State, 3,300 out of 3,700 employees, mainly field personnel, were not covered. In this State, even though not all employees were covered, the merit system provided the following benefits:

- It had an important and stabilizing influence on the organization and administration of the State highway department.
- It minimized political considerations in employment and tended to provide sound principles and criteria for the guidance of administration over the years.
- It enforced higher standards in qualifications, education, and experience for new employees.

Generally, the findings indicated that mere passage of a law does not assure the success of a merit system; consequently, periodic review and revision of a system are required to meet changing employment conditions.

Effective administration of a merit system must be supported and guided by top management, which must approve personnel requirements and propose measures to meet new problems. Lack of proper guidelines can create many problems, such as failure to include personnel requirements in the department budget, or failure to develop personnel requirements in terms of skill shortages and position vacancies caused by retirements, resignations, and transfers.

Partial merit systems

Some highway departments had personnel management policies that provided many of the features of a merit system, but not all of them. In one State, it was noted that the policy was adequate but needed improved administration and the consultant recommended the following actions by the department:

- Issue a clear statement of policy to provide positive direction and guidance in personnel matters.
- Organize the personnel office in accordance with an approved organization chart.
- Intensify recruiting to attract engineering and other college graduates, as well as technical and skilled workers.
- Upgrade performance evaluation so that it becomes a useful and productive practice and not just an annual exercise.

Many highway departments administered their classification and compensation functions under plans based on minimum standards set by law, executive order, or general policy. Generally, the consultants in the studies considered such standards inadequate to meet the criteria for an approved civil service merit system. The standards in use in six States had been established by one or more of the following methods:

- Special acts.
- Career employment policy.
- Biennial legislation of State salaries.
- Policy establishment of formal job classification and evaluation.

Some personnel-administration problems encountered under these standards are reviewed in the following discussion:

Special acts.—In one State the consultant noted that not all employees were covered under the three legislative acts on merit—one act was passed in 1951 and two in 1961. Engineers, higher level technicians, and administrative employees were covered under the acts, but employees in these classifications comprised only about one-fifth of the total number of employees in the highway commission. Consequently, as each change in political administration occurred, four-fifths of the employees were subject to removal for political expediency.

Career employment policy by executive action.—To improve the situation in that State, the consultant recommended a career policy, which the Governor implemented by establishing a career employment policy under an executive order. The consultant specified the position classifications to be included under the policy and established the conditions and procedures for installing and administering this merit-type system. Approximately 40 percent of the total employees, comprising 106 classifications—engineering, nonengineering professional, administrative, supervisory, and technical categories—were covered under this system. These employees were not blanketed in under the policy; their qualifications, abilities, and performances were required to justify their statuses. Additionally, the personnel director was chosen for professional qualifications and experience, with the approval of the State highway commission, and the following professionally qualified assistants were assigned to him to upgrade personnel administration: classification and training director, personnel representative (technical and professional), personnel representative (patronage employment), safety director, and personnel records supervisor.

Immediate benefits from the implementation of this policy were as follows:

