Draincrete in Pavement Rehabilitation

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Draincrete is an open-graded concrete of relatively low strength with a high void ratio. It is used in pavement construction and rehabilitation where water is to be rapidly removed from the pavement system. For new pavement structures the draincrete is used as a water-transporting layer under a concrete pavement. With the strength often specified at 800 psi, it also serves as a rigid subbase. Its major application, however, has been as a water-collecting medium for edge drains in pavement rehabilitation work. Specification provides for a minimum as well as a maximum strength to avoid confusion with ordinary concrete. As an additional safeguard, requirements are also set to limit its unit weight range to secure sufficient void ratio. Draincrete used for edge drain serves the dual purpose of providing drainage as well as strengthening the subbase where the subbase ledge has been removed to provide the drainage channel. Many miles of edge drain draincrete have been installed on the Florida interstate system. As these installations have only been in place for less than 4 years, their functioning and durability over extended time periods cannot be adequately judged. All indicators suggest, however, that an edge drain system using draincrete, as used in the Florida interstate system, will function for extended periods of time with a minimum of upkeep.

Ingress of water into a rigid pavement system has been recognized as a causative factor in pavement deterioration and eventual failure since the early 1930s. The early studies defined the three pavement pumping factors as *(a)* water at the pavement and subbase interface, *(b)* heavy traffic loads, and *(c)* pumpable fines in the base or subbase. It is suggested that any impermeable base will pump, given sufficient time. Present techniques and procedures concentrate the three pumping factors at the pavement edges for pavements on low permeable bases by permitting the pavement to slope to the outside and requiring heavy traffic to travel in the lane where the maximum amount of runoff water and deflection generally occur. Early studies suggested that the solution to the pumping problem was by

1. preventing water ingress by sealing of joints and cracks, or
2. draining ingressed water away from the system using a permeable subbase or by the use of drains.

As roads were built in the 1930s and 1940s, the edge drains did not prove time effective, nor did the use of dowels modify or eliminate the problem. The use of sealant for cracks and joints provided only a temporary prevention of water ingress and required maintenance on a regular basis. Subsealing was considered an annual maintenance chore.

The onset of construction for the interstate pavement system often relied on the structural advantage of a firm and unyielding base for load capacity and for improved pavement ride characteristics. It was thought that bases made with a cementitious material were non-erodable and therefore would not pump. Experience has demonstrated that even the strongest of base structures has a tendency to erode under the combined influence of load and of water. An edge drain is required for all pavements placed on poorly draining subsoil because of the problem of preventing water ingress.

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EXPERIMENTAL PHASE

The Florida Department of Transportation (FDOT) recognized the open-graded concrete, also called draincrete, as a medium by which water could be accumulated and led away from the pavement system. For repairs, the strength of the original base system could be maintained or improved by the draincrete structure and also strengthened by using the draincrete as an edge beam. The strength capacity of the pavement at edges and corners could thus be maintained and sometimes improved when the edge beam system was used. In new pavements the draincrete could be used as a subbase structure while at the same time permitting infiltrated water to drain away or percolate into the subgrade soil.

The use of draincrete by the FDOT has been exclusively for edge drains in pavement rehabilitation work. A typical edge drain is shown in Figure 1. The trench provided is 1-ft wide and the depth is sufficient to drain water from the pavement-subbase interface or subbase-subgrade interface. A 4-in. perforated drain pipe is placed in the bottom of the trench. The trench is lined with a filter fabric and is filled with draincrete to a level permitting the shoulder pavement to be restored. Outlet drains are spaced at distances of 200 to 500 ft, depending on the circumstances. The draincrete is stricken off, or may be tamped or lightly rolled into place.

Mix Design

Various aggregate types and sizes have been used for draincrete. The No. 89 coarse aggregate by AASHTO specifications has been found from experience to provide sufficient strength and stability and to contain an adequate amount of fine particles for a mortar. Crushed stone aggregates will give a no-slump concrete and better stability than will concrete made with gravel. No effort is generally required to consolidate or compact the material in place. A light tamping is all that may be required. The strength requirement for edge drains and open-graded base course has been set at 800 psi. For Florida aggregates and conditions, a four-bag mix at a water-cement ratio of 0.40 or less will meet the strength requirement.

