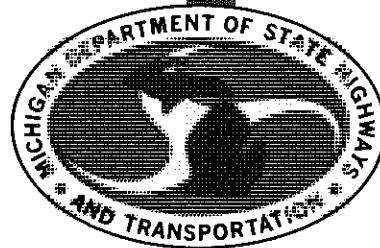


EXPERIMENTAL LIGHTWEIGHT FILL

Construction Report



**TESTING AND RESEARCH DIVISION
RESEARCH LABORATORY SECTION**

EXPERIMENTAL LIGHTWEIGHT FILL

Construction Report

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**A Category 2 project conducted in cooperation
with the U. S. Department of Transportation,
Federal Highway Administration**

**Research Laboratory Section
Testing and Research Division
Research Project 75 E-54
Research Report No. R-1053**

**Michigan State Highway Commission
Peter B. Fletcher, Chairman; Carl V. Pellonpaa,
Vice-Chairman, Hannes Meyers, Jr., Weston E. Vivian
John P. Woodford, Director
Lansing, March 1977**

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Introduction

This report describes the construction of a bridge approach fill which utilized an experimental lightweight fill material called 'Elastizell Concrete.' The bridge site is located on M 28 at the Waiska River, about four miles southeast of Brimley. The good general condition of the old bridge foundation made it necessary to replace only its superstructure. Because the east abutment and approach fill had settled as much as 1.5 ft, it was necessary to redesign and reconstruct the east approach. On the basis of the Departments 'Subsoil Analysis Report,' it was determined that a slip failure was taking place in soft alluvial clay subsoils and that the weight of the approach fill was the driving force (1). Analysis indicated that the movement could be stopped by removing or reducing the weight exerted by the approach fill. The two available design alternatives were to remove the existing approach fill and lengthen the bridge structure, or to remove the existing approach fill and replace it with a lightweight material. The least expensive alternative was to replace the existing fill. On the basis of the results of laboratory studies it was determined that Elastizell concrete, a low density (cellular) concrete marketed by the Elastizell Corp. of America, was suitable material for lightweight fill (2, 3).

The construction and placement of Elastizell concrete was done in accordance with MDSHT Plans (Project No. RF18-4(201), Job No. 07521A), and Special Provisions for Low Density Concrete dated June 2, 1975 (Appendix). Material inspection was the responsibility of the Construction Division. During construction it was found that the Elastizell concrete did not meet the 100 psi minimum compressive strength required by the Special Provisions, so the minimum compressive strength was reduced to 50 psi.

The short-term purpose of the project was to evaluate Elastizell concrete during the construction phase by determining the density, strength, and construction characteristics as it was placed. The long-term purpose of the study is to evaluate the durability of Elastizell concrete and to determine if it is effective in preventing vertical movement of the bridge approach area. This work is being done by the Michigan Department of State Highways and Transportation as a "Category 2" project, in cooperation with the Federal Highway Administration.

Project Description

The M 28 - Waiska River Bridge was reconstructed during the 1976 construction season; the location of the bridge is shown in Figure 1. An elevation and section of the east approach are shown in Figure 2. Approximately 5 ft of sand subbase fill was placed over the Elastizell concrete to

minimize the number of freeze-thaw cycles to which it would be exposed. Thus protected, the low freeze-thaw durability of the Elastizell concrete was thought to be of little, if any, disadvantage. Also, the very slow water sorption rate reported in Refs. (2) and (3) indicated that Elastizell concrete would maintain, over the life of the structure, a wet density close to the 35 lb/cu ft design density.

The elevation and section shown in Figure 2 indicates the general shape of the Elastizell concrete fill. The two-way slope of the fill surface, transverse and longitudinal, was difficult to construct because the Elastizell concrete tended to flow down slope. This was the only design problem encountered. The Elastizell concrete fill had been designed to include an edge drain along the outer edges.

Construction of the Elastizell Concrete Fill

The subgrade surface was shaped with a small bulldozer and front-end loader and formed as shown in Figure 3. The initial pour was made in the area adjacent to the bridge abutment to a depth of approximately 12 in. This pour was so large, in comparison to the plant's capacity, that it took the contractor about 14 hours to complete. For subsequent pours, the fill area was formed off into smaller sections that could be poured in eight hours or less (Fig. 4). After the entire subgrade had been covered with the initial 12-in. thick pours, forms were held in place by driving stakes into Elastizell concrete. The Elastizell concrete was made in batches of a little less than 1 cu yd, pumped to the site through a 4-in. diameter hose, and the surface finished with a hand held rake. Figure 5 shows the procedures used for the second layer and Figure 6 shows the appearance of the completed fill surface and the step tapered sides.

