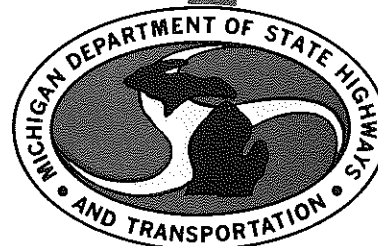


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ELASTIZELL CONCRETE LIGHTWEIGHT  
FILL CONSTRUCTION

(Pine River Bridge, St. Clair)



**TESTING AND RESEARCH DIVISION  
RESEARCH LABORATORY SECTION**

**ELASTIZELL CONCRETE LIGHTWEIGHT  
FILL CONSTRUCTION**

**(Pine River Bridge, St. Clair)**

**E. C. Novak, Jr.**

**Research Laboratory Section  
Testing and Research Division  
Research Project 75 E-54  
Research Report No. R-1064**

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

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During 1977 the Department placed experimental lightweight fills at two bridge sites. The fills consisted of a mixture of cement, water, and a proprietary compound "Elastizell." Elastizell is a foaming agent and causes a void-filled lightweight concrete to be produced.

The construction of the largest of these fills, located at the Waiska River on M 28 southwest of Sault Ste. Marie, was handled as a "Category 2" project in cooperation with the FHWA and has been covered in Departmental Research Report No. R-1053 (1).

The other lightweight fill, located on M 29 in St. Clair, was constructed at about the same time using the same supplemental specifications as used for the Waiska River job.

During construction it became apparent that the 'Supplemental Specifications' would have to be modified and several problems and questions arose concerning appropriate construction procedures. Most of these were discussed in Research Report R-1053 but were common to both jobs. This report describes the construction of the St. Clair project as well as supplemental studies that were made in an attempt to improve future construction procedures and obtain a better understanding of Elastizell lightweight fill as a construction material.

#### DESCRIPTION OF THE ST. CLAIR PROJECT

Elastizell lightweight concrete was used as part of the fills for both the north and south abutments of the newly constructed M 29 Pine River bridge at St. Clair. The original bridge had been rebuilt in 1933 and had become increasingly difficult and costly to maintain. Located in an area of deep, soft alluvial clays, the approaches and abutments had settled to such an extent that major underpinning was required. The new bridge, a twin leaf bascule, was designed with a grade raise of 3-1/2 ft. Because of the soft clay subgrade, two design alternatives were considered; the construction of additional approach spans, or the use of appropriate lighter weight material in the approach fills. Estimates indicated that the use of lightweight fill could save as much as \$200,000 and this design option was selected.

The location of the St. Clair bridge and approaches, constructed during 1976, are shown in Figure 1. Plan and elevation views, showing the lightweight fill construction, are included in Figure 2.