Properties of Draincrete

The desired properties of draincrete are *(a)* sufficient voids to permit water drainage and some storage and *(b)* strength and

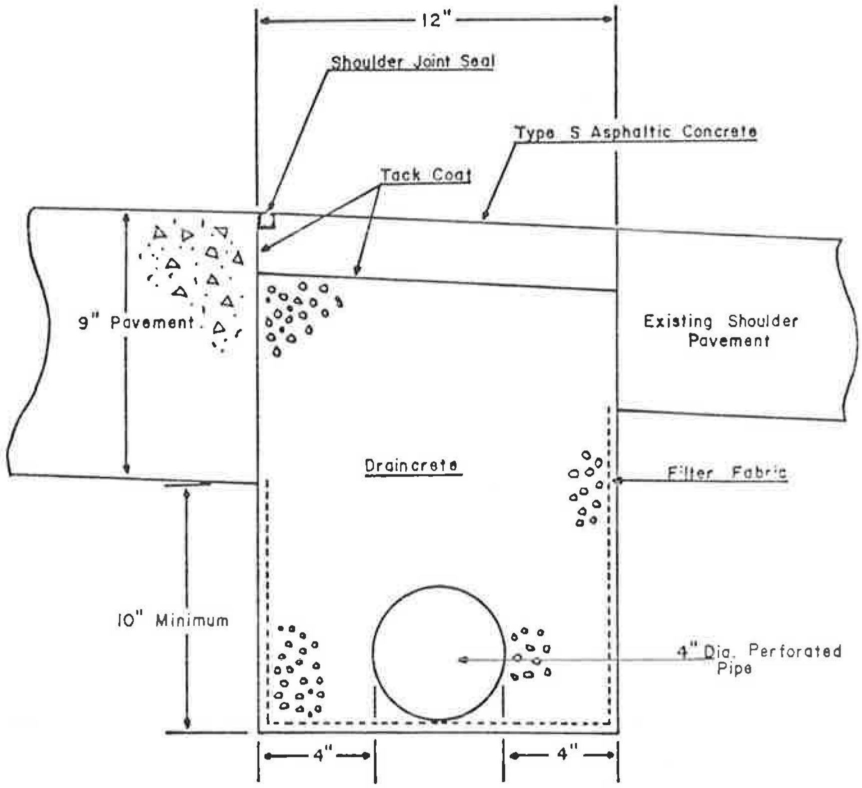


FIGURE 1 Typical cross-section for draincrete edge drain.

stability. The amount of voids may be expressed by the void ratio, e, in percent as:

$$e = V_v/V_s \times 100 \text{ percent} \quad (1)$$

where

V = volume,
v = void, and
s = solid

Typical void ratios are in the range of 30 to 40 percent. The porosity, n, is defined as,

$$n = \frac{Vv}{V} \quad (2)$$

where V is the total volume.

Based on the correspondence between n and e, of $n = e/(1+e)$, the porosity is in the range of 20 to 30 percent for the void ratios listed previously.

The flow of water through a 6-in. by 12-in. cylindrical specimen was measured using a 12-in. extension to the specimen. All flow was in the vertical direction. The result of the flow of water through draincrete is given in the following table. Note that the rate of flow was recorded after 1 min. Most of the flow occurred during the first 30 sec. The 4 percent not flowing through was probably retained on cavity walls.

cement content bags/yd^3	3	4½	6
compressive strength 7d., psi	354	861	920
porosity, n, percent	30	27.4	25.0
rate of flow, percent	96	96	96

In another laboratory experiment, a 3-ft-long draincrete edge drain, 1-ft wide and 1½-ft deep, was placed next to a well-compacted A-2-4 shoulder soil (as shown in Figure 2). The two materials were separated with filter fabric. Water was flowing into the soil area and regulated to provide a 1½-in. hydraulic head. The measured inflow of water in gal/min is shown in Figure 3 for the first 15 days. After a gradual reduction in flow over the first 6 days from 3 gal/min, the flow stabilized at about 0.6 to 0.8 gal/min.

