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The Local Sand as Heavy Pavement Construction Material, the experience and tests done into Genova Port

Introduction

The paper presents the performance achieved for the sand material when it is confined inside a 3D cellular confinement mattress. The test area was located inside the Genova Port in order to validate the potential improvement of the 3D dredged sand confinement solutions as alternative layer of the expensive well graded crushed rock aggregate. Among the various techniques available for ground improvement, the 3D Cellular Confinement (3DCC) system provides a higher stiffness and shear strength layer also using sand, fly ash or RAP - Reclaimed Hot Asphalt.

In situ 3D Cellular Confinement reinforcement test

The goal was to examine the impact of the 3DCC system, as sub base layer of a heavy duty pavement, using plate load tests and pressure cells to monitoring the vertical stresses developed immediately underneath the reinforcement and comparing them to the vertical stresses developed at the same elevated location in a traditional section. The Genoa Port Authorities chose to test the 3D mattress reinforcement as structural pavement reinforcement to:

1. Reduce the total pavement thickness;
2. Replace the traditional granular sub base layer with locally dredged sand

Materials

• *Subgrade and infill soil for 3D Cellular Confinement system*

The subgrade consists of **A3** AASHTO class, its dredged sand having a maximum grain size of **2mm**. The other parameters are: internal friction angle **24°C**, water optimum **w_{opt} = 10,3%**, **C.B.R.$_{imb}$ = 6,43%** (soaked).

• *Subbase – granular material from original prescription*

The performances requested were: well graded crushed aggregate, Los Angeles <30%, **C.B.R.>70%, Liquid Limit<25, Plastic Limit<6, deformation modulus M_d>100MPa** -150-250kPa- (test method CNR UNI n.164 and SNV 10317), maximum grain size 71mm.

• *3D Cellular Confinement system (3DCC)*

The 3DCC performances were: **Flexural Storage Modulus at 45°C > 700MPa** (ASTM E2254 DMA); **long term plastic deformation at 51°C < 0,6%** (ASTM D 6992 SIM); Single Cellular Dimension 245x210x 150mm

Field test demo

Two demo sections, measuring 2,5m wide x 4,0m long 37cm high at 2,00m distance each other, were constructed. The first had dredged sand reinforced with 3DCC system and the second had the conventional well aggregate infill material. The test involved static plate loading (test method CNR UNI N.146 and ASTM D 1194-93) and simultaneous measuring of subgrade stress, using the pressure cells (*Sisgeo*, model *CRD-400*, vibrating wire, maximum load capacity 700kPa), which were installed on the subgrade surface in order to assess the vertical stress.

Plate Load test results

The **deformation modulus M_d** (CNR UNI N.146) was calculated according to the following formula (first load cycle): $M_d = (\Delta P/\Delta s)\phi$ where: M_d = deformation modulus [kPa]; ΔP = variation pressure [kPa]; Δs = settlement [cm]; ϕ = plate diameter [cm]

The **E modulus** (ASTM D 1194-93) was calculated according to $E=0{,}791(1-\mu^2)(\Delta P/\Delta s)D$ where: E = modulus [kPa]; 0,79 = plate constant[/]; D = plate diameter [cm]; P = loading pressure [kPa]; s = settlement [cm]; μ = Poisson's ratio[/]

• *Traditional granular sub base Section, Results*

M_d = 12,7MPa between 50-150kPa; **M_d = 8,6MPa** between 150-250kPa; **E = 5,6MPa**. In this section a <u>failure</u> was noticed, at the local subgrade soil, at 350kPa during the loading of the static plate load test at the first cycle (*fig.1*). The stress transfer from the test plate to the pressure cell on the subgrade surface of the unreinforced section was 20-27%.

• *3DCC Reinforced section, Results*

M_d = 19,9MPa between 50-150kPa; **M_d = 22,9MPa** between 150-250kPa; **E = 17,1MPa** In this section the loading easily reached **700kPa without any sign of failure** (*fig.2*)

The stress transfer from the test plate to the pressure cell on the subgrade surface with 3DCC system was only 12-18%.

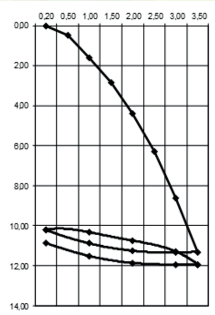

fig.1

Conclusion

In situ field testing of the *3DCC system* demonstrated that it reduced subgrade vertical stress of the dredged reinforced sand by **-33%** to **-40%** vs the good quality crushed gravel. The Plate static load test showed that the bearing capacity of the sub base reinforced layer increased by **+1,6 times** (deformation modulus 50-150kPa), by **+2,7 times** (deformation modulus 150-250kPa. In terms of E modulus (ASTM D 1194-93) the bearing capacity of the sub base reinforced layer increased by **+3,05 times**.

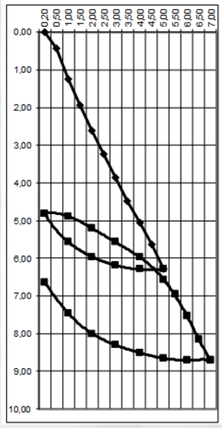

fig.2

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