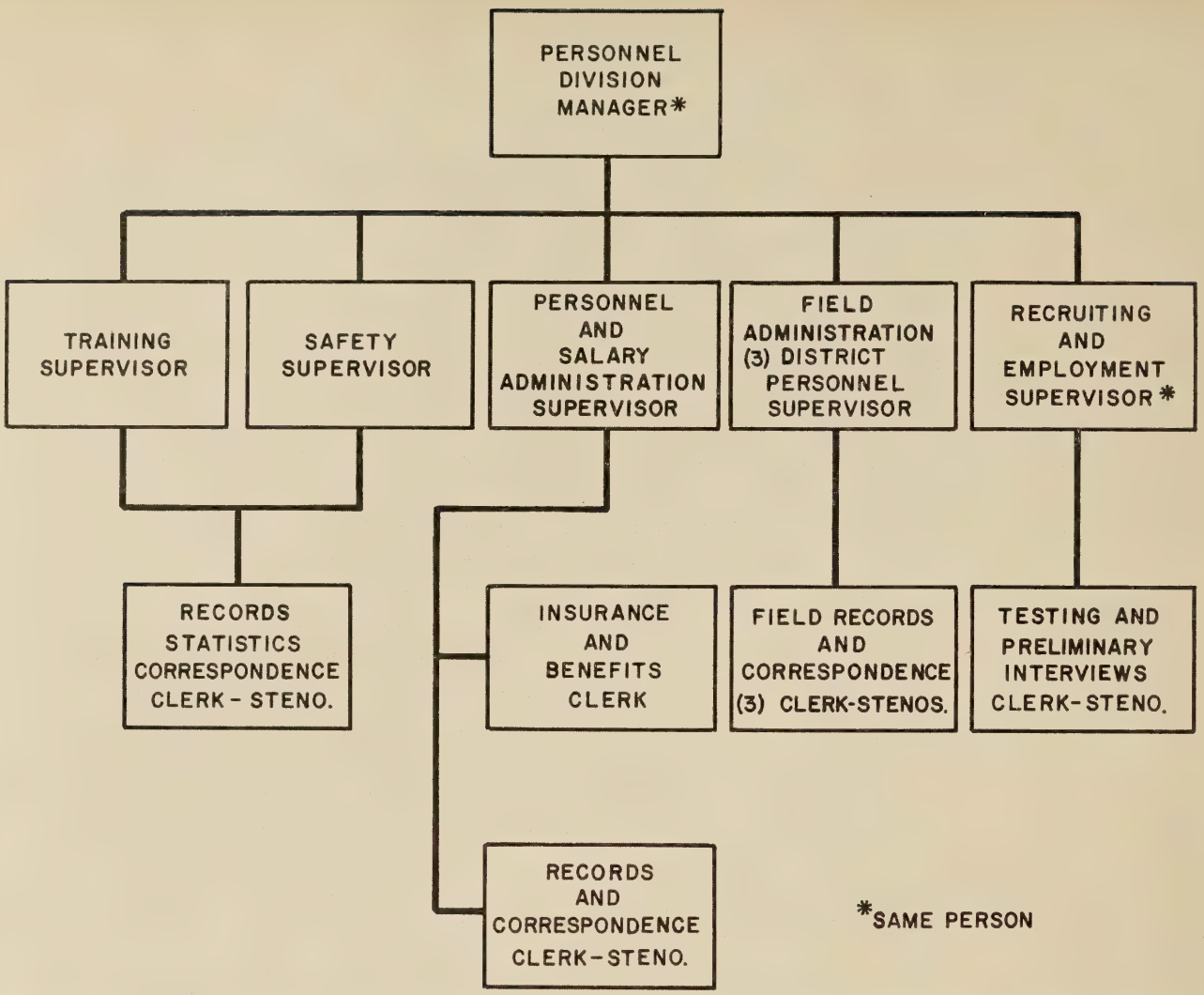
- Better performance.
- New recruitment sources.
- New tool to attract qualified applicants.
- Developed training plans.
- Clear line of demarkation between patronage and nonpatronage positions.
- No direct and indirect political pressures applied to employees in covered positions.
- Basis for planning and developing a longer-range personnel program.

However, despite all these improvements, the consultant strongly urged that the State adopt a permanent, legislated merit system. It was felt that a change of administration might jeopardize a policy that had been implemented by executive order.

Biennial legislation of State salaries.—In another State, although the legislature prescribed salary ranges each 2-year period for most classes of personnel, the classification of workers within these legal salary steps was largely a local matter, as the personnel function was decentralized. Although regular job reviews and employee performance evaluations at the district level constitute some elements of a merit system, no uniform recognized plan was in operation. There was no overall requirement for preemployment testing or for personnel to be rotated to obtain well-rounded backgrounds, nor was there any central training program. To effect some improvement in the personnel management, the consultant recommended that employment and training be coordinated under a central personnel division.

Policy establishment of formal job classification and evaluation.—Top management in another State had established a formal job classification and evaluation system and had been basing salary increases on a combination of service and merit. Although in operation for more than 20 years, the consultant noted some disadvantages in the system, and his report commented on some of the practices and suggested methods for improvement. For example, job worth was being determined on a quantitative basis. Position descriptions for new jobs were being written by the individual performing the duties, or by his immediate supervisor, and many had not been updated for nearly 20 years, even though the job content had changed. Also, there was little control over the consistency of rankings because justifications for grade selection were not being recorded. Compensation for outstanding individual performance or length of service was often granted by reclassifying a position into a higher salary grade, and numerous compensation inequities were evident. To improve some of these practices, the consultant recommended that the highway department write a policy manual to define policies and procedures for administering these functions.

In still another State, the highway department was authorized by law to administer its own personnel policies and procedures. At the time of the study it had been administering its personnel function through a series of administrative memoranda that summarized department-wide policies and procedures. Although the memoranda covered numerous personnel functions, they were mainly con-



Proposed organizational structure for a centralized personnel division.

cerned with fund distribution and personnel details. In addition to the memoranda, interoffice letters of procedure were being developed independently by each division or district.