The system described was allowed to dry over a 2-week period. This was followed by a 24-hr saturation period. It was found that the flow measured the following day was similar to that measured before drying.

Based on these and other tests, it was concluded that draincrete can substitute for any gravel or stone filter and has the advantage of structurally strengthening the pavement system.

The unit weight of the draincrete may be used in construction quality control and is estimated from the relation:

$$\gamma_{dc} = \gamma_c (1-n) \quad (3)$$

where

γ = unit weight
c = concrete
dc = draincrete

For γ_c = 150 lb/ft^3 and n = 0.30, the unit weight of the draincrete is 105 lb/ft^3.

The porosity may be adjusted by gradation of coarse aggregate, by the introduction of up to 300 lb of fine aggregate, and by the amount of cement. A well-operated concrete plant can keep the unit weight within ± 5 lb/ft^3 limits.

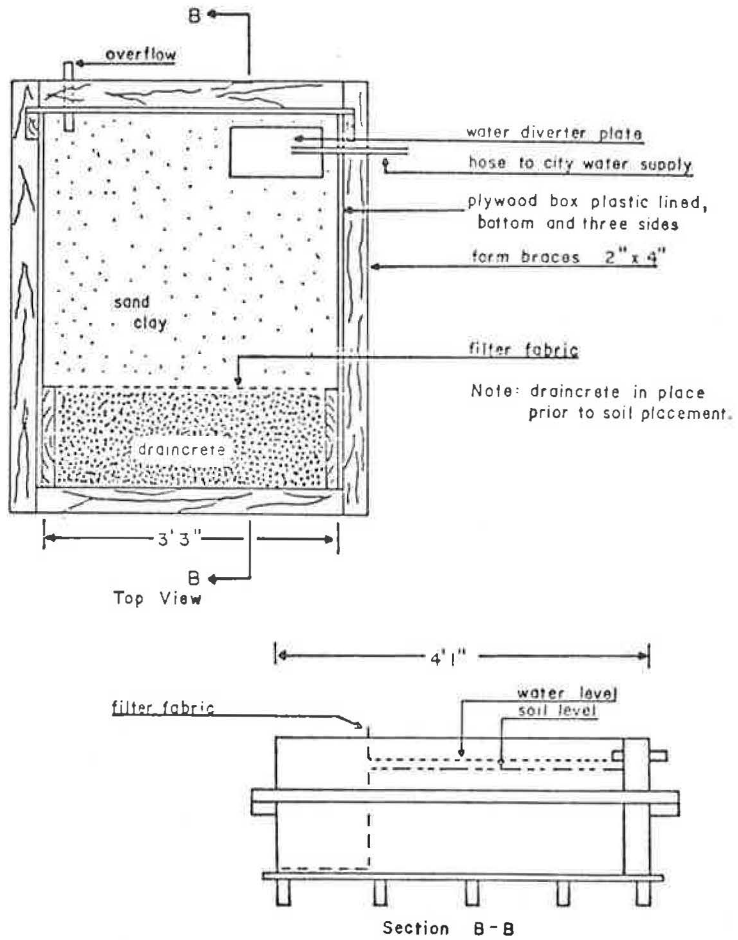


FIGURE 2 Draincrete test setup for simulated pavement drainage condition.

