TIRE CHIPS AS LIGHTWEIGHT BACKFILL
FOR RETAINING WALLS

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PROPOSAL SUBMITTED TO:
NEW ENGLAND TRANSPORTATION CONSORTIUM

DECEMBER, 1990
INTRODUCTION

Waste automobile and truck tires can be processed into chips which are durable, coarse grained, free draining, and most importantly have a low unit weight. These waste tire chips have the potential to be put to a beneficial use as construction material. The proposers are currently conducting a project funded by the Maine Department of Transportation entitled, "Use of Tire Chips as Lightweight and Conventional Embankment Fill". The main objective of this current project is to study the compressibility of 2-in. minus tire chips and evaluate how they can best be used as fill beneath paved roads. In the following we propose to build on this initial base of research and to determine the properties that would be needed to use tire chips as lightweight backfill for retaining walls.

TECHNICAL APPROACH

Literature Search. The literature search for our current tire chip project will be updated using the Highway Research Information System and other databases which are available at this university. The search performed for our current project has shown that there is only limited published literature on the subject. However, there are several projects which have been completed recently or are currently underway. The results of these projects will be obtained by contacting the responsible research groups.

The sources of tire chips in New England will be determined by contacting the following groups: (1) the solid waste management agencies in each New England state; (2) the manufacturers of tire chipping machines to determine what companies in New England have purchased them; and (3) known producers of tire chips such as the Sawyer Environmental Recovery Facility in Hampden,
Maine and Nathan Palmer of North Ferrisburg, Vermont. Samples of tire chips will be obtained from each identified source for gradation analysis. The gradation results will be submitted to the NETC Technical Committee who will select up to three gradations for further analysis.

Establish Testing Methods. The large size of tire chips necessitates that special procedures and equipment be used for all but gradation and absorption tests which can follow standard ASTM procedures for aggregates. The loose and compacted unit weight of tire chips can be determined in a large volume compaction mold. A 10-in. diameter mold is being used for 2-in. minus chips as part of our current project. To determine loose unit weight the tire chips are simply poured into the mold. The compacted unit weight is determined by compacting the chips with a compaction hammer using standard or modified Proctor compactive effort. It is anticipated that the same mold and procedure will be used for the proposed project.

The permeability of tire chips will be determined in a large diameter permeameter fabricated from 12-in. diameter PVC pipe. The tire chips will be placed in a vertical section of pipe and water under a known head will flow upward through the pipe. The resulting flow rate will be measured, yielding the permeability. Samples will be tested in both the loose and compacted condition. Tire chips are highly compressible so the permeability will vary with the applied vertical load. Therefore, the apparatus will be designed to allow a vertical load to be applied, and the permeability will be measured under several vertical loads.

The corrosive potential of tire chips on steel and concrete will be tested using ASTM standard G31, Laboratory Immersion Corrosion Testing. However,
before performing this test, a literature search will be made on the corrosive potential of tires on steel and concrete. It may be possible to completely discount the possibility of corrosion based on this search, in which case, the researchers will consult with the NETC Technical Committee on the need for actually performing the corrosion tests.

The density versus load, compressive stress/strain relationship, and long term consolidation can all be determined using the compressibility apparatus which we have fabricated as part of our current research project. A 12-in. diameter plastic cylinder is used to contain the tire chips. The cylinder is instrumented with strain gages so that the horizontal stress can be measured during the test. This will allow the coefficient of lateral earth pressure at rest ($K_o$), defined as the ratio of the horizontal stress divided by the vertical stress, to be calculated. This is needed to determine the horizontal force on walls which are prevented from moving outward, such as many bridge abutments. The vertical stress is applied using an Instron 4200 computer controlled universal testing machine. The apparatus is illustrated in Fig. 1. The strain gage measurements and data reduction is also done by computer using apparatus and computer programs developed as part of our current tire chips research project.

The direct shear strength of tire chips will be determined in a large scale direct shear box fabricated as part of the proposed research. The design will be similar to direct shear boxes used to test soil/geosynthetic interface friction. A review of available devices has recently been completed by our department1. The shear box will be square in plan. The dimensions

Fig. 1 Apparatus for compression testing of tire chips.
will depend on the maximum size of tire chip in the gradations chosen by the NETC Technical Committee. The vertical stress will be applied by dead weights placed on a lever arm with a ratio of 10:1. This will allow a substantial vertical load to be applied with only modest applied weight. The horizontal stress will be applied using a continuously variable speed gear box which we have on hand. The horizontal force will be measured with a load cell. Horizontal and vertical deformations will be measured using displacement sensors (LVDTs). The load cell and LVDTs will be attached to our computer controlled data acquisition system. It is anticipated that the basic design of the apparatus will be as shown in Fig. 2.

For each gradation and test type a representative number of tests will be performed to determine the average and range of the property being measured. Our experience with our current research project has shown that test results generally fall in a narrow range. If this holds true for the proposed research, it is anticipated that three to six tests will be sufficient for each gradation and property.

Physical and Performance Testing. Physical tests for loose and compacted unit weight, gradation, absorption, permeability and corrosion will be performed for the selected tire chip gradations. Between three and six trials will be performed for each test to determine the range of each property.

Compression tests will be performed on loose and compacted samples of tire chips with the gradations selected by the NETC Technical Committee. The applied stresses will be typical of those encountered behind retaining walls used for highway applications. By measuring the vertical settlement at each applied vertical stress we can develop curves of density versus load and
Figure 2. Direct Shear Box and Frame
compressive stress versus strain. By measuring the horizontal stress at each applied vertical stress we can develop curves of horizontal stress and $K_0$ versus vertical stress. To determine how the compressibility and horizontal stress vary with long term loads, several tests will be performed in which the vertical stress will be held constant for periods up to 1 month while the settlement and horizontal stress are measured.

The direct shear strength will be determined using a large scale direct shear apparatus as described above. Samples will be tested in compacted and loose states. Tests will be performed with at least three different vertical stresses to determine how the shear strength varies with vertical stress. The range of vertical stresses will be representative of those typically encountered in highway retaining walls.

After completion of the testing the researchers will present the results to the NETC Advisory Committee. After receiving the committee’s approval the researchers will prepare a report summarizing the results of the project.

RESULTS OF RESEARCH

The proposed project will determine the basic properties needed to use tire chips as backfill behind retaining walls. These properties include: unit weight, gradation, absorption, permeability, corrosive potential, compressibility, coefficient of lateral earth pressure at rest ($K_0$), and shear strength. The gradation will be used to determine if long term infiltration by adjacent soils will occur. It will also help determine resistance to erosion. $K_0$ can be used to estimate the pressure on walls which are restrained from moving and will provide an upper bound estimate of the pressure on walls which are allowed to rotate outward, which is the normal
case for retaining walls. The unit weight and shear strength will allow earth pressures on retaining walls to be calculated by various methods such as Rankine and Coulomb's methods. The compressibility will be used to determine settlement of the backfill. The measured compressibility and resulting horizontal stress will provide the input needed to analyze the stresses on retaining walls using finite element methods.