The specifications required the wet density of the Elastizell to be 30 ± 2 lb/cu ft with a modified compressive strength of 50 psi. Density was controlled by the contractor who weighed a tared 1 cu ft container (Fig. 7). Because the Construction Division did not have the equipment needed to check the compressive strength of the Elastizell concrete, the Research Laboratory obtained a representative number of samples and tested them in accordance with specifications.

In pouring the last layer of Elastizell concrete the plans required both transverse and longitudinal slope. The contractor had considerable problems trying to hold to these slopes since the Elastizell concrete tended to flow downhill as shown in Figure 8. It is suggested that future fill designs include only transverse slope, and if the surface of the fill must slope longitudinally, that this be accomplished by a series of step tapers.

Initially there was some question as to how long Elastizell concrete must cure before another layer could be poured over it. If the Elastizell concrete had set so that it was strong enough to support a man's weight, it was considered ready for the following pour. In some cases light footprints could be made in the surface even after a reasonable length of curing time (Fig. 9). This is thought to be due to an accumulation of air near the surface of the pour, due to exposure to warm sunshine, and resulting in a thin weak surface that, however, did not extend deep enough to cause significant weakness in the overall structure.

Specification and Test Results

Specifications used for construction of the low density fills are included as an Appendix to this report. The specifications were generally satisfactory; however, wet density and compressive strength requirements need revision. The most important component of Elastizell concrete is the portland cement content which can be controlled only by a dry density requirement. The 28-day compressive strength is not practical since the entire fill was poured before it was known if strength requirements of the first pour had been met. The specifications could be improved and would be more practical if dry density (rather than wet density) and compressive strength at 2 or 3 day cure time (instead of the 28-day strength) were specified.

Elastizell concrete samples were collected about once every hour in standard 4 by 8-in. cardboard concrete molds. It was noted that samples collected in the morning tended to rise in the mold while those collected in the afternoon tended to shrink, due to the effect of temperature change on air volume. These samples were moist cured for 27 days and oven dried for 24 hours before being tested for dry density and compressive strength; the test results are summarized in Table 1. The small batch size, less than 1 cu yd, is a source of large variation from test to test. Therefore, a statistical sampling plan should be developed to take this construction factor into account.

In order to get some idea of compressive strength during the construction operation, 4-in. diameter samples were cut from each pour with a portable coring rig. These cores were immediately tested for compressive strength using a small 2-ton Wykeham Farrance constant rate of strain load frame which is a part of the Research Laboratory's portable soils testing equipment. The soft wet layers and large voids of the cores, characterize poorly placed Elastizell (Fig. 10). For satisfactory application, the cores were uniformly solid as shown in Figure 11. More information related to the quality of Elastizell concrete will be given in a research report

soon to be published. Because the compressive strength of cores two or more days old was very low, it seemed certain that they would not meet the 100 psi compressive strength at 28 days. The limit was therefore lowered to 50 psi which all but one of the pours was able to meet. Since the contractor was anxious to begin backfill operations, it was necessary to determine when the fill had gained sufficient strength to safely carry the loads applied by the backfill operations.

TABLE 1
AVERAGE COMPRESSIVE STRENGTH AND DRY
DENSITY OF TEST CYLINDERS

Pour	Average Corrected 28-Day Oven Dry Compressive Strength, psi	Average Dry Density, lb/cu ft
A	62	21.1
B	82	21.7
C	99	22.4
D	102	22.8
E	25	18.9
F	82	20.4
G	97	22.4
H	64	20.5
I	67	19.5
J	104	21.5
K	63	22.1
L	61	20.7
M	56	20.0

It was assumed, on the basis of the specifications, that the contractor would place the first sand fill in a layer no less than 2 ft thick. It was further assumed that the maximum tire pressure would be 80 psi, applied over a circular contact area 12 in. in diameter. The vertical stress on the surface of the Elastizell concrete was computed using the following equation from Scott (4):

$$\sigma_z = P \left[1 - \left(\frac{1}{1 + (a/Z)^2} \right)^{3/2} \right]$$

where: σ_z = vertical stress at depth Z (Z = 24 in.)
P = vertical pressure applied by the tire (80 psi)
a = radius of the tire contact area (6 in.)

The calculated vertical pressure on the Elastizell concrete surface using the equation is about 7.0 psi + 1.7 psi for overburden pressure. Therefore, a compressive strength of about 8.7 psi would be required to support construction equipment. Assuming a safety factor of two, the Elastizell concrete should have a minimum allowable compressive strength of 17.5 psi. The contractor was permitted to begin backfill operations when the cores taken from the last pours had a compressive strength of at least 17.5 psi.

