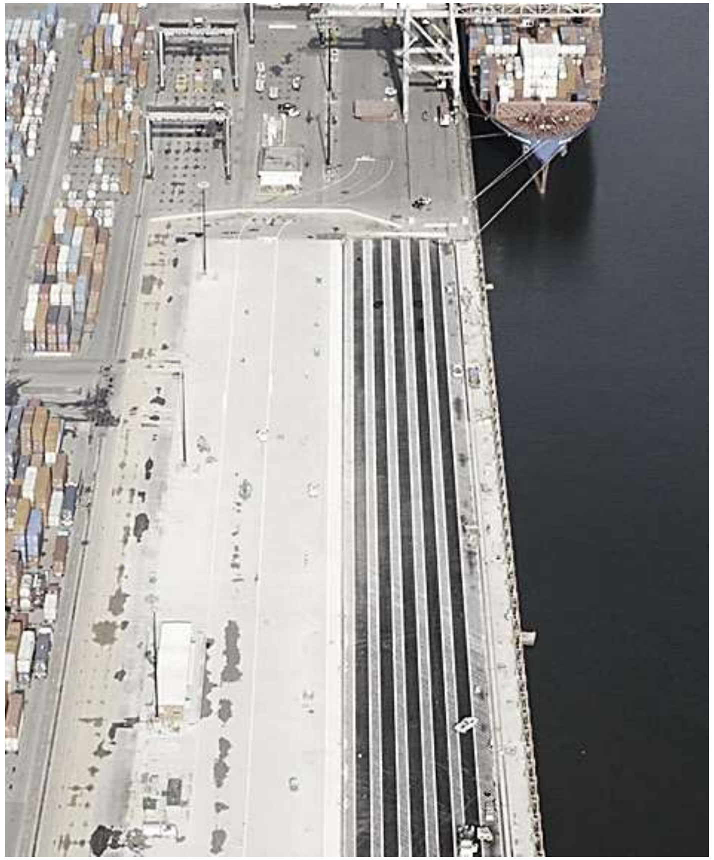
NNP Inc. Heavy Duty Pavement
Global Experts in wet and dry Ports

NIGEL NIXON
PARTNERS Inc.

INTRODUCTION



Barbours Cut Terminal – Berth 1

- **DESIGN DRIVER**

- Cost Effectiveness
- Remain serviceable longer and extend assets life
- Consideration of section options ensuring best buy

- **PLANNED MAINTENANCE**

- Appropriate repair/renewal
- Timely intervention to prolong asset's life
- Pavement monitoring
- New techniques and materials

- **PAVING TECHNOLOGIES AND NEW MATERIALS**

- RCC and Porous pavements: performance/construction time
- and serviceability compliance
- Experience with new technologies, automation and lessons learnt from failures

Example of tire damage

LESSONS LEARNT

NIGEL NIXON PARTNERS Inc.

DEVELOPING INNOVATIVE SOLUTIONS

NIGEL NIXON PARTNERS Inc.

- With a highly qualified team, the company seeks continuous improvement in the offer of adequate targeted solutions to the constraints and challenges it faces, developing paving system design methods and pioneering the use of different methods and solutions, which the following stand out:

  - ✓ *British Ports Association – BPA Design Methods*
  - ✓ *Tensar 2D Reinforcement*
  - ✓ *Concrete Pavers – Port application*
  - ✓ *Roller-Compacted Concrete – RCC in POLA*
  - ✓ *Geoweb 3D confinement grids*

National Concrete Pavement Technology Center

GUIDE FOR ROLLER-COMPACTED CONCRETE PAVEMENTS

Second International Conference on Concrete Block Paving/Delft/April 10–12, 1984

CONCRETE BLOCK PAVEMENT DESIGN IN THE U.K.