The consultant in the study noted several areas in the memoranda system that needed revision. For example, each district and division office maintained its own duplicate records using its own forms. Moreover, position titles had no corresponding position descriptions; the responsibilities of employees with identical position titles varied from district to district. Accordingly, in agreement with the consultant's recommendation, the State highway department completely documented its administrative policies and procedures, and centralized its control of the personnel function. The personnel division was reorganized in accordance with the consultant's organization chart which is shown in the accompanying illustration. Under this organization plan, the personnel manager reports directly to the assistant director of administration.

Classification and Compensation Plans

A classification plan establishes a system to identify different types and levels of positions that have similar job requirements, skills, or abilities. After a plan is installed, operational policy must include procedures that keep class titles and position descriptions current. Position responsibilities within class titles must be so nearly equal that the same pay range can be applied fairly to all individuals. These titles, or classes, are then used to set up clear standards to provide sound bases for assigning positions in the salary structure.

Once the classifications are set up, success of the plan will depend on continual periodic evaluation of individual positions. Any changes in the organizational structure or in assigned duties and responsibilities must be reflected by position reclassification. Such changes may also affect salary structure, and salaries should be adjusted to keep them at the general level paid by other employers, publ or private—an accomplishment that requir close coordination between the personnel offi and the operating division and section head

Classification

The research consultant in one State note an excessive number of position classifica tions, nearly 300 different ones, and suggeste that clerical and related series be combine into useful and meaningful classes. The su gested consolidations which were adopte reduced the number of classes to about 100. new engineering associate series was estal lished not only to provide career ladders a adequate advancement opportunities for eng neering support personnel, but also to disti guish nonprofessional-technical classificatio from engineer classifications. For engineer separate and distinct classifications wi fewer levels and higher standards we approved. Adoption of the new classificati system by the State resulted in better e ployee harmony and reduced the rate of pe sonnel turnover.

In a second State, the consultant found position descriptions so broad in scope that most of them were meaningless as standards for employee responsibilities and actual duties performed. As a prelude to the development of a more systematic and objective position evaluation program, all positions were comprehensively analyzed. In a department with a wide variety of positions, it is necessary initially to evaluate each position on an hourly, clerical, or managerial basis to assure the comparison of positions that are closely related or have similar functions.

In a third State, the consultant noted that for the same job classification, an incumbent's duties and responsibilities varied among districts. Although jobs had identical titles and pay, there were significant differences in workloads, and it was recommended that the department establish several steps for each position so that the responsibility and workload of an incumbent in one district would be the same as that of an incumbent in another district. It was noted that grade distinctions should govern pay differentials to reward employees who are asked to transfer into more demanding jobs in other districts.

In a fourth State, the consultant suggested that the highway department assemble a work force in which individuals are capable of performing satisfactorily in more than one narrow specialty of highway engineering, and that employees be given the opportunity to progress into top administrative and managerial positions in highway engineering by acquiring additional skills and training. Also, it was recommended that engineering classifications specify superior engineering capabilities as requisites for advancement, and not require the employee to assume increased supervisory responsibilities to progress.

In a fifth State, the classification plan occasionally was altered by the use of options, or special classes, to recognize special ability or seniority as compensation for unrealistic pay scales. Such options, or special classes, should be used sparingly to avoid fragmentation within a broad class, and it was recommended that examinations be used to measure special abilities to qualify for options.

In a sixth State, the highway personnel office reported directly to the highway director, but major policies and procedures were determined by the State personnel department. Because extensive action by the state personnel department was required to change the master organizational pattern, the consultant recommended that the highway department be delegated the authority to classify its own positions.

Compensation

Compensation structures should be developed on the basis of equal pay for equal work, which requires not only that positions in the same class have the same salary ranges, but also that salaries in different classes be related respectively to the comparable duties and responsibilities.

Success of a salary structure depends on administration of the structure. The suggestions given here to increase efficiency in the administration of a compensation plan were offered by respective consultants to improve operating policies in effect in several of the States under study.

One consultant realized that recommended changes in the State's compensation plan would significantly increase expenditures for salaries. However, it was felt that the increase ultimately could be offset by a reduction in turnover. Additionally, the consultant indicated that adoption of the following suggestions could increase output and thereby reduce personnel requirements:

- Use machines and modern equipment when possible.
- Eliminate unnecessary tasks or parts thereof.
- Simplify tasks where possible.
- Improve supervision.
- Employ better trained and qualified personnel.
- Improve work standards and provide incentives.