If Elastizell concrete is to be used in the future, it is clear that the specifications should be improved. It will also be necessary for the Construction Division to acquire testing equipment needed to determine compressive strength in the field. Additional data such as the relationship between compressive strength and time of cure and dry density requirements will also have to be determined to ensure proper construction of subsequent Elastizell concrete fills.

Instrumentation

The east abutment was instrumented to determine if lateral movement would again take place. A secure area for placing reference monuments could not be found in the abutment area so they were placed as shown in Figure 12. By setting a theodolite over monument A the instrument can be properly aligned by sighting on monument B. Right or left movement is read directly from a calibrated target mounted on the abutment end wall. By turning the angle to reference point C, a very large power pole, it should be possible to determine if monuments A and B are moving. Any change in angle CAB would indicate monument movement. The power pole appears to be set in a good stable area.

The vertical movement of the east approach fill will be monitored by running a line of levels down the centerline of the pavement and comparing these elevations with 'as constructed' elevations. A railroad spike driven in the north side of power pole C has an elevation of 621.68 ft and is the benchmark used to establish the 'as constructed' elevations shown in Figure 12. On the project construction plans this benchmark is identified as (7A) and it is located 52 ft right of Sta. 75+31.

A new scheme will be worked out in the future to place permanent reference points for monitoring lateral movement of the east abutment.

Summary and Conclusions

Construction of the Elastizell concrete fill proved to be easy with relatively few construction problems developing. The only design problem was the longitudinal as well as transverse sloping of the surface which caused the very low viscosity Elastizell to flow downhill. Transverse sloping of 0.01 ft/ft for as long as 30 ft caused no visible flow. For future jobs longitudinal sloping should be achieved only by step tapering.

The materials section of the specification needs to be modified in order to enable acceptance on the basis of two or three day compressive strength and on the basis of dry density. The specified values for dry density and compressive strength, as well as guidelines for pour sequence and cure time before backfilling will be given in a soon to be published research report.

Acceptance testing for this project was done by the Research Laboratory because the Construction Division did not have the required equipment. The question of who will do the acceptance testing and provide testing equipment should be resolved prior to further use of Elastizell concrete for lightweight fills.

Because of material property characteristics (such as low compressive strength, non-homogeneity, water sorption characteristics, and equilibrium wet density) noted in this and another project, Elastizell concrete cannot be recommended for general use as a lightweight fill material without qualification. Studies concerning the use of this material are continuing in the Research Laboratory and more positive recommendations will be presented in a subsequent report.

REFERENCES

1. Ostrowski, R. W., "Subsoil Analysis Report for M 28 Bridge Over West Branch of Waaska River 8.7 Miles East of Raco, Chippewa County," Michigan Project B-1 of 17063, Job No. 07521C, Michigan Department of State Highways and Transportation, November 1974.
2. Bidwell, E. L., "Freeze-Thaw Testing of Low Density Elastizell Lightweight Concrete," Unpublished report prepared for the Elastizell Corp. by the University of Illinois, Champaign-Urbana, April 1975.
3. Mainfort, R. C., "Laboratory Evaluation of 'Elastizell' as a Lightweight Fill," Michigan Department of State Highways and Transportation, Research Report R-956, January 1975.
4. Scott, R. F., "Principles of Soil Mechanics," Massachusetts: Addison-Wesley, 1963.