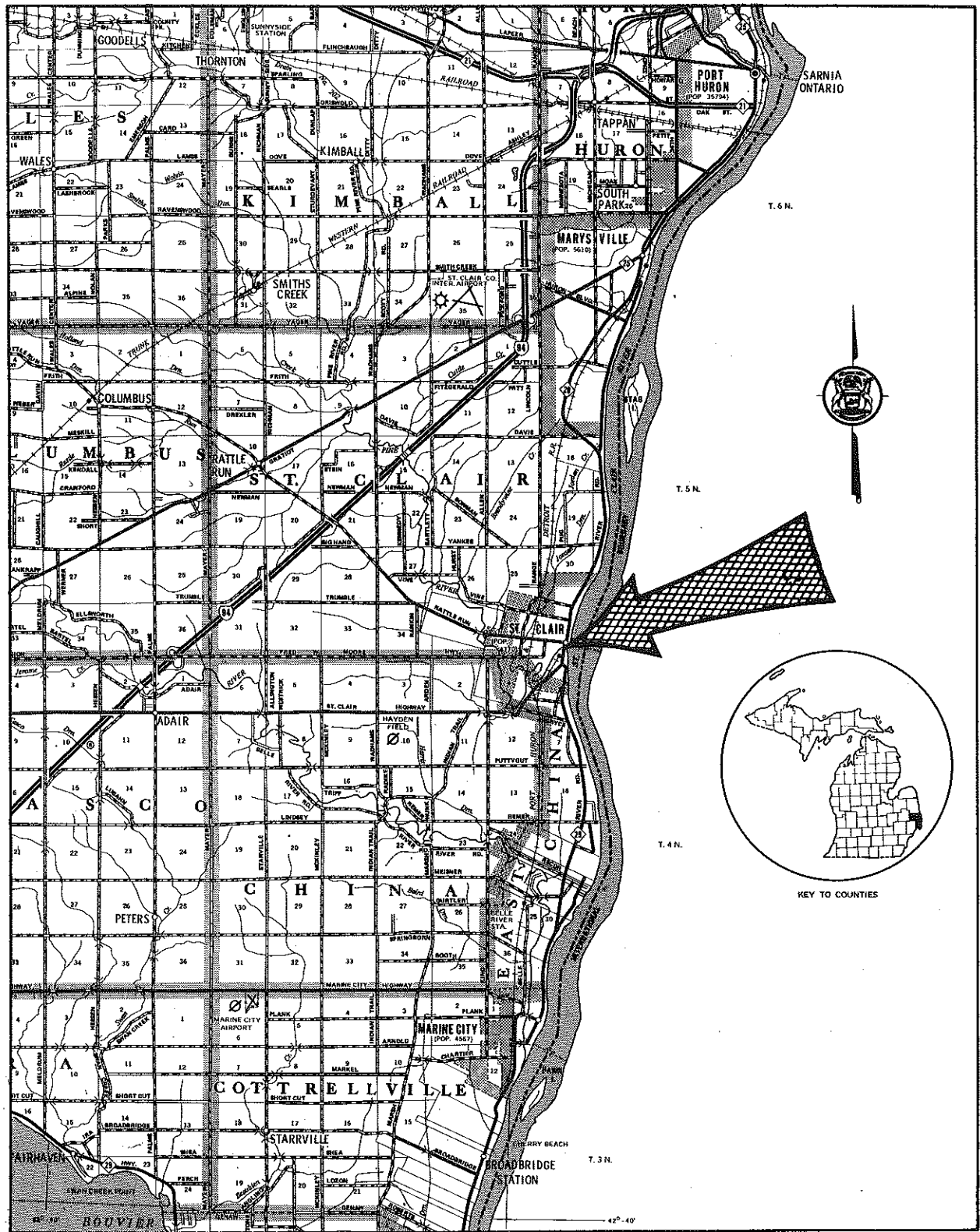


Figure 1. Location of experimental lightweight fill, Project No. 77052, Job No. 07565A, reconstruction of Pine River Bridge, M 29 in St. Clair.

