

TURK SALTY MORTAR THROUGH ADDITION OF PLASTIC AND COTTON WASTE MATERIALS TO STABILIZE PROBLEMATIC COASTLINES

AFSHIN TURK¹, BAHRAM MOMBENI², SOHRAB AFRASIABI³ and SHABNAM GHANAVATIZADEH⁴

¹Dept of Dam –Developing and Utilization, Ministry of Power, KWPA, Ahwaz, Iran ²Dept of Water Supply, Ministry of Power, KWPA, Ahwaz, Iran ³KTNSE, East South Water Company, KWPA, Ahwaz, Iran ⁴Dept of Biology, PNU University, East of Tehran, Iran

Invention of Turk Salty Concrete is recommended for the GOTVAND Reservoir Dam, SW of Iran. This new type of concrete can be mixed with pure salty water to stabilize the salty domes. For the development of the mix, a ratio was defined as the proportion of the salty water mass to the mass of the materials used (clay, bentonite, cement type II). These proportions varied from 0.8 to 1.80 in the mix. The proposed mix presented a significant compressive strength when mechanically tested. The maximum bearing capacity was measured to be more than 10,500kpa. This is a significant capacity for salty cementation mixtures. In this paper, new mixture designs are reported developed by adding waste materials such as plastic bottles and cotton fibers. As the waste materials are detrimental to the environment and coastlines health, the inclusion of waste would have the added benefits of helping in the environmental issues. The results were found to be encouraging since it is shown that they improve durability, breaking stress and the modulus of toughness. Other research studies are currently underway examining the behavior of Turk Salt Mortar (TSM) by adding wasste materials such as date palm tree fibers. TSM can be used in deep injection grouting for protection of shorelines that come in contact with sea water.

Keywords: GOTVAND Dam, Fibers, Palm tree, Salty, Shorelines, Injection grouting, Clay, Bentonite.

1 INTRODUCTION

In ancient Egypt (Waltari 1945), bodies were mummified by filling them with pure salt to preserve them. Similar findings were discovered in the Chehrabad salt mines of Zanjan, Iran (Saltmen 1993). Similarly, the TSM mixes incorporate a huge amount of pure salt with clay and cement to form and possess rock-like properties (Turk 2007, 2008). TSM mix was shown to be a mix that could be used appropriately in dry or saturated conditions (Turk 2017). The mix is produced by the mixture of ultra-saturated salt water, Shushtar Ceramic Clay, Bentonite and Cement type II (Turk 2006, 2018; Damough 2011). This research study began in 2016 and was continued by the addition of waste materials. The new mix displays a different behavior in comparison with the original mixes. The broken, unreinforced samples show 30°-60° plane slope rupture as shown in Figure 1. When fibers were added, vertical failure cracks appeared in the broken samples that showed improvement in failure resistance (Figure 2). Figure 2 also shows

failure patterns of samples when date palm tree fibers, cotton, and plastic shredded wastes were added.



Figure 1. Pictures demonstrate mortar behavior at 30°-60° plane stress of non-fibers (KTNSE 2016, 2017).



Figure 2. Fibers: A) Palm Tree 1.5% B) Cotton 0.11% C, D) Useless Plastic 2.13% (KTNSE 2017, 2018).

A tri-axial UU test was conducted for sample S970216P-2 per BS standard 1377 Part 7, at two days age, with 2.1% weight ratio of plastic fibers at a cell pressure of 600kpa, strain 6.27%, and rapture stress 1'853kpa. Sample S970216C-2 was also tested per the BS standard at two days age with 1.54% cotton fibers, strain 1.81%, and rapture stress 7'240kps. It seems that the sample S970216P (plastic fibers) has more flexibility behavior than S970216C (cotton shards). In the initial days, flexibility of plastic fibers is 400% more than cotton fibers. This ratio decreases in the following days when the age of samples rise to 30days. This value is incredible and remarkable in contrast to the previous samples that were tested by TSM (Turk 2017). In Figure 2, fibers of plastic stick inside the TSM strongly, which acts such as a reinforced concrete. It is noted that the mortar is created by an ultra-salty mixture.