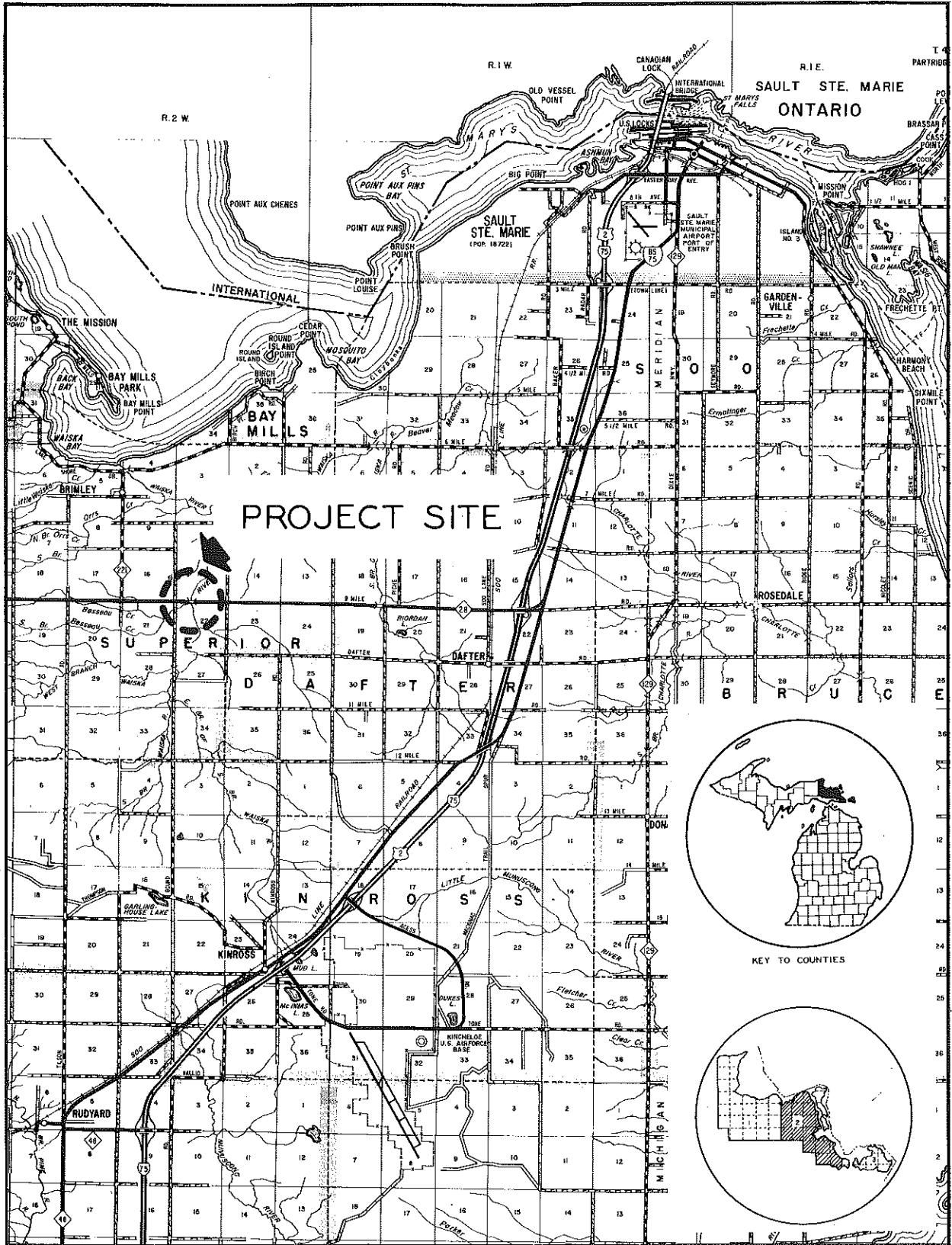


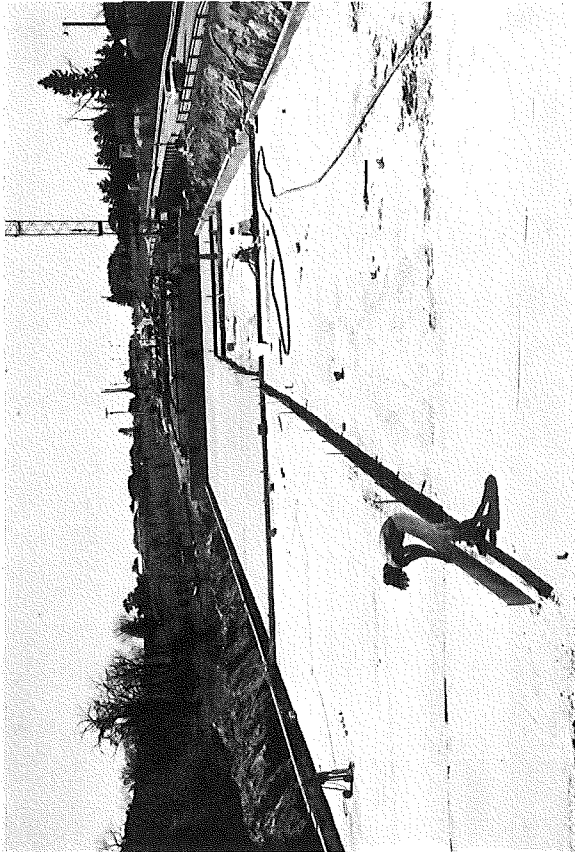
Figure 1. Location of experimental lightweight fill, Project No. RF 18-4(201), Job No. 07521A, bridge reconstruction of Waiska River Bridge, 6.0 miles west of I 75 on M 28.