To administer a compensation plan successfully, the overall salary structure must be set at levels that are compatible with those of the private labor market. A consultant in one State noted that when wages were set too low, only substandard workers applied for employment. Although a department may consider that it is more economical to pay low wages, it could lose money by employing less competent employees, which would require a larger work force. It was noted in another study that higher salaries do not necessarily mean higher costs, because qualified employees are usually more productive. One consultant reported that maximum salary levels set too low inspire many younger employees to leave for higher paying salaries in private industry as soon as they have been trained. The investment in the training of these young employees represents a considerable amount of money, which should be protected by competitive salaries that induce employees to remain on the job.

Performance evaluation

Performance evaluation is one of the established criteria for determining promotions, demotions, separations, and salary increases. However, in two States, some divisions or districts annually rated their employees, but the process seemed more of an exercise than a useful and productive practice. The importance of evaluation generally was misunderstood, and performance-rating application differed among units. The consultant recommended that supervisory personnel be required to provide closer supervision and guidance over individual performance, and arrange for additional training and experience as needed. Also, the consultant indicated that training and individual performance needed correlation to improve production and efficiency.

In another State, the consultant interpreted salary dissatisfaction and recruiting difficulty as indications of a need for better job evaluation. Accordingly, it was suggested that each individual's job be analyzed and evaluated and that reviews be scheduled on a periodic basis. Accordingly, a complete job evaluation and compensation study was undertaken under State sponsorship and it has since been reported that the recommended evaluation and review procedures have been implemented and that employee morale has improved considerably because of the new practices.

In two studies, use of appraisal systems was investigated in detail. One consultant recommended that improved performance and employee qualifications, not necessarily related to salary increases, should be the objectives of periodic appraisals and reviews of individual performances. It was suggested that the elements of the appraisal system include:

- Factors of the person's appraised position and performance standards for each factor.
- Grade performance rating of below standard, standard, or well above standard.
- Evaluation of personal characteristics and traits of personality as assets or liabilities, performance, or potential.
- Written description of strong or weak points of an employee's performance.
- Indication of particular positions for which the employee has become qualified as a result of additional training or education.

The other consultant set up a proposed plan of appraisal methods to identify and develop middle and top management employees as follows:

- Appraise annually, by supervisors' formal written reports, classifications below division maintenance superintendent, project engineer, and equivalent administrative grades.
- Establish an appraisal committee in each district and headquarters division to evaluate classifications for levels between maintenance superintendent through senior highway engineer. The committee would consist of the district engineer, or division head, and three other members from the district or division, each of whom would be appointed by the district engineer, or division head.
- Establish a department appraisal committee, headed by the deputy director, with three district or division heads, to appraise classifications for supervisory highway engineer or equivalent.

Work measurement

Six studies reported that work-measurement and manpower-control programs are needed not only in clerical areas, but also in the maintenance, engineering, and administrative areas to project future manpower needs according to staffing and budget limitations.

Work-utilization techniques help determine which employees need development or training. As one consultant indicated, it is necessary to ensure that individual knowledge, skill, and ability are used to the best advantage, and to achieve this, the following factors should be measured: time utilization, skill utilization, job knowledge, ability, performance, levels of difficulty, and ratios of work. The consultant suggested that manpower utilization could be improved if the number of classifications correspond to the number of levels of difficulty, if levels of classification and salary progress agree with levels of diffi-

culty, and if staffing patterns reflect the number of persons required to accomplish the workload assigned to each classification.

As an example of work-measure effectiveness, it was reported that implementation of another consultant's recommendation to install a clerical work-measurement program increased work output in the highway department.

Recruitment

A good recruitment program should assure that adequate and fully qualified personnel are employed on a merit basis. Recruitment policy should be determined by a State highway personnel board, or equivalent unit, and job descriptions should clearly define qualifications, skills, and backgrounds required of incumbents. Recruiting objectives should be correlated with manpower requirements and budget and should be derived from the highway commission's schedule of future highway improvements.

Effective recruiting demands a continuous review of the program. Highly qualified, potential employees should be reached by every means including, among other things, attractive employment pamphlets or brochures, news items, regular advertisements in newspapers and trade journals, campus visits, professional meetings and conventions, personal employee contacts, and referrals. The department image projected by recruiting brochures should be that of a progressive, forward-looking organization, and all printed matter should emphasize the benefits and advantages of State employment—merit system (or similar system) and plans for sick leave, vacation, insurance, and retirement. Moreover, opportunities offered by State employment for careers filled with challenging assignments, rewarding experiences, professional accomplishment, and advancement should be well documented.