2 MATERIALS OF TSM

TSM is a mixture which occurs in the natural Anbar salt mine, and consists of water, Shushtar Ceramic Clay, Bentonite and Cement type II. The study aimed to stabilize the GOTVAND salty domes inside the fresh lake reservoir. TSM can be injected under pressure in deep formations (Gutiérrez 2016). Figure 3 explains the ratio of materials that should be mixed for TSM.



Figure 3. Materials will use in TSM Samples S(yy, mm, dd, ages, fiber, σ_Z) mixture design (Turk 2017).

2.1 Criterion of TSM Resistance and MTE

The maximum breaking stress was 13,800 kpa as registered by the compressive hydraulic jack. It belonged to Sample S950713 at 26 days on October 4th 2016. It can be selected as a relative criterion for all samples. Eq. (1) to Eq. (4) interpret the relative criterion (Turk 2018) and modulus of toughness energy per volume (Beer 2012). Samples have different cell pressures.

$$\zeta_{Turk} = \frac{W_{SalWater}}{W_{Clay} + W_{Bentonit} + W_{Cement}}$$
(1)

$$\zeta_{Turk}^{\prime} = \frac{\left(\sigma_{yymmdk0}\right)_{i}}{\sigma_{95071,00}} \times \left(\zeta_{Turk}\right)_{i} \tag{2}$$

$$\left(U_{TSM}\right)_{i} = \int_{0}^{\varepsilon_{Ri}} \sigma_{Zi} d\varepsilon_{Zi}$$
(3)

$$\left(\psi_{Turk}\right)_{i} = \frac{\left(U_{TSM}\right)_{i}}{\left(U_{TSM}\right)_{\circ}}, i = 1, 2, 3, \dots, \left(U_{TSM}\right)_{\circ} = \int_{0}^{\varepsilon_{R}} \sigma_{Z^{\circ}} d\varepsilon_{Z^{\circ}} d\varepsilon_{Z$$



Figure 4. Modules of toughness energy respect to their σ_Z , σ_X and sample ages (KTN 2018).



Figure 5. The value of ψ_{Turk} S970216P2-600kpa plastic fibers is the highest TSM (KTNSE 2017, 2018).



Figure 6. Breaking resistance of Samples registered from 17 April 2017 till 27 June 2018.

2.2 Criterion of TSM permeability

TSM is slightly different from the ACI 318 manual for concrete structural mixture design. In permeability testing, horizontal cross section is taken to obtain the percentage of water leakage. Eq. (5) to Eq. (7) and Table 1 explain Darcy's law of permeability using the cylindrical samples (Das 2010). Tri-Axial samples were tested by saturation rate, S97020920P100%, S97030135G and S970231S0.0% (60 min in $100^{\circ C}$ oven), in a pressure chamber with longitudinal sections.

$$Q = \frac{\Delta V}{\Delta t} = \frac{(W_1 - W_{\circ})}{\Delta t} = k \cdot Ai = k \cdot (d \times h) \cdot \frac{\Delta H}{h}$$
(5)

$$k = \frac{Q}{d \cdot \Delta H} = \frac{0.0009}{3.8 \times 7'000} = 2.9 \times 10^{-3} (cm/day)$$
(6)

$$\delta_{Turk} = \% \frac{\Delta W}{W_{\circ}} \tag{7}$$

Table 1. Permeability and water adsorption calculation, d=38mm, ζ_{Turk} =1.80, 1.86, 1.85 (KTNSE 2018).

Sample	Age	Fiber	W1	W0	Sr	h	Δt	Δh	Q	K	δ_{Turk}
	(day)	%	(gr)	(gr)	%	(cm)	(s)	(cm)	(cm ³ /s)	(cm/day)	%
S970209P	20	0.11	139.44	138.63	100	8.7	900	7000	9.0E-4	2.9E-3	0.40
S970301G	5	0.0	156.05	155.29	35	7.9	1380	8366	5.5E-4	1.5E-3	0.49
S970231S	29	0.0	161.3	153.77	0.0	8.7	1800	7110	4.2E-3	1.34E-2	4.90

