PAP-741

Analysis of Crushed Gravel Envelopes, Memorandum Dated November 14, 1996

by

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IN REPLY REFER TO:
D-8560
RES-3.50

NOV 14 1996

MEMORANDUM

To: Rod Tekrony, D-8550

From: Jim Higgs
Hydraulic Engineer

Subject: Analysis of Crushed Gravel Envelopes

BACKGROUND

Crushed gravel in subsurface drain envelopes has been under scrutiny and thought to fail in situations where river run material would perform adequately by using the criteria in Reclamation's *Drainage Manual*. Subsequently, the use of crushed gravel envelopes has been discouraged. The objective of these tests was to investigate the design parameters for crushed gravel in subsurface drain envelopes. This should decrease cost of some construction projects due to an increase of materials available for use.

CONCLUSIONS

Testing and analysis of crushed gravel envelopes is complete. The crushed gravel envelope material performed better than river run material. The limits for gravel envelopes listed in the *Drainage Manual* are appropriate for both crushed gravel (highly angular) and river run (rounded) materials.

INVESTIGATION

The first set of tests used the lower limit allowed for by the *Drainage Manual* for base materials with D_{60} ranging from 0.05-0.10 mm. The base material used was a very clean, fine sand. Results for the base material and all gravel envelope materials for the gradation test is shown in figure 1 and permeabilities in table 1.

The procedure for testing the lower limit gravel envelopes was similar to procedure USBR 5605 of the *Earth Manual, Part 2*. The base soil was compacted to be 4 in thick and to be consistent with soil with 9 ft of overbearing pressure. The 4-in thickness was limited by the head available to cause failure. This simulated the bottom of the trench where groundwater flows from the undisturbed base soil into the gravel envelope, then into the drain pipe. The applied gradient for these tests on both crushed and river run materials exceeded 22 inches/inch without failure. This gradient exceeds the maximum sustainable gradient found at the bottom of a newly excavated trench.

Table 1. Gravel envelope and base material properties. These values show that the head loss in gravel envelopes are insignificant to the head loss of the base material.

