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Case Study

Application of foam bitumen in cold recycling and hydrated lime in airport pavement strengthening

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ABSTRACT

Due to the growth of commercial activities in port of Lengeh in south Iran, it was necessary to rehabilitate and upgrade the existing airport which is almost one hundred years old. Severe distresses that occurred in runway and other aircraft operational areas required that the bearing capacity of the existing pavements should be increased. Limited dimensions of the runway and other operational areas in the airport (i.e. runway, taxiway and apron) required these to be extended and widened.

A full recycling program was planned including sub-grade and sub-base stabilization with lime in widening areas and base strengthening with foam bitumen and cement slurry in both existing and new constructed sections. The mix design for the foam bitumen cement bonded mix was performed using both Indirect Tensile (ITS) and Unconfined Compressive Strength (UCS) Testing. To avoid extra stiffening of foam-bitumen cement slurry stabilized layer that could lead to formation of fatigue cracking, Marshall Quotient was established to obtain the optimum cement content. The results showed that CBR values of the sub-grade and sub-base layers were increased appreciably by adding 4% hydrated lime powder, hence the local material was successfully used to construct these layers. In addition, foam-bitumen cement treated base layer was gained ITS and UCS strength values well above the specification requirement. Using the mentioned stabilization and recycling methods resulted in protection of the environment and savings in construction time and virgin materials.

1. Background

Foam bitumen has been used as a stabilizing agent in pavement since 1956 (Csanyi, 1957). After modification its production process from injecting steam to cold water into hot bitumen in 1976 (Muthen, 1998), and also introducing new machineries in the market in mid-1990 (Mohammad et al., 2003), numerous road and highway stabilization and recycling projects performed using this technology (Wirtgen Cold Recycling Technology, 2012; Geoff, 2013). Although there are many case studies available for using of foam bitumen in road and highway recycling and stabilizations, there are few studies on using this technology in the airport pavement construction.

Foam bitumen stabilization was introduced into Iran in 1998. For the first time, an airport runway was constructed in Assalouyeh, south of Iran, using lime stabilization of subgrade and sub-base layers and foam bitumen-cement stabilization of

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the base layer. Kavussi and Atabaki (2001) reported this project as a case study and showed that using this method lead to great saving in time and also environmental protection benefits. Afterward, this technique was used for construction and rehabilitation of different road and highways in Iran and also construction of Ardebil International Airport Intersecting Runway in 2006. As Kavussi and Hashemian reported (Kavussi and Hasheman, 2008), by using this method, besides all the environmental and economical benefits, total construction time was reduced appreciably that was of great importance as the seasonal working time of the area was quite short due to the cold climate of the region. Between all of the constructed airports with this technology in Iran, Bandar Lengeh airport is the best example of using this technology in both pavement in-suite recycling and also stabilization using the local material at the same time. This case study is also a very good example of using local unsuitable soil for the base and sub-base layers by strengthening the layers applying of hydrated lime powder.

Despite of the wide range of using foam bitumen stabilized materials all around the world, there is no standard mix design procedure established for these mixes yet. According to South African Technical Guideline (Guideline for the Design and Construction, 2009), the major mechanical properties of these mixes could be evaluated using Indirect Tensile Strength (ITS) and Unconfined Compressive Strength (UCS) test methods. The major challenge of using these test methods is the lack of controlling the flexibility of the mixes, while it is quite common to add a few amount of pozzolanic and cementitious materials such as cement or lime powder to increase tensile strength. The addition of mentioned additives could be resulted in excessive stiffening of the mixture which leads to formation of fatigue cracking in foam stabilized layer (Guideline for the Design and Construction, 2009). In this study, to control this inappropriate phenomena, besides the ITS and UCS tests, Marshall stability test was performed on all of the samples. By establishing an acceptable range for Marshall Quotient value (ratio of Marshall Stability to flow), the acceptable amount of applied cement was calculated.

2. Introduction

Port of Lengeh is located in Hormozgan province in south Iran, facing Persian Gulf. The weather in the area is hot during the summer and mild in winter. Airport of Lengeh which was opened in 1918, is the second airport constructed in Iran. Due to the commercial growth of the area, a program was planned in order to rehabilitate the old airport. This consisted of extending the runway and strengthening the pavements of runway, taxiway and apron. In the rehabilitation program, two processes were carried out. In a full recycling process, the subgrade and sub-base layers were stabilized with lime and in the upper layers (i.e. the base and asphalt layers) a combination of foam bitumen and cement slurry was applied.

3. Airfield rehabilitation plan

The existing runway was 2000 m long and 45 m wide. It contained also 2 m × 15 m asphalt paved shoulders. The taxiway was 140 m long and 30 m wide. The apron dimension was 135 m × 86 m. Several severe distresses were observed on the pavements, including shrinkage cracking, raveling and fatigue cracking.

The aim was to upgrade the airport so that it could be operated by B737-400 aircrafts. According to the design specification, the runway length and width should be extended to 2800 m and 60 m respectively and the taxiway width to 38 m. The apron length was also planned to be extended to 205 m.

3.1. Pavement rehabilitation program

Based on field and laboratory testing results of the sub-grade and the planned traffic design, if the pavement had to be reconstructed, the conventional pavement design of the whole pavement would be as it follows:

- 100 mm bituminous overlay,
- 100 mm black base layer,
- 200 mm granular base,
- 150 mm granular sub-base,
- Filling layers (as required) to get to sub-grade project level.

With the aim of recycling the existing pavement layers and at the same time strengthening the aged and distressed pavement, the following approaches were taken:

- The top asphalt layers of the existing area were removed and were placed on the pavement sides to be used in the widening sections.
- The rest of the existing pavement, including part of the base and asphalt layers was recycled applying foam bitumen and cement slurry.
- In order to have a homogenous pavement in the widening area, the lower layers were stabilized applying hydrated lime. On the upper layers, the above same strengthening method using foam bitumen and cement slurry was applied, although the materials were a combination of the existing area milled asphalt and imported virgin aggregates.

Considering the above construction processing, the following pavement design was approved for the widening area: