23 Year Assessment and Total Reconstruction of Apron at Ellington Airport using Beam on Elastic Foundation Technique

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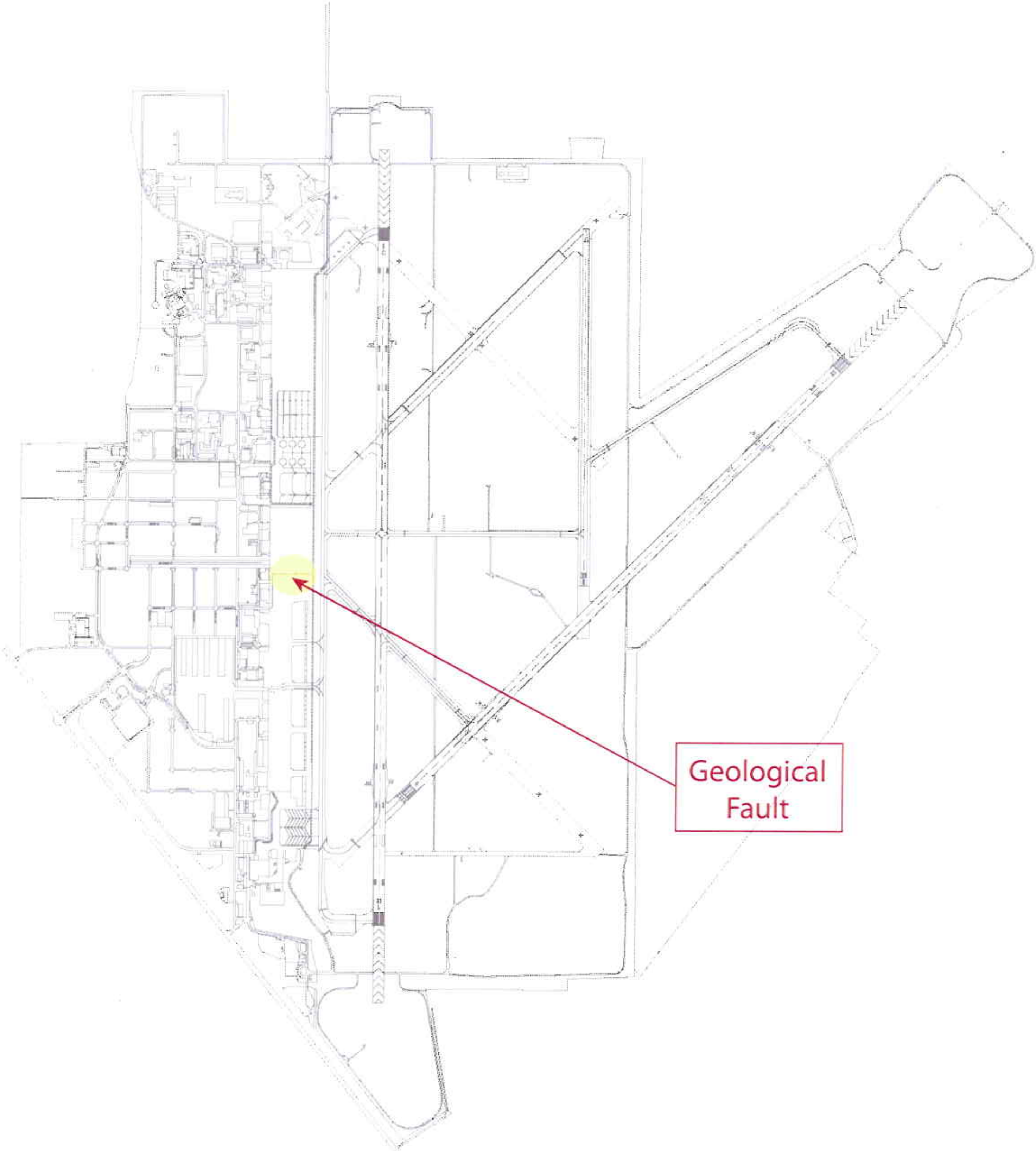
Houston Airport System



Ellington Airport

HOUSTON AIRPORTS

The apron at Ellington Airport had settled about 9" to 12" due to the movement of the geological fault. The apron is about 40 years old and this happened in 1984-1985 time period. Therefore, the apron had to be shut down in this vicinity as there was a deep and large hump in the apron (about 6" to 12" in depth).