Several recruiting problems were found to be fairly common among the States in which studies were conducted. One problem, was the inability to recruit college graduates. A college education is almost indispensable to a potential executive or manager, because it develops the kind of active, logical mind required to handle the complex and challenging problems of highway administration; consequently, recruitment of college graduates is essential. In two States, the consultant recommended a combined program of summer employment and training rotation that would be open to students in good standing, not only to attract college graduates but also to help retain them. With proper handling and guidance, students would be expected to return each summer and probably even look for a career in the highway department at graduation time. As college graduates, especially engineers, expect to receive some on-the-job training from their employers, a valuable recruiting aid is a training and orientation program aimed at fitting the graduate engineer quickly into the organization. The consultants emphasized that starting salaries for college graduates should be competitive with industry and that adequate top salaries and career-advancement opportunities need to be provided.

Another problem was a general lack of professional recognition in State highway departments. The graduate engineer attaches much importance to professional status and prestige, and prefers to associate with a truly professional group in an organization that provides a professional atmosphere. This environment is essential, as the quality and quantity of highway work performed depends largely on the competence of engineers. In many States, legislation requires registration and regulation of engineers performing private work; therefore, it seems reasonable that like requirements should be extended to engineers performing at public expense. To improve recruitment programs, it is suggested that each highway department adopt a policy in which college graduation for engineers, and registration for professional engineers, are requisites for employment and advancement in engineering classifications.

An additional factor often overlooked is recruitment for engineer-support personnel. Engineers need competent technical and clerical aides to free them from time-consuming support duties and permit them to devote their major efforts to engineering. Appropriate technical and clerical classifications should be set up as required and should provide adequate career steps for technicians. Also, some clerical-position classifications should be expanded to provide additional salary steps.

In some States, it was noted that highway departments recruit primarily for civil engineers. Although the civil engineering discipline includes highway engineering, a variety of engineering talent is needed—mechanical, electrical, industrial, and geological. Highway departments also often overlook the need to recruit specialists in other fields such as law, right-of-way personnel, finance, and accounting. Qualified personnel are also needed in these specialties to staff modern highway departments for ever-expanding functions. Further, highway departments must have adequate, permanent, full-time staffs to provide continuity of experience and knowledge in all phases of highway work to prevent disruptions of ongoing programs by losses of key personnel.

Turnover

In the majority of the studies, consultants noted that personnel-turnover rates were too high to keep State highway departments operating at top efficiency. The following reasons for personnel turnover were obtained from several of the reports:

- Low and uncompetitive salaries.
- Little opportunity for career advancement and professional recognition.
- Uncertain or insecure employment tenure.
- Lack of reimbursement cost for changing residence.
- Poor personnel management, particularly with regard to functions like manpower inventory and long-range planning.

One consultant successfully used exit interviews to determine the causes of personnel turnover, and accordingly, recommended that the highway department continue the practice to analyze turnover.

Where the turnover of employees was considered a serious and costly problem for one highway department, the consultant reported that the overall turnover rate was more than 28 percent in 1961 and about 27 percent in 1962. Turnover percentages were based on the ratio of the number of terminations to the total number of employees, by classification. For the years 1961–63 the department experienced a turnover rate of about 50 percent for engineering employees and nearly 40 percent for administrative and clerical personnel. The rate was even higher for custodial employees during these years, in which the number of terminations exceeded the number of people normally hired. The general impression was that most of the employees who terminated were in their first year of employment—a concensus that was not confirmed by the consultant's data for the first 10 months of 1963, which indicated that although more than 50 percent of the turnover occurred among first-year employees, 20 percent occurred among employees with 3 or more years of service. An accurate estimate of the considerable time, effort, and money invested in the training and development of employees who terminated in 1963 was not possible, but a conservative estimate by the consultant of the salaries paid these employees during their service was more than $5 million.

Turnover data in another study were reported for merit-system employees only. In fiscal year 1957–58 there were 295 separations out of a total of 2,700 merit employees, or 11 percent turnover. In fiscal year 1963–64, the turnover rate was more than 28 percent. In other words, turnover rate increased from 11 percent to over 28 percent in 6 years. In 1964 a total of 1,008 persons were hired and 914 were separated—a ratio of 10 persons hired to nine separated. In the central office alone, the comparable ratio was about 10 hired to eight separated. In one of the field divisions, the number of separations equaled the number hired. As mentioned previously, these data were reported for merit system employees only; no similar information was available for the 3,300 employees not covered by the merit system.