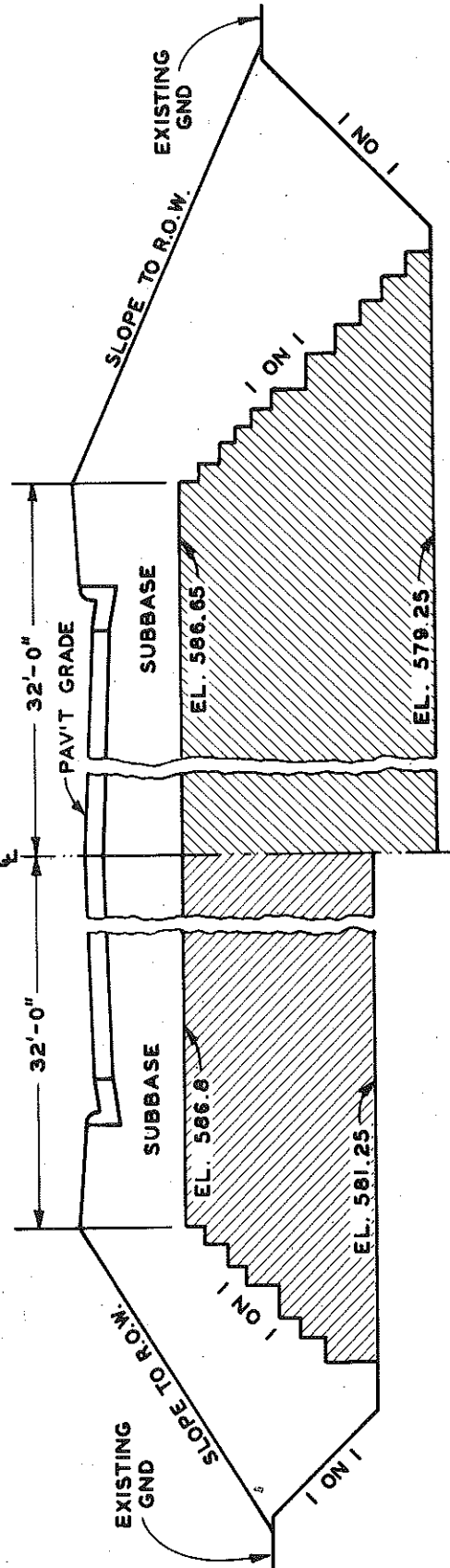
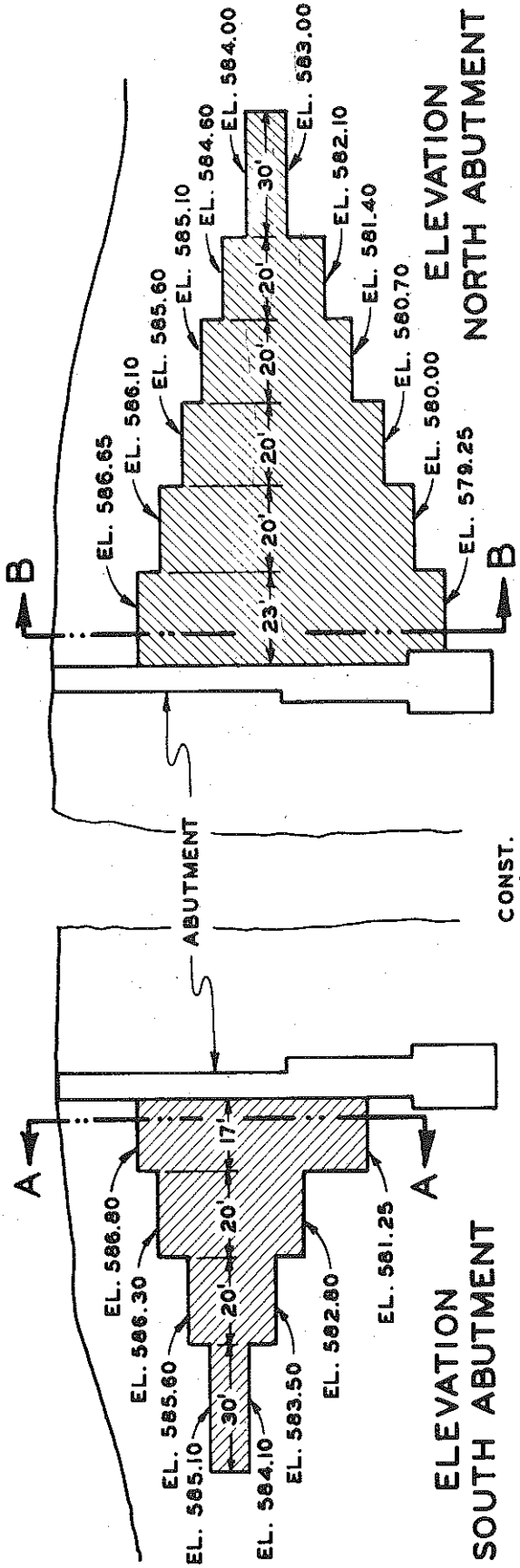


Figure 2. Elevation and section views of Elastzell lightweight fill.

The lightweight fill was designed with the assumption that the wet density of Elastizell concrete would stabilize at no more than 35 pcf after construction. Approximately 4 ft of sand subbase fill was placed over the Elastizell concrete to minimize the number of freeze-thaw cycles to which it might be exposed.

## CONSTRUCTION AND TESTING PROCEDURES

The construction details of the project were, in general, the same as described for the Waiska River project (1) and, with indicated modifications, in accordance with the Special Provisions for Low Density Concrete included as an Appendix to this report. The only major change resulted from a sudden rain storm which flooded the construction site and floated a corner section of the lightweight cellular Elastizell fill. This section was removed and repoured. Edge drains were installed at the base of the fill to prevent a similar occurrence.

Early in construction, as mentioned in the Waiska River report, it was found that the Elastizell mixture would not meet the 100 psi 28-day strength requirement so the specified value was lowered to a still satisfactory 50 psi requirement. The use of the 28-day test, however, was of no value as a construction control because the entire job was finished in much less than 28 days. For this reason the required compressive strength was computed based on maximum probable loads applied to the fill during construction. As described in Ref. (1), using a safety factor of two, the minimum allowable compressive strength should be about 18 psi. However, in order to obtain more reliable information for any future jobs, samples were obtained during construction for laboratory testing. For this purpose, samples were collected in 4 by 8-in. waxed cardboard concrete cylinder molds at one hour intervals during pouring operations.