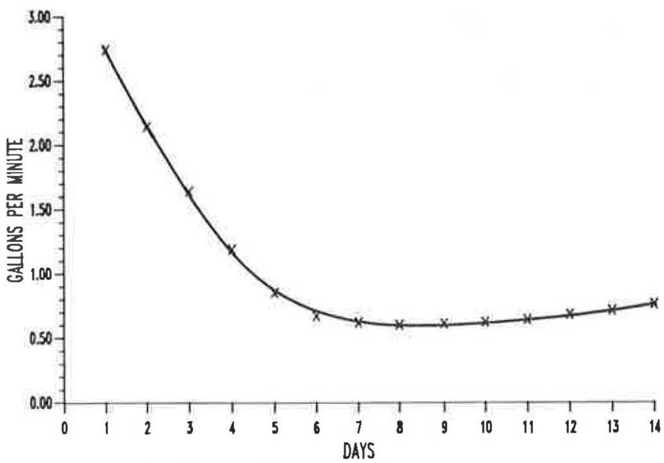


FIGURE 3 Draincrete flow capacity.

DRAINCRETE IN PAVEMENT REHABILITATION

After a determination has been made of voids and pumping of a pavement, consideration should be given to the extent an edge drain will remedy the situation. The decision to install edge drain will generally coincide with other rehabilitation measures such as sealing of joints, subsealing, grinding or milling of surfaces, and overlay. If subsealing is to be made, the edge drain should be installed after the subsealing.

Typical Section

The need for edge drains in pavement rehabilitation has resulted in speciality items such as complete drainage systems, various kinds of perforated drainage pipes, and filter fabrics. A typical draincrete edge drain installation was shown in Figure 1. The configuration shown in Figure 1 was tested using a 3-ft-long trench segment and applying loads through imprint areas, as would be expected from straying truck traffic. The capacity of the draincrete system to sustain static load was a direct function of its compressive strength and well beyond the expected load intensities with a comfortable factor of safety. Many of the filter fabrics presently in use will clog and reduce the inflow rate. The slurry material generally pumped contains particles finer than the No. 200 sieve. The filter fabric is not recommended to cover the opening through which the water and slurry enters the system. The need for filter fabric to envelop the draincrete has not been established.

A 4-in. diam perforated plastic pipe or a 5-in. diam corrugated pipe will provide ample cross section for flow. Spacing of outlets depends on circumstances and should not exceed 500 ft. The outlet pipe is not perforated and is generally not encased in draincrete.

Specification

Draincrete is specified using a Type I cement with no pozzolan, a Size 89 coarse aggregate, a water-cement ratio not to exceed 0.40, and a minimum four bags/yd^3 cement factor. The compressive strength is specified in the range of 800 to 1,500 psi. The unit weight must be within ± 5 lb/ft^3 of the value established in the mix design. After placing, the draincrete may be tamped or rodded lightly to ensure uniform distribution.

Tests

The specimens for compressive strength are made similar to those for ordinary concrete but with these exceptions:

1. The tamping rod is a 2-in. by 2-in. wood instrument 24 in. long.
2. The draincrete is placed in the 6-in. by 12-in. cylindrical mold in two approximately equal layers.
3. Immediately after finishing, the specimen is covered with impervious plastic until placed in the standard curing facility.
4. Curing, capping, and testing for compressive strength follow those used for standard concrete.

Included in the quality control and acceptance testing is measuring the unit weight of the draincrete. Again, the tamper is the same as the one used for the compressive specimen. The draincrete is tamped in two layers in a 1/10-ft^3 cylindrical measure using 25 blows for each layer.

Construction Quality Control

The data discussed in the following section were obtained during one of the initial draincrete construction projects in the state of Florida. The lot size and production were such that only one data set was obtained for each day of construction. Also, at this point the test procedures had not been clearly established. It is believed that the present test procedures would reduce the data variations shown here.

In Figure 4, the compressive strength data are plotted versus unit weights, showing lower and upper acceptance limits for both variables. The regression line is indicated, and the variance, r, indicates low or no correlation between the two variables. The figure shows that two data sets failed to meet both strength and unit weight requirements while three other data sets did not meet the strength requirements.