Because engineering personnel are essential to State highway department operations, one consultant compared the number of engineering employees terminated by the department with the number hired during the period from January 1959 through June 1964 and noted that terminations occurred at an average annual rate of 54, and hires at an average annual rate of 91. These data along with projected retirements were used to project new employment needs to maintain the current number of engineering personnel for the next 5 years.

Although causes of turnover are difficult to determine, consultants and key personnel agreed that high turnover is costly and that additional analysis of this problem is needed.

Manpower Planning and Development

In addition to administering the entire personnel-management function, personnel divisions are responsible for developing manpower requirements. Manpower needs must be estimated and scheduled in advance to insure that the department's mission is achieved efficiently and effectively. Requirements should be projected on a multiyear basis and updated annually. To be realistic, they must be based both on the budget and on the schedule of construction and improvements. Extended annually, these projections provide a continuing master plan to recruit and develop personnel, which also assures a current inventory of manpower that can be used to train and promote department personnel. The inventory should include data on performance, qualifications, and potential of employees, as well as a complete personal history on each employee, to provide a comprehensive summary of the strengths, weaknesses and training needs of individual employees. Analysis of other factors, such as ages of employees, facilitates the projection of turnover rates. Manpower projections should anticipate not only attrition, scheduled retirements, promotions, and transfers, but also organizational changes, shifts in program emphasis, and improvements in technological development. Regular and efficient use of such a plan enables management systematically to control manpower development.

A few manpower-planning and development problems among the State highway departments are briefly discussed here, as are the suggested recommendations for improvements.

In one study, the consultant noted a general lack of both short- and long-range manpower planning and development. Personnel replacement needs, seniority considerations, changes in the impact of department emphasis, and the effects of technology, all factors to be considered in manpower planning, had not been integrated into a formal manpower plan. The consultant proposed a manpower inventory that included data on age and education and suggested that a total plan be developed to include such factors as technology and automation, manpower utilization, training, and manpower statistics. It was believed that analysis of these factors would clarify both short- and long-range needs, and that management supervisors should be responsible for the individual development programs of their staffs. The highway department has implemented these recommendations and now maintains a complete background on each individual that includes an up-to-date record of qualifications and special skills. These records also indicate the employee's progress in training programs, as well as his ability to accept responsibility. In the future these data will be used to insure that positions are filled more effectively.

It was noted in another study that seven-eighths of the total manpower resources were concentrated in 25 decentralized district organizations in which workloads, particularly for engineering and right-of-way personnel, varied intermittently from district to district. Also, staff assignments within a district organization frequently did not match workloads, and it was recommended that manpower controls be established for construction engineering activities. The suggested controls required supervisory engineers to estimate monthly staff work and projects using a standardized system or format, and to use the estimates to anticipate future staffing requirements. In time, sufficient data would be collected on different types of construction-engineering work to establish standards for each work function. For maintenance forces, studies were recommended to determine the number and size of personnel complements necessary to complete routine highway maintenance tasks. It was suggested that, first, work methods be standardized by applying work-simplification techniques to existing maintenance tasks, and that standard crews then be assigned to these tasks as a basis for determining budget and personnel requirements in each district. Once these standards were set up, if the staffing did not match the workload, or vice versa, the variance could be detected and controlled through a routine budget-reporting system.

The consultant in another State had recommended establishment of a division for management scheduling and control under the office of planning. It developed naturally that this division could report accurate future manpower needs as determined by the critical path method. It would still be necessary, of course, to correlate these manpower requirements with the budget, and to include the needs in the personnel division's recruiting program.

Personnel Records

Personnel divisions usually are required to maintain manuals that set forth rules and regulations on personnel policies and procedures and to disseminate this information to the operating units. They are also expected to maintain a personnel information system, usually master records of all personnel actions in the department—employment, termination, leave, training, compensation, payroll deductions, employee appraisal and evaluation, and related information. Consolidated reports on these actions are prepared periodically for use by operating officials and for developing data on manpower planning and development requirements. Problems in the maintenance and dissemination of personnel information in several of the States are reported herein together with recommendations for improvements.

At least three States lacked adequate personnel manuals, and the consultant in each State recommended that standard operating procedures manuals be established to complement the department's various technical manuals and that they be updated at 2-year intervals. It was suggested that general policies and procedures developed for the manuals include the following items:

- Organization charts describing principal authorities and responsibilities for each office, district, or division.
- Documentation of all forms and reports in use.
- General administrative policies and their relations to other agencies.
- Legal interpretations or opinions affecting the agency.
- Personnel policies on all functions of the personnel-management system.