Realizing that it is very complex and difficult to bridge across an actively moving geological fault, I used a unique and novel technique for pavements, namely, beam on elastic foundation technique. This is an advanced technique used in Foundation Engineering. I had used it extensively in Nuclear Power Plant Design and therefore decided to use this technique for this complex issue where the geological fault was causing a settlement and pavement separation of about 12" depth in 25 years.

The geological fault line was conspicuous and so I decided to demolish and reconstruct 120 foot (north-south) length of the apron and full width of about 1000 feet (east-west) of the apron.

The down throw side of the geological fault is the more treacherous side, so I selected 80 foot on the down throw side of the fault and 40 foot length on the up throw side of the fault.

The computation worked out to 21" Reinforced Concrete pavement over 6" cement stabilized crushed limestone base over 6" lime stabilized subgrade. Due to the excessive stresses and strains in the concrete pavement, caused by the movement of the fault, I decided to put two layers of reinforcing steel, one near the bottom of the concrete pavement and one near the top surface of the concrete pavement. The pavement cross-section is shown in Figure No. 1.

The design was performed for the pavement to bridge across the geological fault, thereby precluding vertical deformations. This technique was successful as the vertical deflections would have caused the pavement to crack. However, this restraint in the vertical direction caused the pavement to move horizontally in tandem with the fault movements.

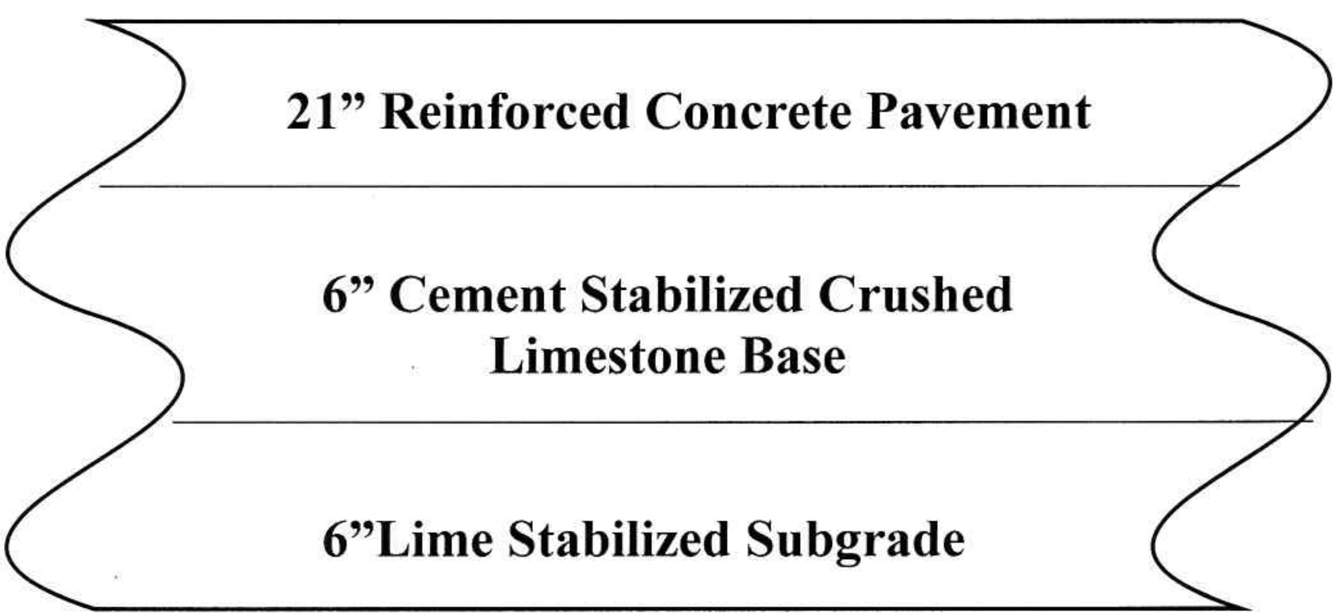


Figure No. 1 : Pavement Cross-Section

The horizontal movements caused the neoprene joint sealants to be squooshed into liquid. Therefore, in about the year 2000, we replaced the neoprene joint sealants with Dow Corning silicone joint sealant, which has been performing well so far.

The flexural strength of the concrete pavement was specified as 650 psi minimum in 28 days. The compressive strength of the cement stabilized crushed limestone base was specified as 650 psi in 7 days.

On December 16th, 2009 a Non Destructive Test was performed on this pavement. The NDT results showed that the pavement was performing well even after 23 years. In addition, there are no cracks nor distresses in the pavement even after 23 years. The Non Destructive Testing Results are summarized herein.

Fault Line Pavement Deflection Testing Results

The following are the non-destructive testing results performed by Applied Research Associates, Inc.

Background

Ellington Field (EFD) faces some unique engineering challenges due to a geological fault line extending across portions of the airside pavement. One such area is located on the terminal ramp near Taxiway Delta. Engineers within the PDC Construction and Design Division of the Houston Airport System (HAS) designed a special Portland Cement Concrete (PCC) section to "bridge" over the fault line and to resist settlement. This unique pavement section was constructed in 1987 and is still in service. Nondestructive deflection testing was performed on December 15, 2009 using a Heavy Weight Deflectometer (HWD) to assess the structural properties of the pavement section.

Analysis

The pavement section consists of 21" of PCC over 6" of cement treated base (CTB) over 6" of lime treated subgrade (LTS). The analysis consisted of backcalculating the pavement layer moduli using an AREA method based on Plate Theory published in the LTPP Data Analysis report Validation of Guidelines for K Value Selection and Concrete Pavement Performance Prediction. Modulus results are presented for an unbonded two-layer structure consisting of 21" PCC over 6" of CTB. The analysis ignored the 6" LTS subbase layer.

Structural Results

Summaries of the structural properties are provided in the following table. The table shows the average, 15th percentile, and standard deviation for the layer modulus values and for the Impulse Stiffness Modulus (ISM). E values (or modulus values) are provided for the PCC, the CTB, and the sub-grade. The ISM provides an indication of the overall strength of the pavement system including the sub-grade. It is calculated by dividing the peak impulse load by the deflection measured under the load plate.

	ISM (kips/in)	E1 pcc (psi)	E2 base (psi)	E4 subgrade (psi)
Average	10,548	10,150,170	761,263	19,622
Standard Deviation	883	2,289,480	171,711	2,052
15^{th} Percentile	9,846	7,985,150	598,886	17,507