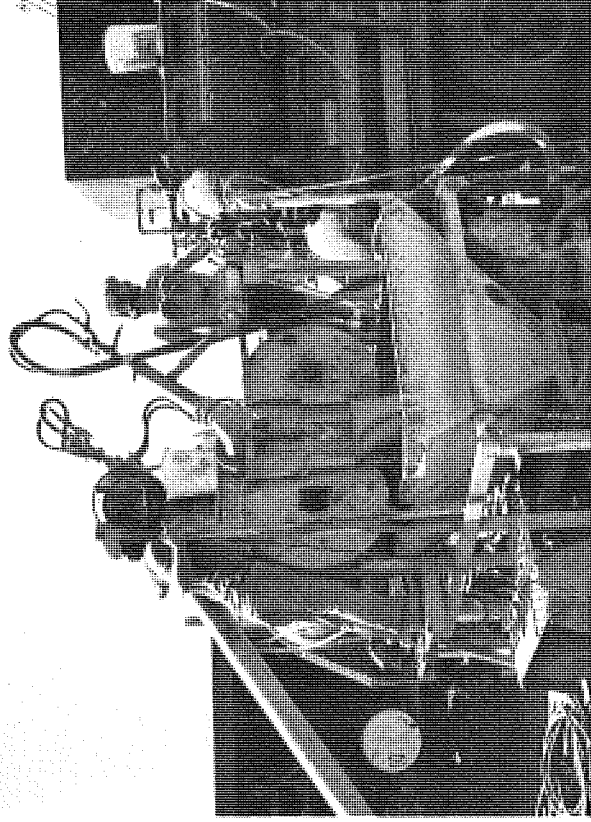
Figure 3. Shaped subgrade prior to pouring Elastizell concrete.



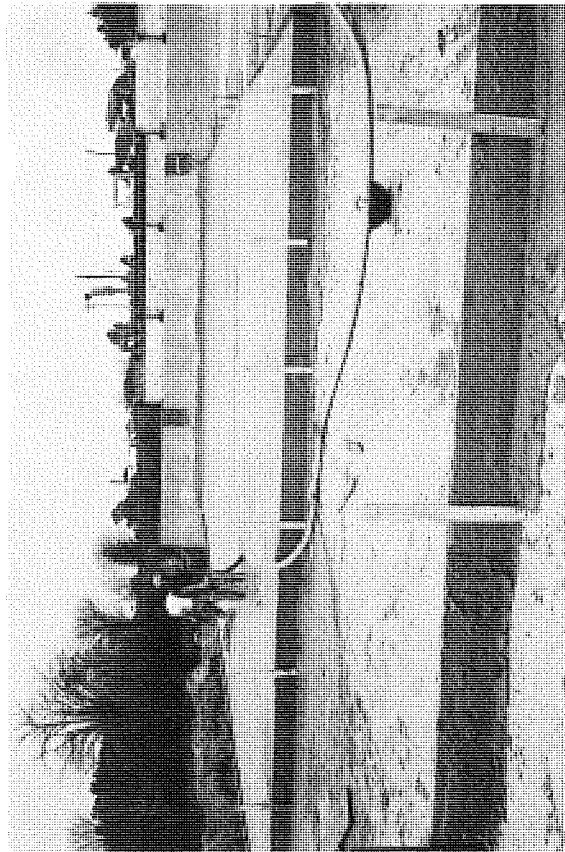
Figure 4. Fill divided into sections small enough to be poured in 8 hours or less.



Forms were set by driving stakes into the first Elastizell layers.

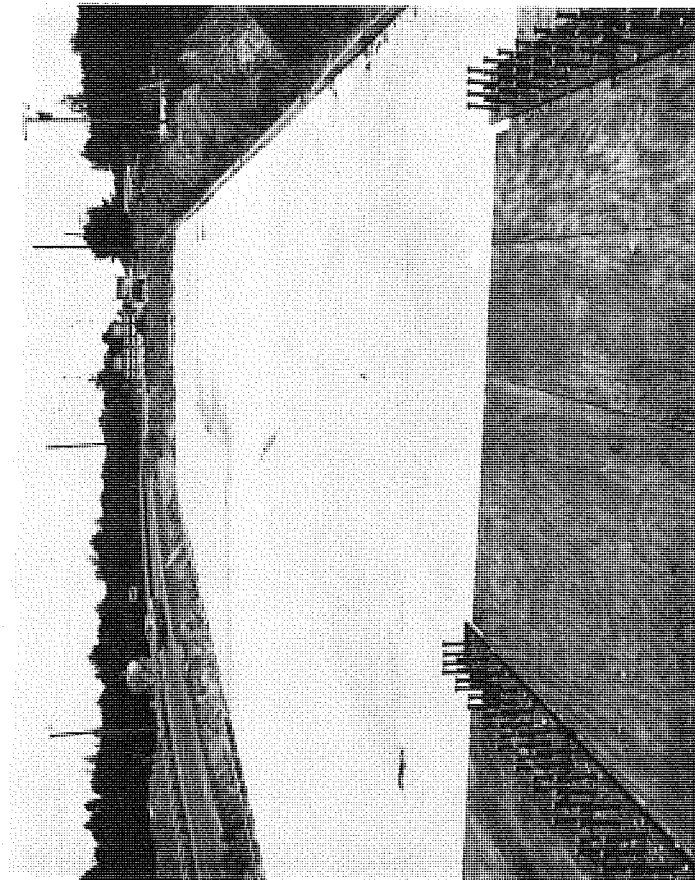


The Elastizell batch plant had about a 35 cu yd per hour capacity.