All three highway departments have since reported that these suggestions have been implemented and that employee morale has been improved.

In at least two States, records were still being kept manually, and the consultants indicated that this obsolete system was too slow and lacked detail. It was pointed out that for personnel records systems, data processing equipment and procedures can easily provide timely, accurate printouts of data and the different combinations needed for a particular purpose. The consultants recommended that the feasibility of applying computer programs to records systems be investigated and that personnel records on classification, personal data, employment history, and salary be maintained for all employees. Statistical reports on turnover, manpower needs, and similar information, could also be prepared for top management as needed.

Conclusions

Some of the more significant problems and recommendations for improving personnel management systems in State highway departments, as noted in studies conducted in 13 States, have been presented. Emphasized in each State study were the elements of the personnel management system that had been causing the most operational difficulty. Common problems reported in different States were noted in the discussion.

A number of these recommendations may have general application for improving the administration of the personnel function in other State highway departments. For example, the consultants in the studies generally recommended that the functions of personnel management be centralized in a personnel division under the major immediate supervision of the office of administration. The illustration of the organization chart, which shows components of a personnel division, could be used as an example to establish a centralized personnel division in a State highway department.

Several consultants indicated that the main requirement for effective personnel management is an adequate civil service merit system established under law to assure permanency. Even under existing civil service laws, not all employees in the department are covered. In some States about half the employees, mainly field maintenance employees, are appointed under a patronage system, and each change in administration results in a large personnel turnover. Further study of the causes of turnover is needed; the exit interview is one method of obtaining data for this purpose.

Keeping the highway department adequately staffed was a problem common to

(*Continued on p. 68*)

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Effect of Absorptive Form Liner on Surface Durability of Concrete

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much of which has been directed toward developing improved surface durability. And yet, widespread surface disintegration is proving costly to repair, not only monetarily but in delays caused by closures of heavy traffic facilities while repairs are made. Absorptive form liner is an effective and relatively inexpensive medium for achieving better, more durable concrete surfaces. It deserves another chance to realize the promise that was so hopefully predicted a generation ago.

BIBLIOGRAPHY

(*1*) *Progress Report on the Development and Use of Absorptive Concrete Form Lining,* Laboratory Report No. C–114, U.S. Bureau of Reclamation, Denver, Colo., Jan. 2, 1941, p. 2.

(*2*) *Final Report, Concrete and Related Subjects, Parker Dam Power Project,* by E. W. Ryland, Parker Dam, Calif., Report of Bureau of Reclamation, Denver, Colo., Nov. 8, 1943.

(*3*) *Final Field Report on Concrete Construction,* by C. F. Pinkerton, Friant Dam, Central Valley Project, Calif., Report of U.S. Bureau of Reclamation, Denver, Colo., Aug. 17, 1942.

(*4*) *How Absorptive Form Liner Was Utilized on Friant Dam Project,* by Wallace Waterfall, Concrete, vol. 50, No. 5, May 1942, p. 18.

(*5*) *Absorptive Lining at Friant,* by Donald S. Walter, Western Construction News, October 1941, p. 298.

(*6*) *The Use of Absorptive Wall Boards for Concrete Forms,* by W. R. Johnson, Journal of the American Concrete Institute, June 1941, p. 621.

(*7*) *Form Linings for Concrete Surfaces,* by Harrison V. Pittman, Engineering News-Record, vol. 135, No. 18, Nov. 1, 1945, pp. 92–96.

(*8*) *Report on Laboratory Tests on Absorptive Form Liners—Norfork Dam,* U.S. Engineer Office, Little Rock, Ark., January 1941.

(*9*) *Wyoming Uses Absorptive Form Lining,* by R. C. Pike, Western Construction News, March 1941, p. 73.

(*10*) *Architectural Concrete Surfaces for Los Angeles Terminal,* by C. W. Pierce, Engineering News-Record, July 6, 1939, p. 64.

(*11*) *Technical Studies on Absorptive Form Lining,* Laboratory, Report No. C–177, U.S Bureau of Reclamation, Denver, Colo., May 14, 1942.

(*12*) *Factors Affecting Resistance of Portland Cement Concrete to Scaling Action of Thawing Agents,* by Albert G. Timms, PUBLIC ROADS, A JOURNAL OF HIGHWAY RESEARCH, vol. 28, No. 7, April 1955.

(*13*) *Use of Perforated Plywood and Perforated Metal Forms to Secure Improved Concrete Surfaces,* by L. P. Witte, paper presented at Research Committee 115, 44th Annual Convention, American Concrete Institute, Denver, Colo., Feb. 25, 1948.