Statistical concepts in the acceptance criteria, for compressive strength, similar to those used in the American Concrete Institute (ACI) 318-83 Building Code, provide the following acceptance requirements.:

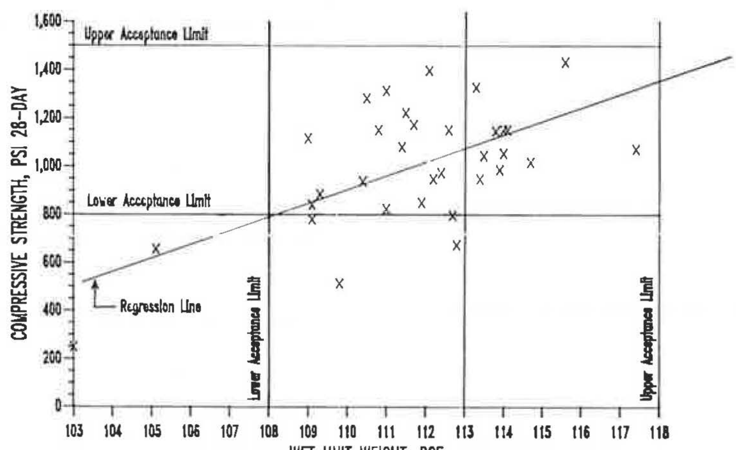
1. No individual strength test, as the average of two cylinders, shall fall below fc′ by more than 200 psi, and
2. The average of all sets of three consecutive tests shall equal or exceed fc′.

Using these criteria, data in Figure 5 show two failures by the first criterion whereas those in Figure 6, plotted according to the second requirement, show no failures. Penalties for low strength would be imposed for two lots.

A similar principle is employed in adopting a specification for unit weight as follows:

1. No individual unit weight test shall deviate by more than 7 lb/ft^3 from the laboratory unit weight.
2. The average of three consecutive tests for unit weights shall be within ± 5 lb/ft^3 of the unit weight determined in the mix design laboratory test.

The first requirement was deduced from field test data and the second was based on data in a laboratory study. Recent information suggests that these requirements for unit weight are reasonable. However, more affirmative limits remain to be determined.



Note: r = 0.593, r^2 = 0.352.

FIGURE 4 Draincrete acceptance criteria.

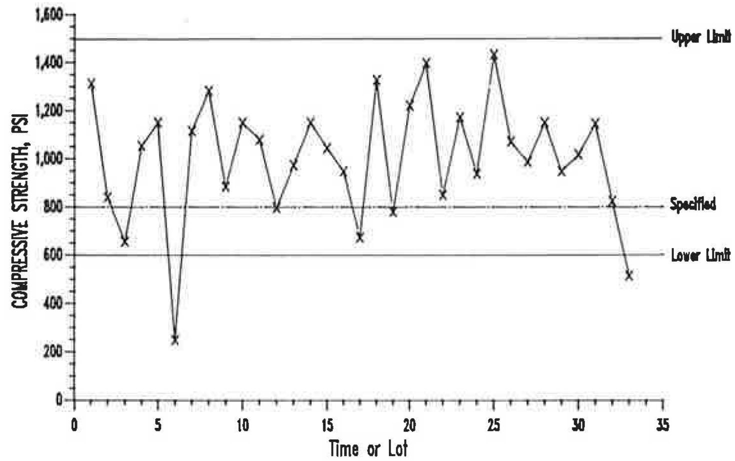


FIGURE 5 Quality control chart compressive strength (single points).

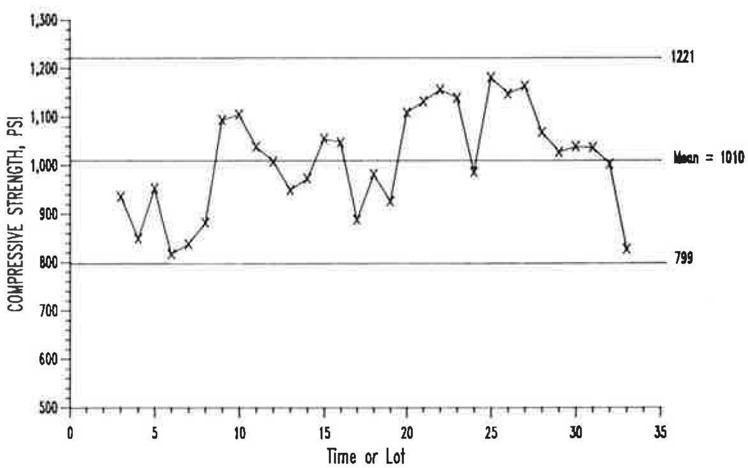


FIGURE 6 Quality control chart compressive strength (average of 3 tests).