Elastizell is pumped to the forms and finished with a light hand rake.

Figure 5. Placement procedure of the second Elastizell layer.



View of the completed fill looking east.



South side of completed fill.

Figure 6. Appearance of the completed fill.

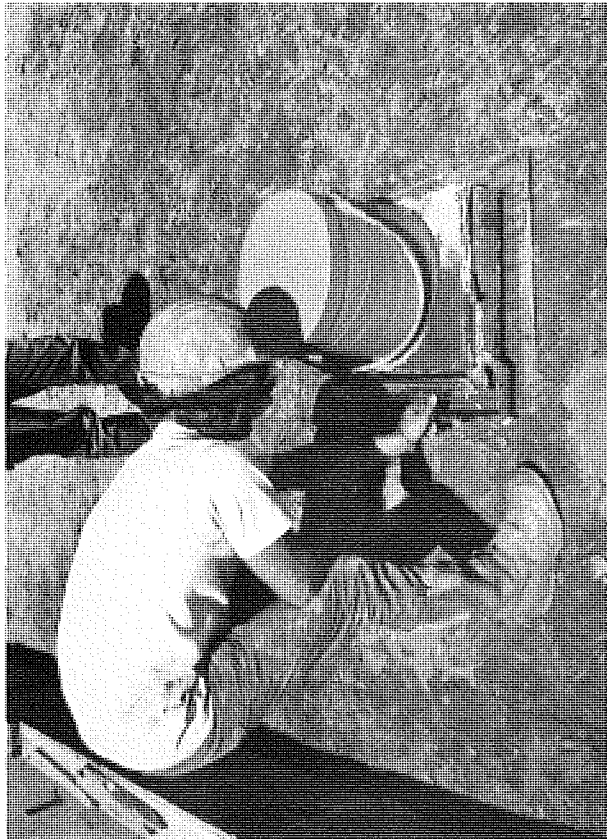
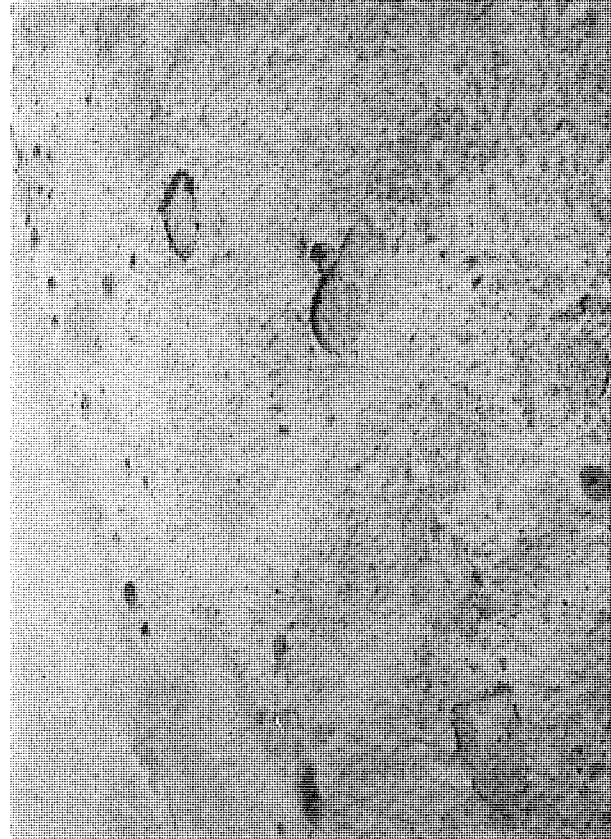


Figure 7. Checking wet density of Elastizell pour using 1 cu ft container.

Figure 8. Flowing of Elastizell on sloping fill surface.



Figure 9. Footprints illustrate the soft surface characteristic typical of some pours.