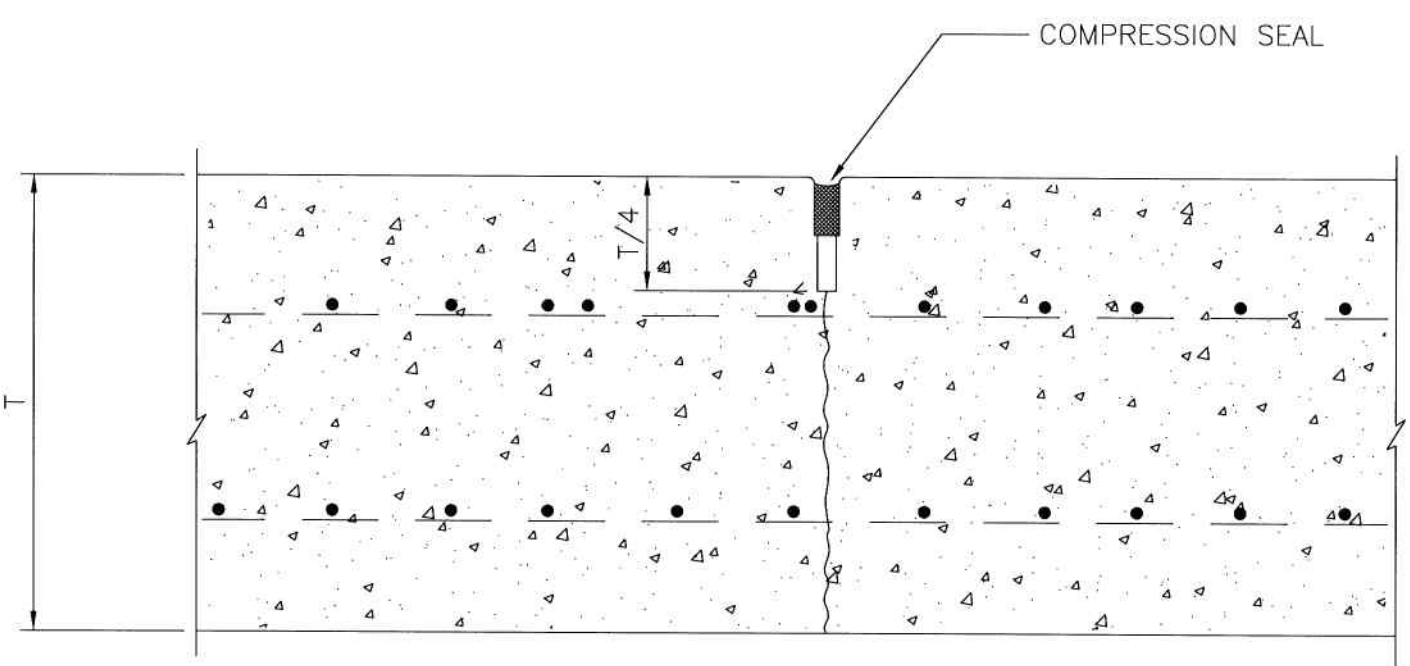
These values are indicative of a very stiff pavement structure. The structural properties compare favorably with pavement of similar thickness throughout the HAS. For example, Runway 8L-26R at IAH has a comparable overall stiffness with an average ISM of 11,440. Results indicate that the pavement section continues to perform very well from the standpoint of strength / structural capacity. Detailed results for each test point are available.

Pavement Condition Index (PCI) Results

The subject pavement sections last received a detailed PCI survey in 2001. At that time, the feature PCI ranged from a low of 70 to a high of 83. Detailed distress results and projections from the 2001 PCI survey are available.

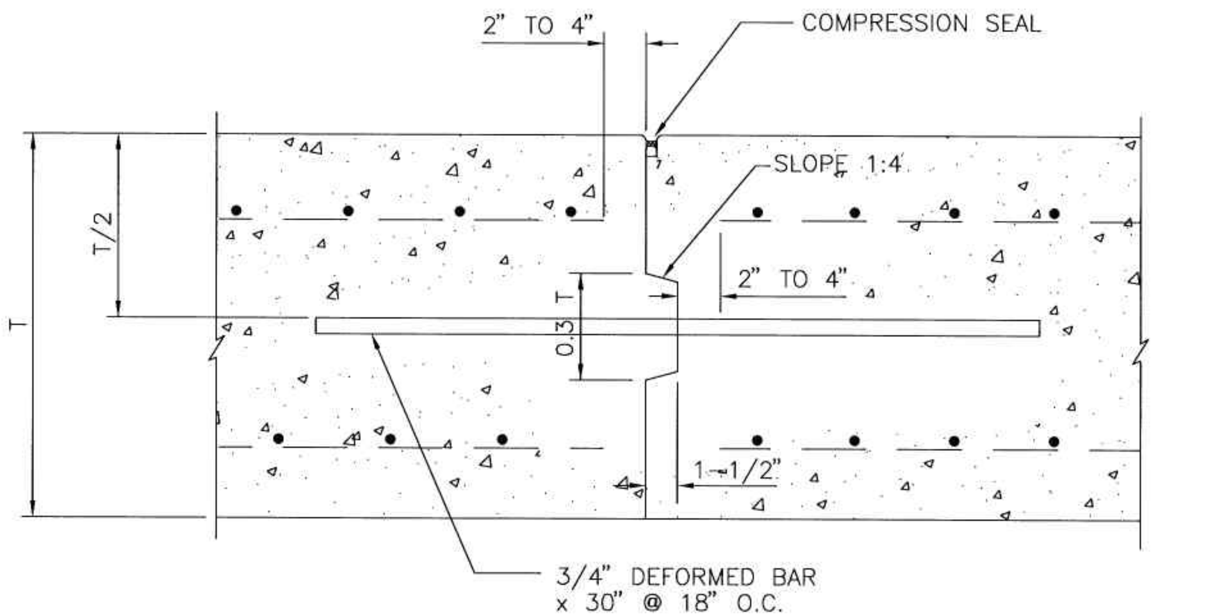
All ramp pavement located over the fault line was above the minimum service level (MSL) when last inspected. The entire area was projected to exceed the 20 year design life, and features 7137 and 7139 were projected to remain above the MSL until 2016. Feature 7135 was projected to be at the MSL in 2010, but routine patching can extend the service life of this feature. We have performed this task of routine patching on this feature 7135 and this should extend the life of this segment significantly.