J. Knapton

Nigel Nixon & Partners, London (UK)

SUMMARY

For both lightly trafficked and heavy duty pavements, the paper describes design methods which are being used regularly in the U.K. It is shown that most U.K. pavements are on low CBR subgrades and that relatively few designs can be used for the great majority of projects. It is shown that the design method developed by the Cement & Concrete Association is a good working method for lightly trafficked pavements and produces cost effective pavements. The British Ports Association design method for heavy duty paving is described, for both new pavement design and for strengthening existing pavements.
Various civil engineering materials are described and a technique for assessing the suitability of granular sub-base materials is suggested. The use of Geoweb materials is discussed and general conclusions are drawn which show that U.K. concrete block paving design methods are now well established and that concrete block paving is being regarded as an orthodox solution for many categories of pavement.

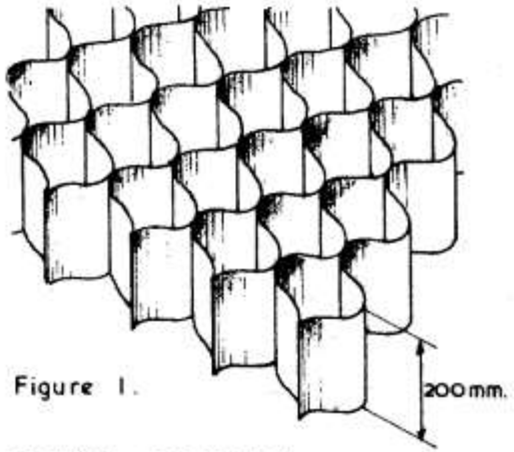


Figure 1.

GEOWEB MATERIAL

STANDARD SECTIONS

- **Adopting a commercial approach**
- **Avoid regurgitation of typical pavement sections**
- **Acknowledge changes in:**
  - Serviceability criteria
  - Variable operational use
  - Use of automated equipment
  - Ground conditions
- **General acceptance of "mill and replace" as often as needed**
- **Little cognizance given to actual operational loading, prevalent ground conditions and serviceability criteria**
- **Essential to agree serviceability criteria then design criteria. Pot holes or pool table**
- **Public and Private sector design approach differences**
- **Interpret operations and convert into pavement loadings.**
- **More zones less flexibility less cost**
- **Interrogate market forecasts to avoid over design**

PAVEMENTS AFFECTED BY GROUND CONDITIONS

NIGEL NIXON PARTNERS Inc.

- **Determination of safe bearing characteristics and settlement expectations**
- **Ground conditions help determine appropriate pavement systems viz rigid or flexible**
- **Consider variety system options with differing blends of base and sub base materials to determine best buy**
- **Design what a contractor can build not what an engineer wants to build**

INNOVATIVE SYSTEMS AND MATERIALS

- DO’S AND DON’TS WITH RCC AND CEMENT TREATED BASES
- LIMITATION IN USE OF TWO AND THREE DIMENSIONAL REINFORCING GRIDS
- USE OF RECYCLED MATERIALS
- EFFECT OF DIFFERING PORT HANDLING EQUIPMENT HAS ON PAVEMENT SELECTION AND BEST BUY APPROACH
- DEVELOPMENT OF MAINTENANCE PROTOCOLS

SUMMARY ADVICE

NIGEL NIXON PARTNERS Inc.

1. Don't take for granted market predictions, satisfy yourself that the envisioned throughputs are sensible with no hint of over optimism. I have often said to my designers if those are the numbers then halve them! I have yet to be proved wrong when offering that advise

2. Never take for granted Geotech's recommendations for parameters used for pavement designs. In my experience many Geotechnical investigations fall short of the pavement engineer's needs. In geotechnical terms geotechnical behaviour is more important in the shallow zones then deep seated knowledge other than long and short term settlement behaviour.

3. Don't be frightened to ask for more data, the more data you collate the more economical your design

4. Agree serviceability criteria and maintenance protocols and hence design life

5. Carry out a thorough understanding of the intended new or existing operations and ensure you have enough knowledge to prepare accurate analyses of the equipment repetitions throughout the design life as well as the wheel loads, dynamics and any static loading.