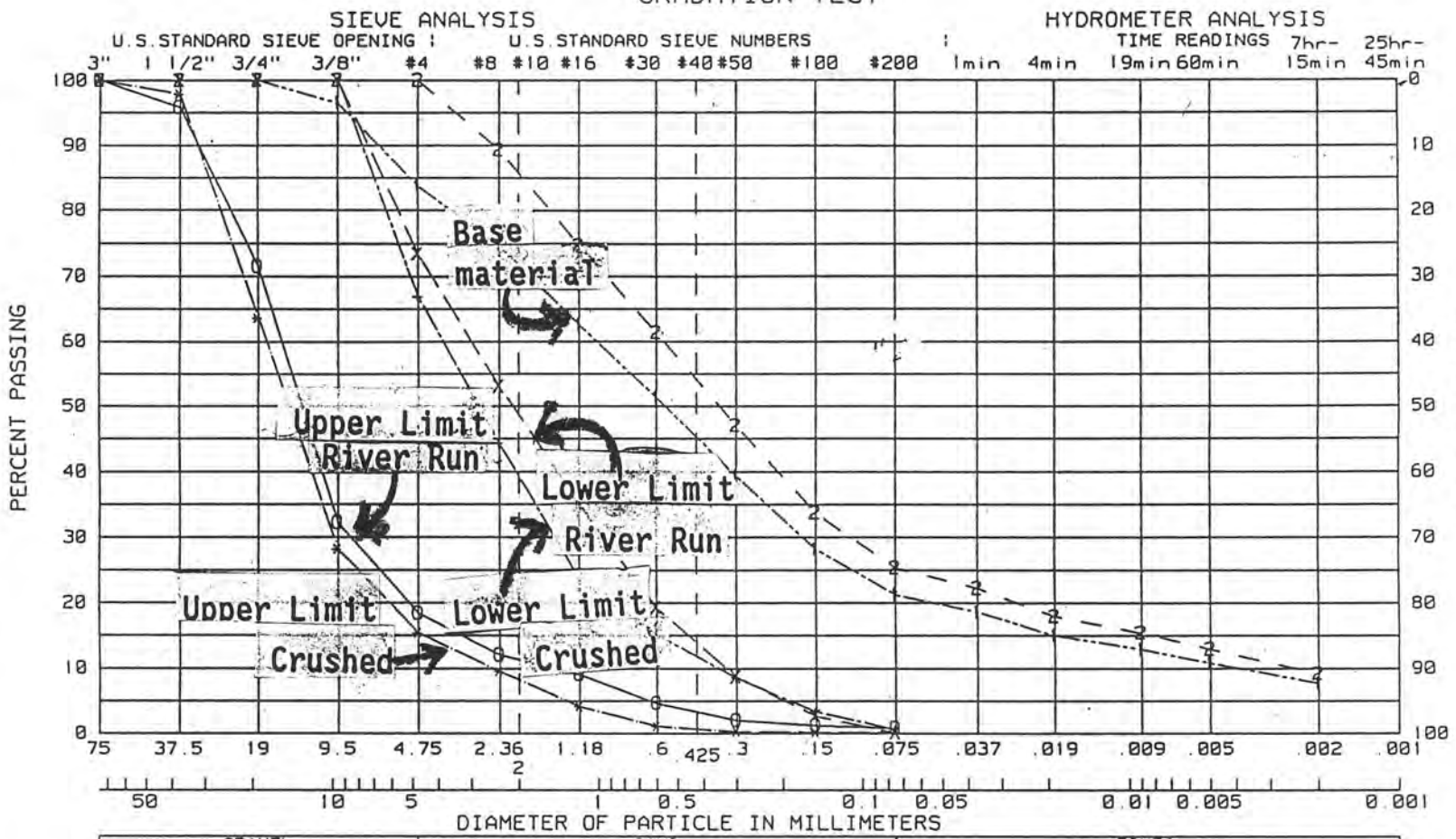
Material	Permeability (ft/s)
Lower Limit River Run Gravel	0.09
Lower Limit Crushed Gravel	0.16
Upper Limit River Run Gravel	3.2
Upper Limit Crushed Gravel	12.1
Base Material	4.1 E -6

The procedure for testing the upper limit gravel envelopes was similar to procedure USBR 5630 of the *Earth Manual, Part 2*. The 4 in of base soil was not compacted and there was no overbearing pressure so that it was consistent with the top of a newly placed drain pipe and gravel envelope with the trench sides caved in. After placing the base material, both of the specimens filled slowly from the bottom up. When the water reached the base material, there was about ½-in settlement of the base material into the gravel envelope materials. The 4-in thickness of base material was used for calculation of applied gradients.

The crushed gravel envelope failed under a gradient of 10.7 inches/inch. The river run gravel envelope failed under a gradient of 7.2 inches/inch. These gradients exceed maximum sustainable gradients found at the top of the envelope material in a newly excavated trench.

cc: D-6700
D-8550 (Sanders, Schaefer)
D-8560
D-8560 (Pugh, Higgs)

GRADATION TEST



PREPARED BY_____ CHECKED BY_____

FIGURE_____

SAMPLE NO.	HOLE NO.	ELEV. OR DEPTH	UNIFIED SOIL CLASSIFICATION				ATTERBERG LIMITS			SPECIFIC GRAVITY		NOTES:
			GROUP SYMBOL	% GRAVEL	% SAND	% FINES	LIQUID LIMIT(%)	PLASTICITY INDEX(%)	SHRINKAGE LIMIT(%)	MINUS NO. 4	OTHER	LEGEND
GRAD #2	RIVER RUN	UPPER LMTS										0
GRAD #1	RIVER RUN	LOWER LMTS										X
GRAD #1	CRUSHED	LOWER LMT										*
GR #2CR UL												+
BASE +4												1
BASE -4												2