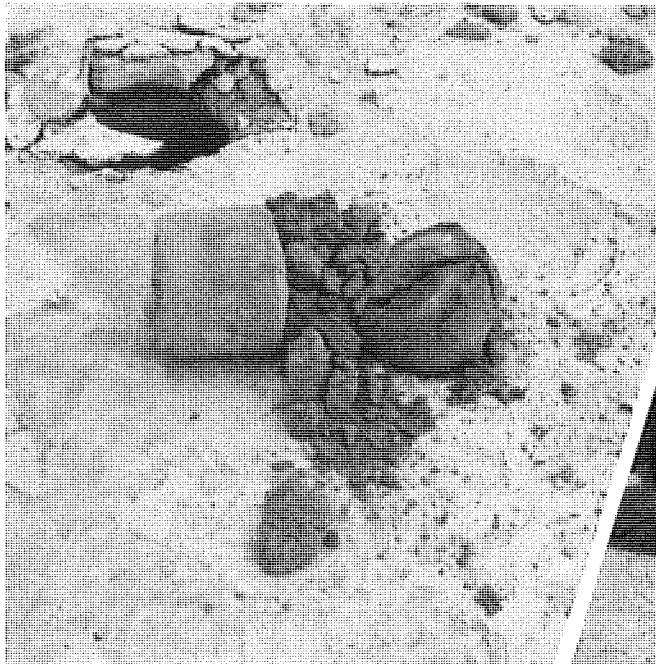


Figure 10. Voids and soft wet spots found in some of the Elastizell pours.

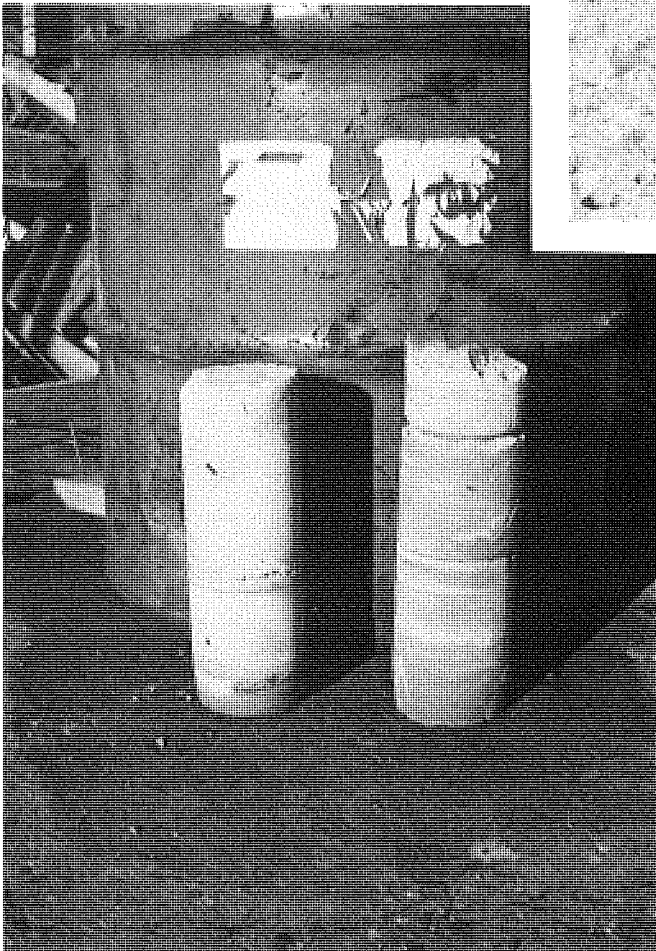


Figure 11. Samples from satisfactory pours free of soft layers.