In addition, samples were cored from the pours during construction and the breaking loads determined in order to check the pour strength as the job progressed. Although considerable variation was found in the compressive strengths, and a few were less than the 18 psi value, it was not felt necessary to remove and replace any pours.

As was noted on the Waiska River job, a 1 to 2-in. thickness of a soft scum-like layer was found at the bottom of some pours. These areas were very weak and gained no measurable compressive strength with curing. They remained wet, had a cellular structure, and could possibly be caused by an excess of foaming agent which could trap excess water contained in the mix. Due to its higher density this portion of the mixture would tend

to settle to the bottom. When finally dried, the cell walls of these weak layers are extremely thin and crumble easily when touched. Similar material was found, to a lesser extent, located randomly in various layers throughout a pour. Samples from these areas were much weaker than those obtained from normal pours. These weaknesses were also apparent in the samples taken for molding into test cylinders during construction, indicating a non-uniformity in the production of Elastizell concrete. It would appear that the production and placing of Elastizell concrete to a wet density of 30 pcf is difficult to control on a large scale, when produced in small batch mixes of less than 1 cu yd. This results in a non-homogeneous completed fill, a condition that cannot be detected until the material is in place and has reached its initial set. Due to the bridging action of the pour as a whole, these weak layers resulted in no observable problems of stability. However, their presence is not desirable and should be corrected in any future work through better control of mixing operations.

As in the previous work, the contractor was allowed to begin building up a pour when the existing layer was capable of supporting the weight of a man. However, backfill operations were not permitted until three days after final pouring, a period allowing ample time for the top layer of Elastizell concrete to reach the desired minimum strength of 18 psi.

#### SUPPLEMENTAL TESTING

During the lightweight construction at both the St. Clair and Waiska River sites it was found that modifications in the provisional specifications used for the work were necessary and that additional information concerning the characteristics and the placing of Elastizell concrete would be necessary for any future use of the material. Some of this information could be obtained by supplemental testing but some must be gotten from observation of the field installations.

##### Relationship Between Strength and Curing Time

During construction it was obvious that the 28-day compressive strength could not be used as a practical means of controlling strength requirements of Elastizell concrete because the entire job was completed in less than half this time. Also, testing of cores from the job indicated that the 28-day 100 psi strength was unrealistic; thus, this value was lowered to 50 psi.

Samples from the St. Clair river job were obtained and tested at 2, 3, 7, and 28-day curing times in order to determine the relationship between



strength and curing time. Test results from 10 pours are plotted in Figure 3. Each point represents the average compressive strength of two samples except for a very large pour, D, where each point represents the average of three tests. For all tests, the samples were air cured in standard 4 by 8-in. concrete cylinder molds.