6. Where possible zone the pavement into discreet operational areas. More the areas cheaper the pavement

7. Designing for a maximum container weight results in an over designed pavement always design for the critical weight and use the BPA method to do so

8. Decide whether the pavement should be flexible or rigid

9. Look at using permeable paving in stone for container stacking

10. Consider all suitable paving systems for cost comparison depending on site location, material availability and local constructability

11. Consider a mix of materials for base and sub base layers, reinforced or unreinforced, to help select most cost effective section

12. Look at pavement levelling systems in extreme cases of excessive differential settlement

THANK YOU.

NIGEL NIXON
PARTNERS Inc.

NIGEL NIXON BSC FICE PE
Chairman

Phone number: +44 7770 613080
E-mail: nigel@nigelnixon.com
Website: www.nnp-engineers.com

Adopting New Pavement Systems

Mark Smallridge, Nigel Nixon and Partners, Inc.

Adopting New Pavement Systems

Roller Compacted Concrete (RCC)

Steel Fiber Reinforced Concrete (SFRC)

Joint Sealants

Gravel Beds

Concrete Pavers

Stone Matrix Asphalt

Geogrids and Geocells

Roller Compacted Concrete (RCC)

Properties

- Typical compressive strengths of 4,000-6,500 psi
- Typical flexural strengths of 500-800 psi
- Elastic modulus is similar to, or slightly higher than Portland Cement Concrete (PCC)
- Fatigue properties are similar to Portland Cement Concrete
- RCC is resistant to freeze/thaw and deicer salt damage
- Low permeability of the compacted mix
- Lower shrinkage and similar expansion properties to Portland Cement Concrete

Roller Compacted Concrete (RCC)

- Construction
  - Trucks unload via transfer vehicle to paver, or direct to paver
  - Pavers use high density screeds using dual tamping bars
  - 12 – 30 feet wide passes of paver with shoes on outer edges
  - Single layers up to 11 inches and double layers up to 20 inches
  - Bond between layers and between passes is important
  - Placement at 90-95% relative density

Mobile Container Terminal (MTC)