(*14*) *Erosion of Concrete by Cavitation and Solids in Flowing Water,* U.S. Bureau of Reclamation, Denver, Colo., July 7, 1947.

(*15*) *Bonneville Dam Stilling Basin Repaire After 17 Years' Service,* by Roy R. Clarl Journal of the American Concrete Institut April 1956, pp. 821–838.

(*16*) *Resistance of Concrete Surfaces t Scaling by De-Icing Agents,* by William F Grieb, George Werner, and Donald O. Wool PUBLIC ROADS, A JOURNAL OF HIGHWA RESEARCH, vol. 32, No. 3, August 1962, pp 64–73.

(*17*) *The Effects of Moisture Loss at Earl Ages on the Subsequent Hydration of Cemen* by R. H. Mills, The Civil Engineer in Sout Africa, vol. 7, No. 12, December 1965.

(*18*) *California Fruit Growers' Exchange– The Architecture,* by A. R. Walker, Architec tural Concrete, vol. 2, No. 1, pp. 3, 4.

(*19*) *Concrete Surfaces Improved by Absorp tive Form Lining,* Engineering News-Record Jan. 4, 1940, pp. 64–66.

(*20*) *Find Way to Eliminate Voids Unde Forms on Concrete Surfaces,* by C. O. Crane Concrete, vol. 48, No. 3, March 1940, pp. 5, 6

(*21*) *Weather-Resistant Surfaces on Concret Created by Absorptive Form Lining,* Concrete vol. 49, No. 3, March 1941, p. 2.

(*22*) *Absorptive Form Lining,* by E. N Vidal and R. F. Blanks, Journal of the Ameri can Concrete Institute, January 1942, p. 253

(*23*) *Field Test, U.S. Rubber Company' Absorptive Form Lining No. 216,* U.S. Engi neer Area Office, Caddoa, Colo., Mar. 1, 194

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the highway departments studied. The consultants proposed several recommendations to improve recruitment and retention of employees. Salaries at all levels should be made competitive with those of private employment. Also, classification and compensation plans should provide opportunity for career advancement, and the importance of professional status and prestige should be considered. To attract employees with the necessary qualifications, skills, and abilities, the department image projected by the recruiting program should be that of a progressive, forward-looking organization that offers challenging assignments and professional prestige.

A survey of implementation by the State highway departments of the recommendations contained in these studies indicated that personnel management had been favorably improved in at least nine States. Many of the recommendations might be adapted to other highway departments with equal success.

BIBLIOGRAPHY

(*1*) *Management Improvement Program,* by Peat, Marwick, Mitchell & Co., for the State Highway Department of Alabama, February 1964.

(*2*) *Management Research Study,* by Management Technology, Inc., for the Delaware State Highway Department, 1967.

(*3*) *Management Research Study of the State Highway Department of Georgia,* by Highway Management Associates, 1965.

(*4*) *Management Improvement Project,* by Roy Jorgensen & Associates for the Indiana State Highway Commission, 1962–1964.

(*5*) *Organization and Management Survey,* by Booz, Allen, and Hamilton, Inc., for the Department of Highways, State of Minnesota, 1966.

(*6*) *A Study to Improve Management Functions,* by Peat, Marwick, Mitchell & Co., for the Mississippi State Highway Department, 1966.

(*7*) *Management Study, Missouri State Highway Department,* by Peat, Marwick, Mitchell & Co., 1963.

(*8*) *Management Research Study,* by Ernst & Ernst for the State of Nebraska Departmen of Roads, 1967.

(*9*) *Management Research Study of the Sout Carolina State Highway Department,* by High way Management Associates, 1964.

(*10*) *Financial Management Study,* by Erns & Ernst for the Texas Highway Department Special Report, 1966.

(*11*) *Research Study of Administrative Prac tices and Control Procedures,* by Worden an Risberg for the Virginia Department o Highways, 1965.

(*12*) *Report on Management Research Projec* by Booz, Allen & Hamilton, Inc., for Washing ton State Highway Commission, Departmen of Highways, 1965.

(*13*) *Highway Management System, Stat Road Commission of West Virginia,* b Management Technology, Inc., 1964.

(*14*) *A Model State Civil Service Law,* by th National Civil Service League, Nationa Municipal League, New York, N.Y., 1953.

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The 1965 Interstate System Cost Estimate, House Document No. 42, 89th Cong., 1st sess. (1965). 20 cents.

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