TEXAS TECH UNIVERSITY
CENTER FOR MULTIDISCIPLINARY RESEARCH IN TRANSPORTATION

Project Summary Report 0-4412-S
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Project 0-4412

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PROJECT SUMMARY REPORT

Use of Alternative Water Sources: Summary

Due to rapid growth in population and construction activity, the demand for good-quality water continues to increase in many parts of Texas. In those regions that receive little rainfall, there is an even greater emphasis on the need to conserve high-quality water sources for drinking and other household uses. The use of non-conventional, or "alternate," sources of water as a substitute for quality drinking water in construction applications could potentially reduce the cost of construction while conserving quality water resources. The Texas Department of Transportation (TxDOT) requires large quantities of water for road construction projects for such purposes as dust control, erosion control, preparing subbase for highways, and rinsing construction equipment. The use of quality drinking water for these types of construction applications may become cost-prohibitive in the future. TxDOT needs alternate sources of water in order to reduce the future cost of construction applications and to reduce the delays in construction work in case of drought or water rationing.

What We Did…

The principal area of contribution by Texas Tech University (TTU) researchers has been the effects of alternate water sources on engineering properties and constructability for transportation activities requiring large quantities of water. This research also focused on legal issues addressing the use of alternate water sources (wastewater from municipal wastewater treatment plants, brine water from oil wells, surface and groundwater that do not meet the drinking water quality standards, and ocean water) in Texas, safety and health concerns of workers and the public, and the impact on the environment by the use of alternate sources of water. Prominent products achieved from the TTU work include:

- A review of the major alternate water sources and a summary of their associated critical water quality parameters
- A review of potential environmental impacts of alternate water sources and their availability
- Determination of construction activities having significant water demands and the associated issue related to performance which might be impacted by the water quality of alternate water sources
- Laboratory testing of various soil types to determine allowable ranges of specific parameters and in some cases development of test methods
- Model development to predict final soil sulfate content and changes in soil resistivity

A comprehensive laboratory test program was undertaken to investigate the most critical concerns that arise when water from alternative sources is used in construction projects, (See Figure 1). These critical concerns include: (a) the effect of soluble salts on soil corrosivity, (b) the potential increase for sulfate heave in base layers stabilized with calcium-based stabilizers, (c) the increase in soil dispersivity and shrink/swell potential as a result of mixing with Na^+-rich alternative water, and (d) the potential impact that soluble salts in alternative water may have on soil parameters that are used in material selection (i.e., Atterberg Limits and Bar Linear Shrinkage). Five different soils were selected from actual TxDOT construction projects to cover the broad range of soils that are commonly encountered in construction, (See Figure 2). Where needed, appropriate test procedures were developed, and in some cases models were formulated to predict final soil properties based on typical water and soil inputs. Finally, a series of decision matrices were developed to aid engineers in determining the suitability of alternate water sources for specific construction activities based on the following considerations: (a) Is there any regulatory control on the use of a

Figure 1. Nilson Resistivity Meter and Soil Box for Determination of Soil Resistivity

specific alternative water source? If so, what permit process should be followed? (b) Is there potential adverse effect on the health and safety of the public or the workers? (c) Is there potential for environmental damage from the use of alternative water? (d) How would the water composition impact material properties and performance of the constructed facility?

What We Found…

Of the alternate waters evaluated, wastewater effluent, and impaired surface and groundwater water, will generally be of the highest quality in relation to critical attributes impacting construction applications. However, this increased quality also impacts the available (proximity and non-committed) sources, which will be an important determinant of their eventual use. Wastewater effluent is generally produced wherever population centers exist. However, in some areas especially where water is scarce, wastewater effluent may be dedicated for other usages. Availability of impaired surface waters and groundwaters is likewise difficult to determine on a broad basis. Water rights can be an issue and should be dealt with on a local basis. Availability of brine and ocean water is mainly a function of access or proximity rather than competition for the source. In general, the success of incorporating alternative sources into construction applications in relation to availability, permitting, and access will be district-dependent.

Numerous construction applications were evaluated; of these, some were more sensitive than others in relation to performance impacts. It should be pointed out that potability does not equate with acceptability for performance, as in some cases potable waters which are currently acceptable for use may not be acceptable for performance standards. Ocean water and brine water will generally be potentially useable only for stabilization (subgrades, subbase, and base courses) and compaction (road subgrades, flexible base courses, and embankment fill). Treated waste water effluent and impaired surface waters are potentially usable for all applications but must be individually evaluated. In most applications it is not possible to evaluate only the water source. The water source soil combination should also be addressed, as soil properties will play an important role in the eventual usability of alternate waters.

In order to evaluate a given water source, a number of models and/or procedures were developed. For instance, a model based on sulfate and chloride content and standard soil properties was developed to predict whether specific soil water combinations would be acceptable for retaining wall backfill. In most cases only a few parameters will impact usability (e.g., sulfate for stabilization or sodium and TDS for irrigation). In order to facilitate the evaluation process and use for the models and procedures developed in this research effort, detailed decision matrices were created. In some cases insufficient research is available to confidently predict performance (e.g., soils subject to shrink/swell and dispersion concerns) and so use of alternative waters has been discouraged. However, additional research may allow for the selection of tests which would adequately evaluate these combinations. The following is a list of the major conclusions from this research effort.