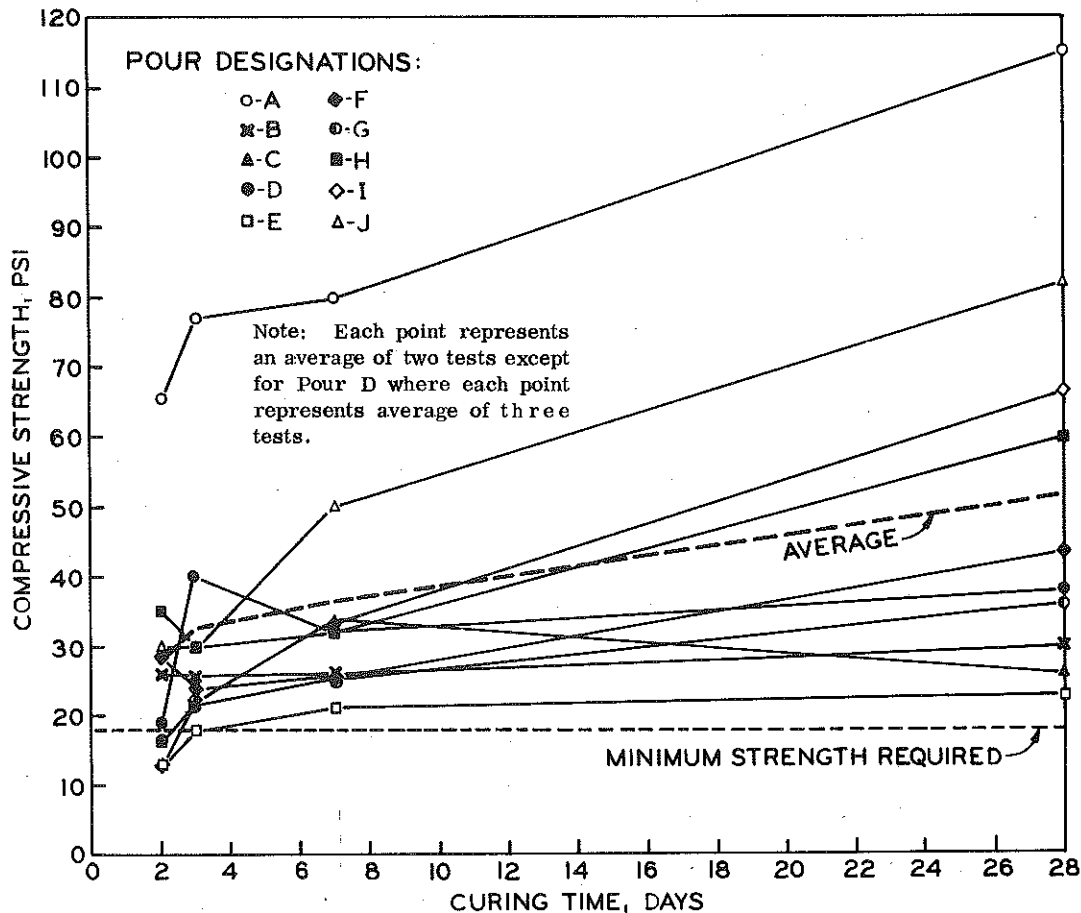


Figure 3. Relationship between curing time and compressive strength (4 by 8-in. samples of Elastizell concrete obtained during pouring).

The tests show a considerable variation in compressive strength of the different pours, indicating that control of the Elastizell concrete mix is not good. Averages of all tests showed two-day strengths well above the 18 psi requirement and that the arbitrary 50 psi 28-day dry strength was attained. However, over half of the individual tests did not meet the 50 psi requirement at 28-days by a considerable amount. The 18 psi value was attained by all samples after three days although three were below this amount for the specified two days. Based on these data it appears that the two-day 18 psi requirement would be reasonable for job control.

## Relationship Between Compressive Strength and Dry Density

Elastizell concrete, at a placement density of 30 pcf, is composed of approximately 5-1/2 sacks of portland cement, 35 gallons of water, and a small amount of Elastizell. The oven dry weight of this mixture is approximately 21 pcf. Because dry density and compressive strength of Elastizell concrete are both direct functions of the portland cement content it was felt that a job might be controlled by dry density measurement alone, rather than by wet density and compressive strength. Wet density of Elastizell concrete can be increased or decreased by merely adjusting water content so this does not offer the same positive control as does the fixed dry density value. A study was made to determine the feasibility of specifying dry rather than wet density for controlling the Elastizell concrete mix.

An attempt was made to oven-dry fresh Elastizell concrete samples immediately after they were poured but this could not be done successfully. When attempting either stove or oven drying the samples foamed excessively and, even with constant attention, it was impossible to dry the samples completely in a single work day. However, it was found that by proper calibration, the Speedy Moisture Tester could be used to obtain the moisture content, from which information the dry density could be computed. This method is, however, more cumbersome than the direct measurement of wet density. Figure 4 shows the relationship between dry densities obtained by the Speedy and the conventional oven-dry methods for use in those cases where dry density might be used to check the cement content of a mixture.

To check the relationship between dry density and the 28-day compressive strength of Elastizell samples, a laboratory study was conducted using field samples obtained from all of the Elastizell construction sites. The relationship, using individual samples, is plotted in Figure 5. This plot shows that density does have an influence on compressive strength but this influence is small and, coupled with the wide scattering of the data points, does not yield a trend suitable for specification control. Further, it would appear that other factors, such as water cement ratio and perhaps the amount of Elastizell in each sample, have a greater effect on compressive strength than does the cement content. It is, therefore, recommended that the wet density measurement be retained as a specification control. Dry density values can be used, if desired, to check cement content of the mixture.

## Increase in Density of Elastizell Mixture Due to Moisture Pickup

In order to retain its characteristic as a lightweight fill, Elastizell mixtures are placed at a wet density of about 30 pcf with the assumption

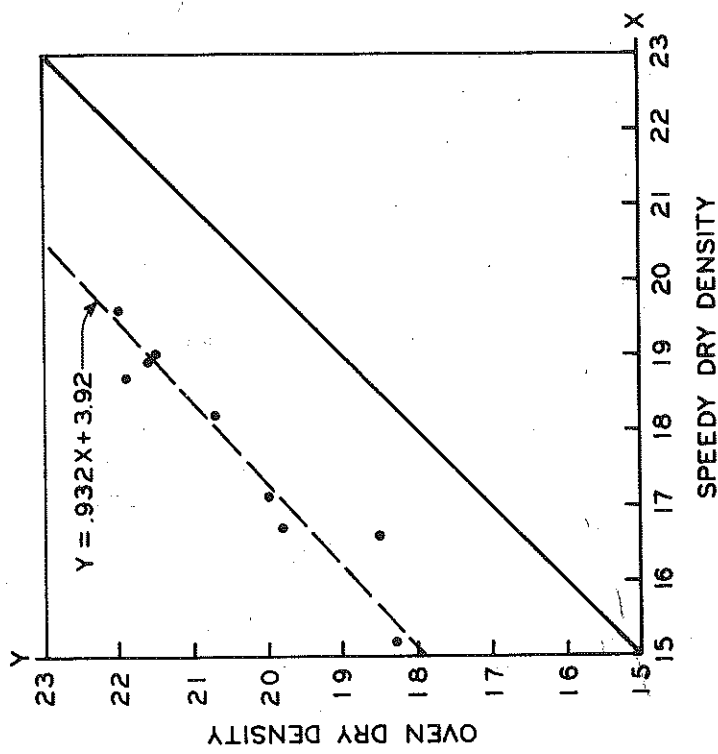


Figure 4. Relationship between dry density determined by oven drying and by the Speedy Moisture Meter.