While typical age related pavement distress has developed over time, the pavement design has met the objective of limiting settlement over the fault line. As of the last PCI survey there was no evidence of pumping, faulting, corner breaks, or any other distress that would indicate problems with settlement.



TRANSVERSE DUMMY GROOVE JOINT

SCALE: N.T.S.



LONGITUDINAL CONSTRUCTION JOINT

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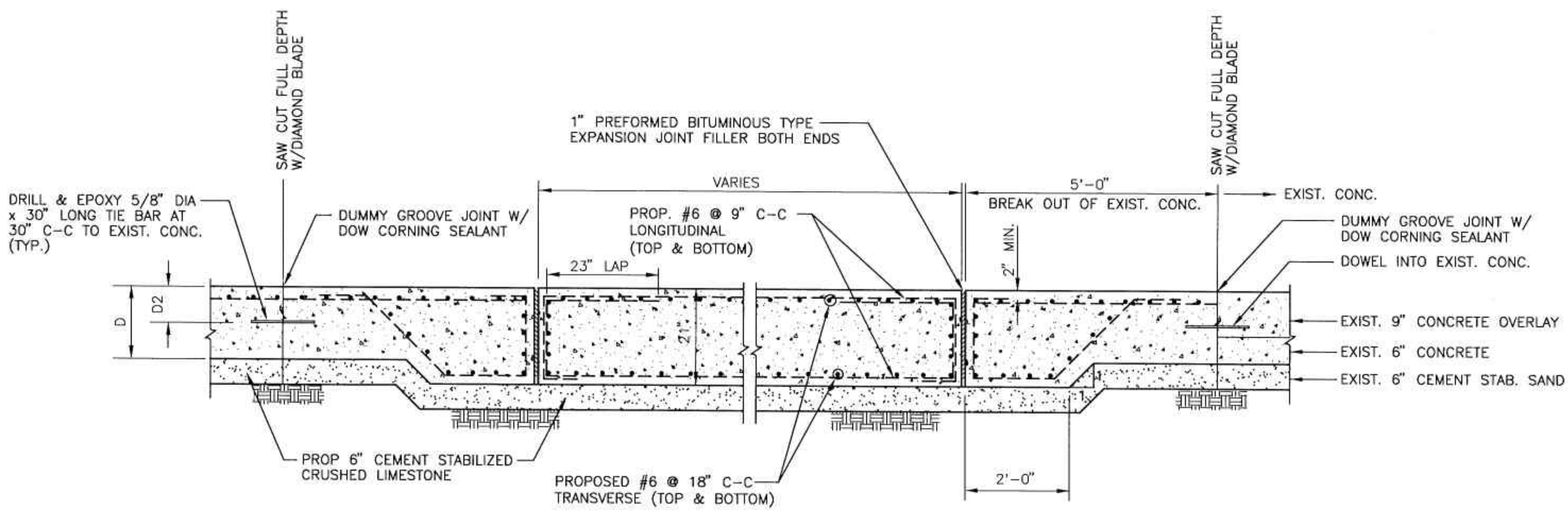

TYPICAL FAULT REPAIR SECTION A - A DETAIL

SCALE: N.T.S.