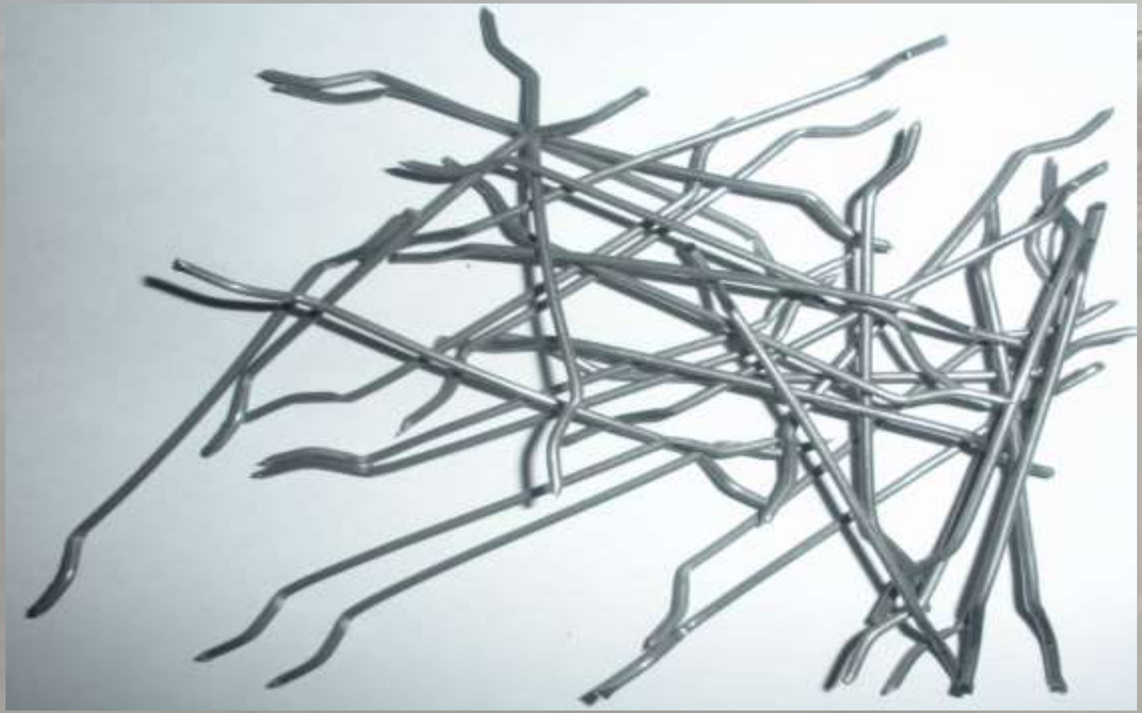
Operations and Equipment

- Linde C 4531 TL/5 reach stackers
  - 157,400 lbs. Tare weight / 99,200 lbs. maximum lift capacity
  - 80,250 lbs. drive axle and 77,150 lbs. steer axle
- Taylor TEC SP155H side lifts
  - 65,050 lbs. Tare weight / 15,000 lbs. maximum lift capacity
  - 42,450 lbs. drive axle and 22,600 lbs. steer axle

Steel Fiber Reinforced Concrete (SFRC)

Properties

- Increased ultimate flexural strength
- Increased flexural fatigue strength
- Increased flexural toughness
- Increased impact resistance
- Increased tensile strength



Steel Fiber Reinforced Concrete (SFRC)

Construction

- Batching needs to be undertaken to achieve uniform dispersion throughout the mix and avoid balling of fibers.
- Fibers added with aggregates at plant, or to fluid mixture in transit mixer.
- High range water reducing admixtures and vibration used during placing.
- Discharge from transit mixer to point of placement, or pumped.
- Strike off with vibrating screed and float finish with care to avoid fiber pickup.
- Brush finish immediately prior to cure coat application (do not use burlap drag).

BEST (Barcelona Europe South Terminal)

Operations and Equipment

- Kalmar Shuttle Carrier SHC 250
  - 51,000 kg. Tare weight / 50,000 kg. maximum lift capacity
  - 21,400 kg. outer wheels and 7,700 kg. middle wheels
- Terex Reach Stacker RS55
  - 94,000 kg. Tare weight / 45,000 kg. maximum lift capacity
  - 116,400 kg. drive axle and 22,600 kg. steer axle

Joint Sealants

- Asphalt and Rubberized Asphalt Sealants
  - Economical, but 5-10 year life
- Silicone Sealants
  - Low modulus with 50 – 100% extension
  - 15-20 year life
- Polysulfide Sealants
  - Intermediate modulus -35 – 50% extension
  - 20+ years life

Gravel Beds

- Used for rubber tire gantry and rail mounted gantry operations.
- Containers sit on reinforced concrete ground beams.
- Infill areas are an open graded gravel to aid with drainage.

Concrete Pavers

- Precast pavers with high standard of quality control
- Hand or machined installation
- Easy to lift and re-install for repairs
- Permeable paving systems using pavers

Stone Matrix/Mastic Asphalt (SMA)