- Alternative water sources may be designated "non-potable" or "impaired" based on considerations (e.g., presence of disease-causing pathogens) that have no relevance to their suitability for use in construction. Therefore, the alternative water sources are not necessarily inferior to water obtained from conventional sources.
- With the exception of ocean water, the variability of composition of all other alternative water sources examined is very high. Therefore, it is difficult to make the acceptance/rejection decisions by the generic water source category. This is possible in a few rare instances (e.g., brine water sources are excluded from consideration for irrigation). More often, the acceptance/rejection decision requires sampling water from the specific source of interest and testing the water or water-soil mixtures.

- The composition of water added to soil materials had significant impact on some soil parameters, while it had negligible or no impact on others. The soil parameter that showed the greatest sensitivity to water composition was its resistivity. Resistivity controls the corrosion potential of soils. Therefore, careful evaluation is needed when using alternative water in construction applications where soil corrosion must be controlled.
- The sulfate and chloride levels in soil can also be significantly influenced by any sulfate and chloride that are present in construction water. Once again, this is most important in construction applications where soil corrosion is a concern. This is because the maximum acceptable levels of sulfate and chloride in soil (200ppm and 100ppm respectively) are quite low for a soil to be considered "mildly corrosive."
- Addition of soluble sulfate from construction water into soil is also a concern when the soil is to be stabilized with Ca-based stabilizers. However, the soil sulfate threshold for low sulfate heave potential is 2000ppm, which is much higher than the threshold established based on corrosion considerations. Analyses conducted in this research showed that when sulfate contents in most alternative water sources and the amounts of water typically added during construction are considered, the soluble sulfate contribution from construction would be fairly small. Therefore, as a general rule, use of alternative water is unlikely to have a significant impact on sulfate heave potential of soils. However, it can make a difference in soils that are marginal in terms of sulfate heave potential.
- The other soils parameters that were investigated, soil pH, Atterberg limits, and bar linear shrinkage, did not change significantly as a result of mixing the soil with alternative water. Other studies have shown drawn similar conclusions with respect the impact of water composition on soil shear strength and compaction characteristics. Therefore, most alternative water sources would qualify for use in dust control, and for soil compaction operations associated with embankment and road construction.
- Furthermore, testing conducted in this research did not reveal any appreciable change in soil dispersion or shrink/swell potentials as a result of adding alternative water. However, these two aspects deserve further study before that conclusion can be extended to soils that are marginal with respect to dispersion and shrink/swell potential.

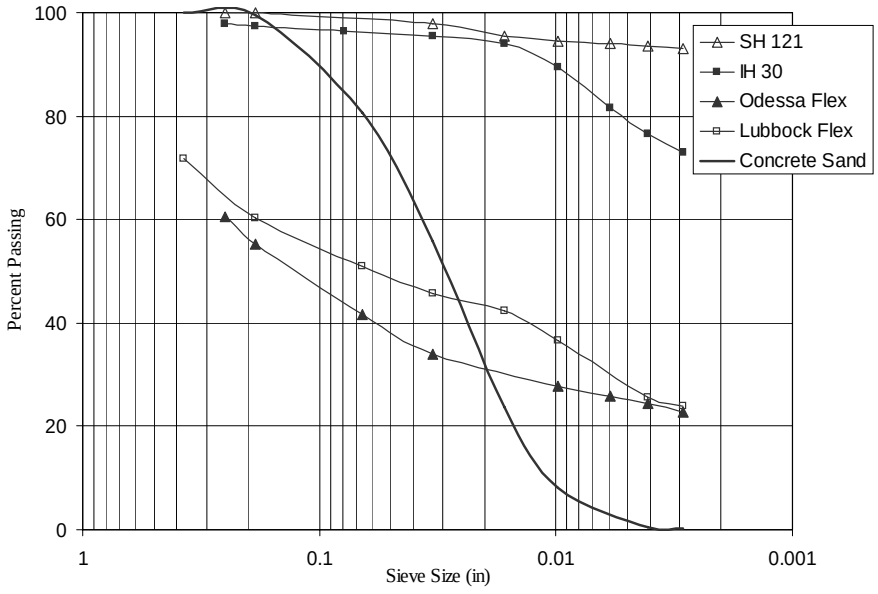

Figure 2. Weight Percentage and Particle Size Distribution Curves for the Experimental Soil Samples

The Researchers Recommend...

In general, the use of alternate water sources can help to reduce the demand on potable water supplies and prevent construction delays in areas of extreme drought. However, a critical need which should be addressed is that of evaluating these results in the field. Issues which should be addressed in an implementation project include not only the usability of the developed decision tools but also confirmation of performance predictions and perhaps most importantly peripheral issues which cannot be addressed by research such as permitting, access, transportation, and coordination of construction activities in relation to alternate water sources.

In addition, further research should be conducted to determine the engineering implications of the use of alternate water sources applied to soils that show moderate to high dispersion potential and moderate high shrink/swell potential. Finally, consideration should be given to the automatic use of some potable waters for specific soils and construction activities that may not be appropriate.

For More Details…

The research is documented in the following report:

Report No. - 0-4412-1 - Use of Alternative Water Sources

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