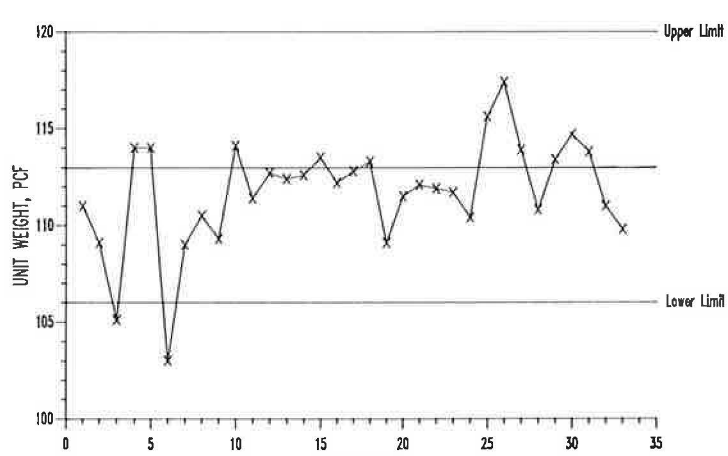


FIGURE 7 Quality control chart unit weight (single points).

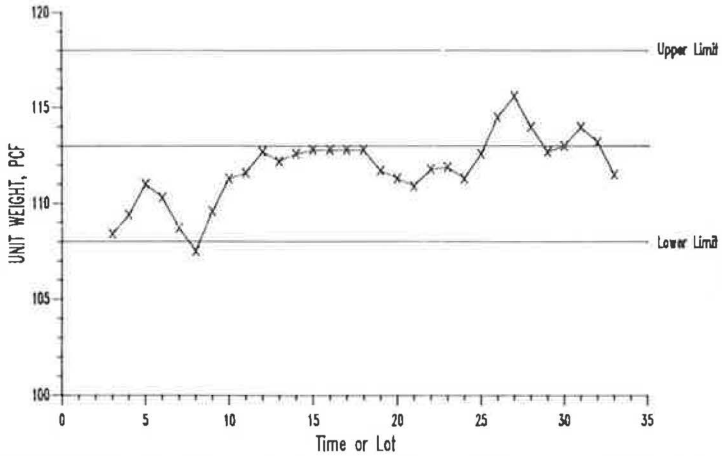


FIGURE 8 Quality control chart unit weight (average of 3 tests).

The data for the individual tests in Figure 7 show that two test values failed the first requirement. Data for the second requirement are plotted in Figure 8 and show that one set failed the requirement. Accordingly, lots Nos. 3 and 6 failed, for which penalties were imposed.

SUMMARY

Over the short time period draincrete edge drain systems have been in place, they have functioned well. It was noted that the intermittent turning of the drum of the ready mix truck during the placing of the draincrete produced an evenly coated aggregate mix with little or no cement paste left in the drum. The cost of draincrete edge drains is competitive with other drainage systems tried in this state.

The presentation of field test data has been merely for the purpose of demonstrating how such data may be used. The Florida Department of Transportation now has standard methods for The Making and Curing Porous Concrete Compressive Strength Test Specimens in the Field, and for Weight per Cubic Foot of Porous Concrete *(1)*.

REFERENCE

1. *Manual of Florida Sampling and Testing Methods*, Bureau of Materials and Research, Florida Department of Transportation, Gainesville, Fla., June 1984.

Publication of this paper sponsored by Committee on Pavement Rehabilitation and Committee on Rigid Pavement Construction and Rehabilitation.