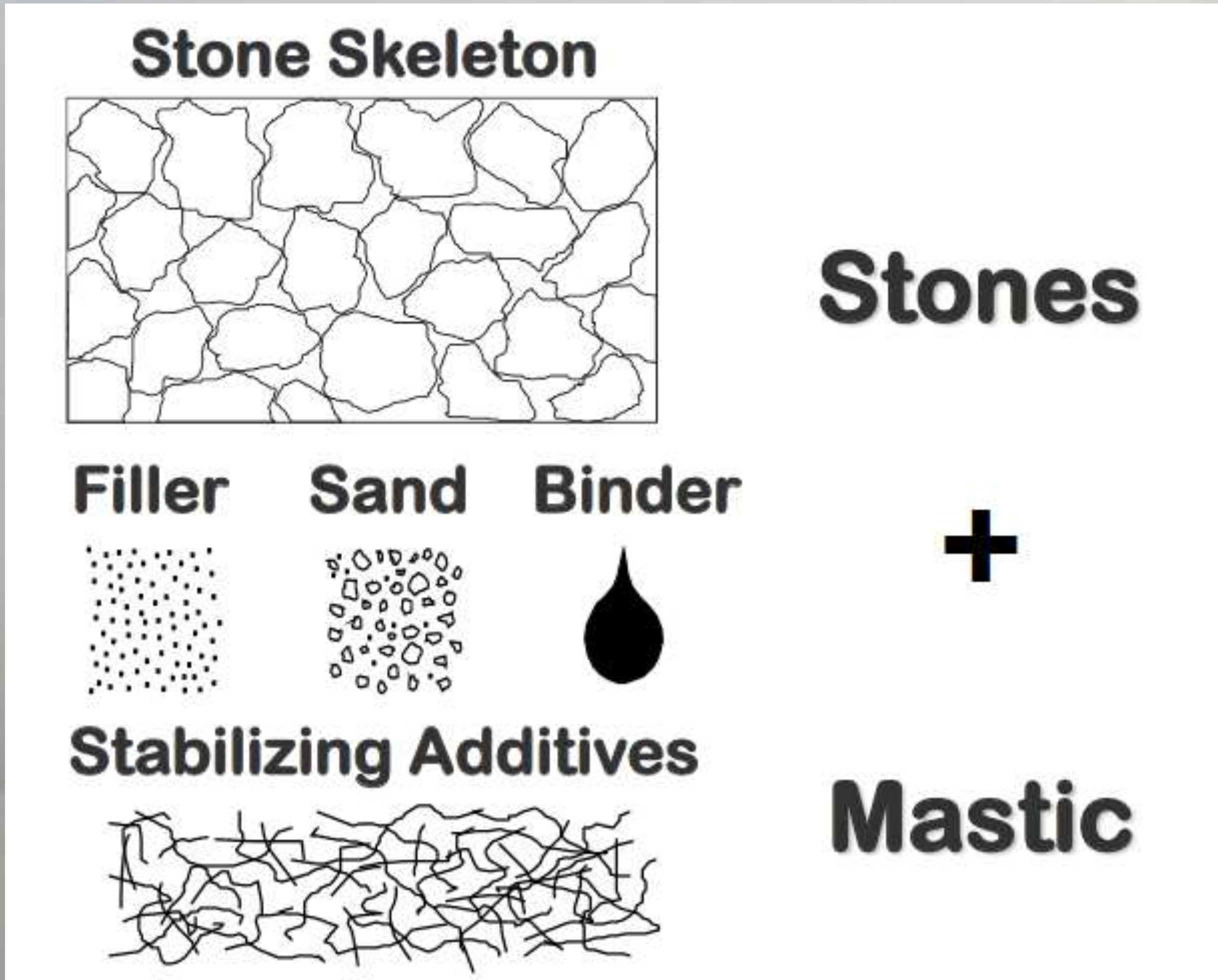
Aggregates

- SMA is more resistant to deformation as the aggregate skeleton supports the load by rock on rock contact
- Use of larger aggregate sizes (typically 1/2 in. to 3/4 in. for surface course and 1 in. for base course
- Use of cubical shape aggregate where possible

Binders

- Asphalt binders are temperature susceptible materials
- Use high temperature grade binders (typically one or two grades higher)
- Modifiers available to increase stiffness an resistance to deformation
- Fibers to reduce drain-down

Stone Matrix/Mastic Asphalt (SMA)



Geogrids

- Aggregate particles penetrate the apertures in the grid and act in confinement.
- Under load, tension develops in the grid at low extension increasing the effective load distribution.
- This reduces subgrade stress, reduces rutting potential and enables savings on aggregate thickness.


Mechanically Stabilized Earth
PRACTICAL
ENGINEERING


Mechanically Stabilized Earth

Port Pavement Design Guides

Thank You

Mark Smallridge, Nigel Nixon and Partners, Inc.