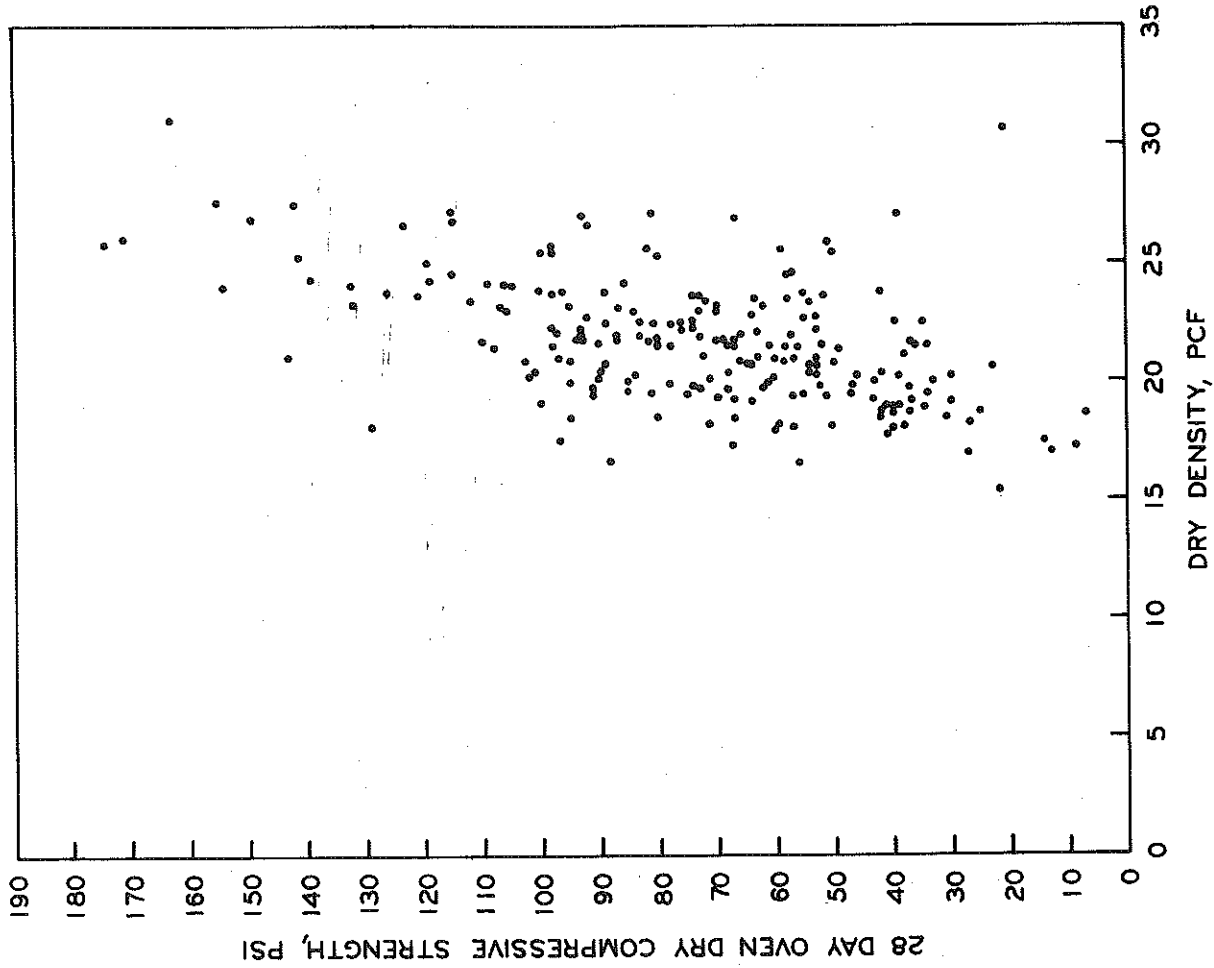


Figure 5. Relationship between compressive strength and dry density of Elastizell concrete.

that moisture sorption will be low, causing no increase in wet density above 35 pcf. This design value was based on preliminary tests in which small samples, furnished by the Elastizell Corp., were subjected to laboratory sorption testing (2). In these tests the samples were sealed in an air-tight container in which the air around the samples was maintained at 100 percent relative humidity while the sample rested in about 1/8-in. of water. It was assumed that this test condition simulated field conditions where there would be free water at the bottom of the fill while it was surrounded by moist sand or soil.

When testing the large number of samples obtained from the field jobs, however, it was necessary to test them for sorption in the Laboratory's concrete-curing moist room. Under these conditions, where the samples were placed on racks and subjected to dripping condensation, the moisture pickup was much greater than that obtained for the original samples. Figure 6 shows a comparison of sorption rates for the two laboratory test methods and clearly indicates that the upper design limit of 35 pcf could be exceeded if the sorption rate of an Elastizell fill duplicates moist room sorption conditions rather than conditions of the original test method.

Field studies of the in-place fills will be made during the next few years to determine which of the laboratory sorption test methods is more nearly duplicated in the field. From this information the ultimate moisture pickup can be determined and a proper design density established. Although it is believed that moisture pickup in the field will be less than that for the relatively small samples used in the moist room tests, the selection of a design wet density should await results of the field observations.

## CONCLUSIONS

Based on the testing and observation of two lightweight fills constructed of Elastizell concrete the following conclusions appear warranted.

- 1) Construction operations proceeded smoothly and no major problems were encountered.
- 2) Any future Elastizell concrete fills should include edge drains to prevent flooding and flotation of the lightweight material.
- 3) The specification controlling placement density should continue to be based on wet density rather than dry density.
- 4) The originally specified 100 psi, 28-day dry compressive strength requirement is not applicable for construction control. The specification