3 CONCLUSION

Salty Domes (HARZA 1968) are hazardous. Correspondingly, an alarm was conveyed to the government by NGOs and the local residents. The Ministry of Power declared that there is no feasible solution to stabilize the Salty formation of GOTVAND Lake. However, TSM is the only way to protect the fresh water against the impact of salts. Saltified TSM can be accepted, per the results of a pilot field using grouting operation inside the salty layers. Tentative samples proved the beneficial behavior of TSM by breaking resistance, durability in water saturation, and in elasticity behaviors. Unused plastic, cotton and palm fibers are combined with TSM cementation, which improves elasticity and strain behavior. Figure 4 and Eq. (4) show the ψ_{Turk} increasing in ratio with unused fibers, in contrast to non-fiber conditions. Unused fibers sharpen the σ - ϵ curve. Also, the toughness modulus increases during initial strain ($\epsilon < 2.0\%$). Modification behavior is clearly represented in Figure 5. Unfortunately, the unused plastic bottles increase day-to-day to destroy the shorelines and natural beauty of coasts. By the adoption of this method, onshore protective structures may be designed to save the dunes, estuary, ports, and more through the use of un-reinforced concrete. The TSM fibers axial test realized more than 8,000 kpa at 36days with $\zeta_{Turk}=1.85$ proportion. Sample resistance grows till 100 days.

References

- Beer, F. P. E., Johnston, R., Dewolf, jr. T., Mazurek, D. F., "Mechanic of Materials." *The McGraw-Hill Companies*, Inc., 6th edition, 2012.
- Damough, N. A., Zarei, H. "Investigating of Dissolution Problems in Gachsaran Formation Salt Layers in GOTVAND Olia Dam Reservoir." Research KUD-84001, KWPA, Iran, 2011.
- Das, B, M., "Principles of Geotechnical Engineering", Cengage Learning Inc., USA, 2010.
- KTNSE, "SE Water Supply, Act of 2016. Pub L. No. 951027." KWPA. 950708 IR.SE, September 2016.
- KTNSE (Kavosh Taraz Niro Soil Engineering), Gotvand Test Act of 2016, research work, Laboratory Soil-Concrete, KTNSE–44890-SE, Pub L., No.951027 stat. 960119-K9631, May 2017.
- KTNSE, Gotvand Test Act of 2018, research work, Laboratory Soil-Concrete, KTNSE–44890-SE, Pub L., No.1200/126238 stat. 970217-K9631, 2018.
- Gutiérrez, F., and Lizaga, I., "Sinkholes Collapse Structures and Large Landslides in an Active Salt Dome Submerged by a Reservoir: The Unique Case of the Ambal Ridge in the Karun River, Zagros Mountains, Iran." Journal of Geomorphology, Elsevier, 254, 88–103, 2016.
- HARZA, Consulting Engineering International, Dam Power Plant Appurtenances, Contract Documents 384-3, KWPA, August 1968.
- Saltmen, National Museum of Iran, https://en.wikipedia.org/wiki/Saltmen on June 1993.
- Turk, A., Stabilization of Pure Salty Formations of the GOTVAND Dam Lake and another Salty Drought Desert Regions through Invention of Turk Salty Mortar", Aerospace Division of ASCE, USA, 2018.
- Turk, A. and Ghanavatizadeh, S. "Micro-pile root net theory to modify earthquake and liquefaction properties of soils based on biologic concepts, laboratory and field tests", presented at the Conference EARTH&SPACE 2006, Aerospace Division of ASCE, USA, 2006.
- Turk, A., Ghanavatizadeh, S., Zaamari, A.A., and Kolahchi, A., "Regeneration of missed record data, vertical axes of Karkheh earth dam using cell pressure, mathematical aspects and SSM", Aerospace Division of ASCE, USA, 2008.
- Turk, A., Salehi, F., Kolahchi, A., and Ghanavatizadeh, S., "Elasticity Module of Karkheh earth dam study & behavior through inclinometers & SSM", ISEC-4, Melbourne, Australia, 2007.
- Turk, A. and Zaemeri, A. A., "Micro pile behaviors study using compressive (or tensile) pile load test and steps stiffness method", CSCE, Saskatoon, Canada, 2004.
- Turk, A., Mombeni, B., Bahmaei, D., Khodabakhshi, H. R., Behdarvandi, A. M., and Ghanavatizadeh, S., "Coastal Protection of GOTVAND Reservoir DAM, EC Perfection of Salty Domes", ISEC-09, Valencia, Spain, 10.14455/ISEC.res.2017.61, 2017.
- Waltari, M., Sinuhe Egyptiläinen, WSOY Press, Finland, 1945, Persian translation by Mansuri, Z., 1985.