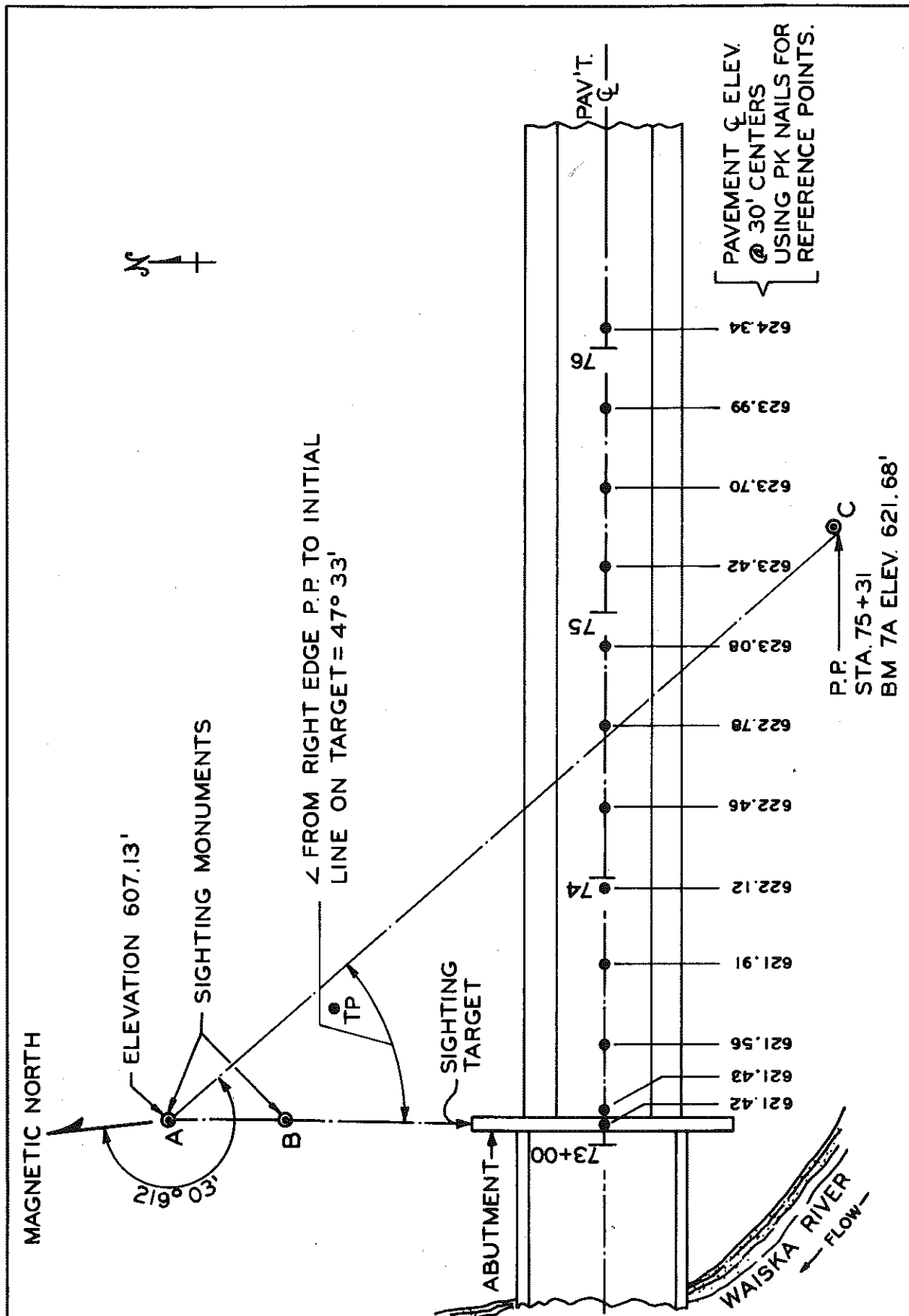


Figure 12. Initial elevations and general layout of monuments B. M. and points of elevation for monitoring lateral bridge movement and vertical movement of the lightweight fill.

APPENDIX

MICHIGAN
DEPARTMENT OF STATE HIGHWAYS AND TRANSPORTATION

SPECIAL PROVISION
FOR
LOW DENSITY CONCRETE

Description - This work shall consist of constructing portions of embankments as shown on the plans, with a low density concrete.

Materials - The materials shall meet the requirements specified in Division 8 of the 1973 Standard Specifications as follows:

Portland Cement, Type I or Type III	-----	8.01
Water	-----	8.11

Foaming agent shall be Elastizell, as produced by the Elastizell Corporation of America, or an approved equal.

Low density concrete shall be proportioned by the Contractor to produce a uniformly mixed concrete composed of cement, water, and stabilized foam having a wet density of 30 + 2 pounds per cubic foot and a 28-day dry compressive strength of not less than 100 pounds per square inch.

Construction Methods - Low density concrete shall be proportioned and mixed at the job site by the use of such high shear mixers and foam generating and measuring equipment as required to produce uniformly mixed, discrete celled, foamed concrete meeting the density and dry compressive strength requirements.

Low density concrete shall be placed in the dry and shall be protected from flooding until the overlying subbase is placed.

Forming shall be adequate to insure placement to the neat lines shown on the plans. Vertical construction joints shall not be continuous through the full depth of low density concrete placed.

The first layer of subbase material overlying low density concrete shall be placed in a single lift with all placing and hauling equipment supported by not less than 2 feet of granular material. Density requirements will be waived for this first 2-foot layer of subbase.

Method of Measurement:

Low Density Concrete will be measured by volume in cubic yards of acceptable material placed within the elevations and lateral limits shown on the plans.

Basis of Payment - The completed work as measured for LOW DENSITY CONCRETE will be paid for at the contract unit price for the following contract item (pay item).

<u>Pay Item</u>	<u>Pay Unit</u>
Low Density Concrete	Cubic Yard

Where dewatering, sheeting, coffer dams, or stream diversion is required to protect low density concrete from flooding and bouyant uplift prior to placing overlying subbase, the cost of such items and the cost of furnishing the proportioning, mixing, and placing equipment at the site shall be incidental to the item of Low Density Concrete.

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