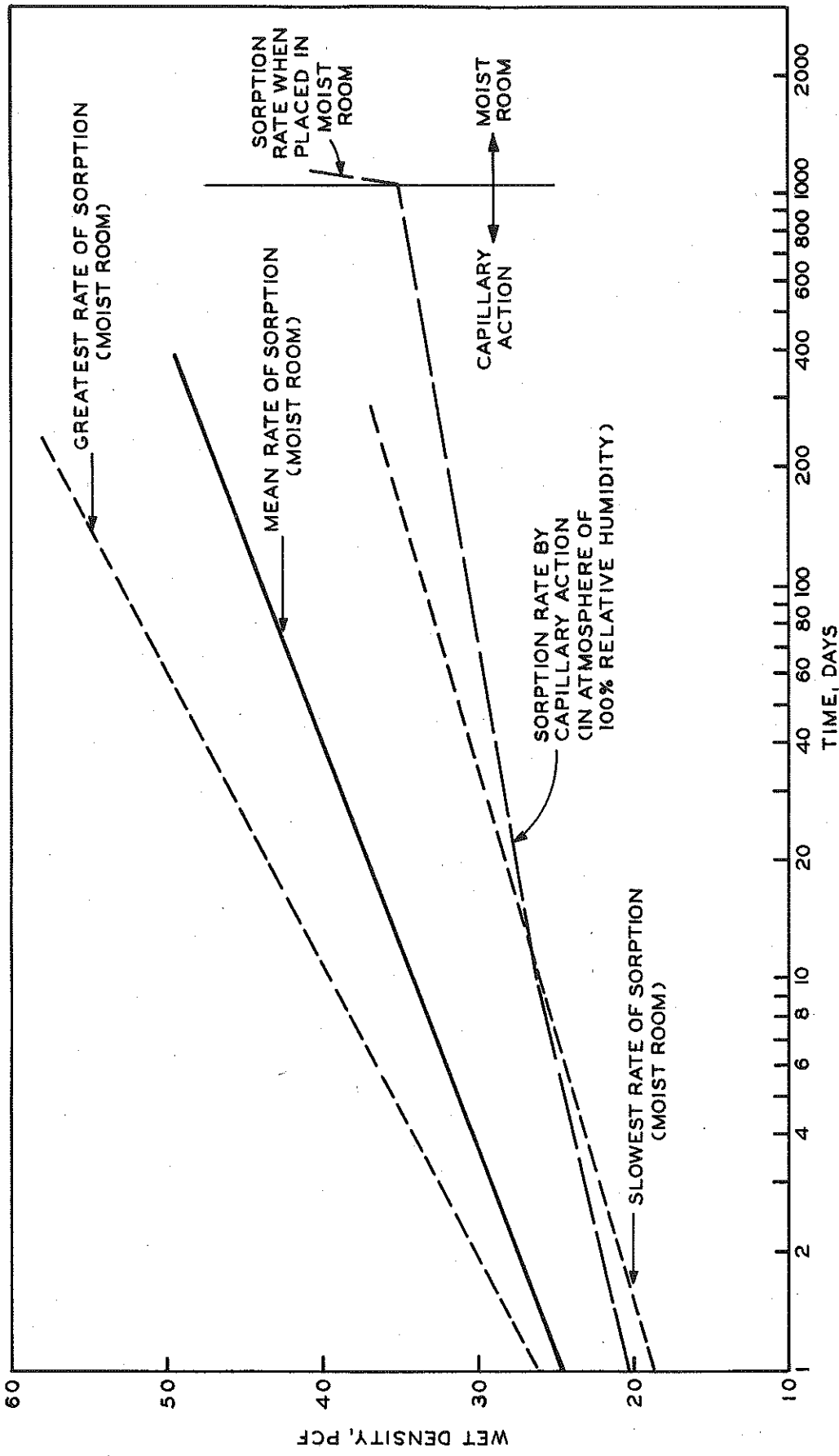


Figure 6. Rate of moisture sorption (laboratory tests).

should be changed to require an 18 psi strength for a sample that is air-cured in a 4 by 8-in. waxed cardboard concrete cylinder mold for a period of two days.

5) Based on moisture sorption tests of field mixed samples, placed in a moist room, it appears that moisture pickup of the Elastizell concrete fill might be higher than originally anticipated. Observation of the existing fills will be made to check this. Should Elastizell concrete fills be constructed before this information is available they should be designed for the possibility of a higher ultimate design weight than that previously used.

6) Testing of samples at the time of pouring and of cores obtained from the hardened Elastizell concrete, indicates that strength and dry densities vary considerably throughout the fill. This indicates a need for more accurate production control of the Elastizell concrete mixtures.

7) Specifications should permit the pouring of Elastizell concrete over any previously poured layer which has cured sufficiently to permit walking on its surface. Backfill operations to cover the completed pour must be delayed for at least three days after the final Elastizell concrete pour has been made.

8) Although Elastizell concrete appears to be a satisfactory fill material it cannot be recommended for general use, at present, because of concern as to the effect that non-uniform mixing (resulting in weak spots) might have on long-term performance and because an appropriate design unit weight, based on moisture sorption rate, has not been established.

#### REFERENCES

1. Novak, E. C., Jr., "Experimental Lightweight Fill," Michigan Department of State Highways and Transportation, Research Report No. R-1053, March 1977.
2. Mainfort, R. C., "Laboratory Evaluation of 'Elastizell' as a Lightweight Fill," Michigan Department of State Highways and Transportation, Research Report No. R-956, January 1975.

**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  $30 \pm 2$  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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