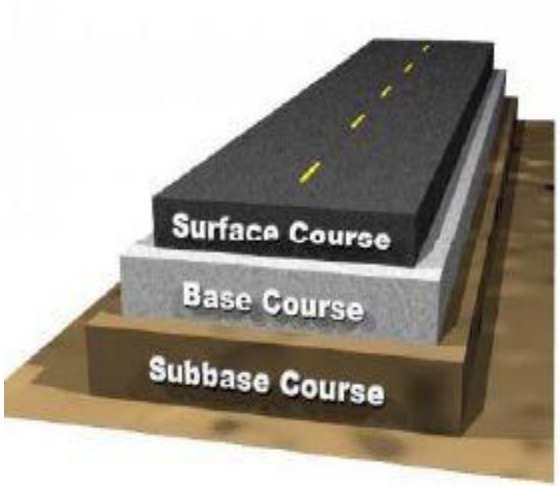
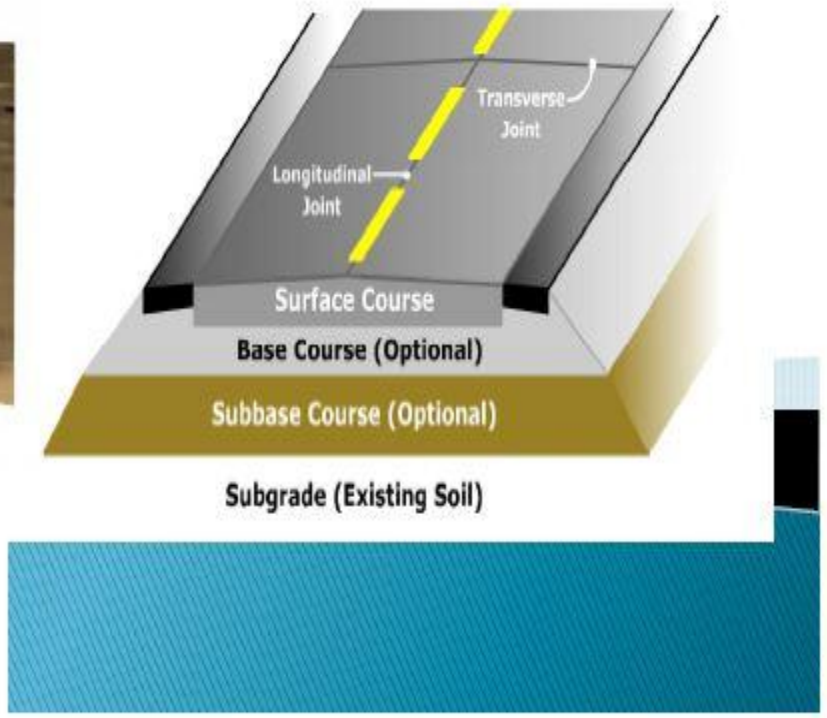
EWCE 351

Transportation Engineering

Highway Pavement

What is a pavement





Highway Pavement

What is a pavement

- A **multi-layer** system that distributes the vehicular loads over a larger area. Or
- HW pavement is a **structures consisting of superimposed layers** of selected and processed materials whose primary function is to distribute the **applied load** to subgrade. Or
- Structures which separates the tires of vehicles from under lying foundation.

Function of Pavement

- A highway pavement is designed to support the wheel loads imposed on it from traffic moving over it.
- Additional stresses are also imposed by changes in the temperature of environment.
- Pavement should be strong enough to resists the stresses imposed on it and should be thick enough to distribute the external loads on the subgrade.

Desirable Characteristics of Pavement

- It should be sufficiently thick to distribute the loads and stress to a safe value on the subgrade soil.
- It should be structurally sound enough to withstand the stresses imposed on it.
- It should provide a reasonably hard wearing surface, so that the abrasive action of wheels does not damage the surface.
- It should be dust free so that traffic safety is not impaired.
- Its riding quality should be good.

Desirable Characteristics of Pavement

- It should be smooth enough to provide comfort to the road users at the high speeds at which modern vehicles are driven.
- The surface of the pavement should develop as low a friction as possible.
- The surface of the pavement should have adequate roughness to prevent skidding of vehicles.
- The surface should not produce excessive level of sound.
- The surface should be impervious so that water does not penetrate the pavement.
- The pavement should have long life and low maintenance cost.

History

Footways

Tracks in jungle

1st hard surface in Mesopotomia---3500 BC

Romans 0-300 BC UK Mcadam & Telford REF2

WW 1 & 2

France P.M Treassage

Brick pavement USA

Wood block Europe, Austalia

Asphalt Paris (1858), UK (1870), USA (1873)

Concrete Pavement Scotland 1865 USA 1909

Roman Road

Roman Roads

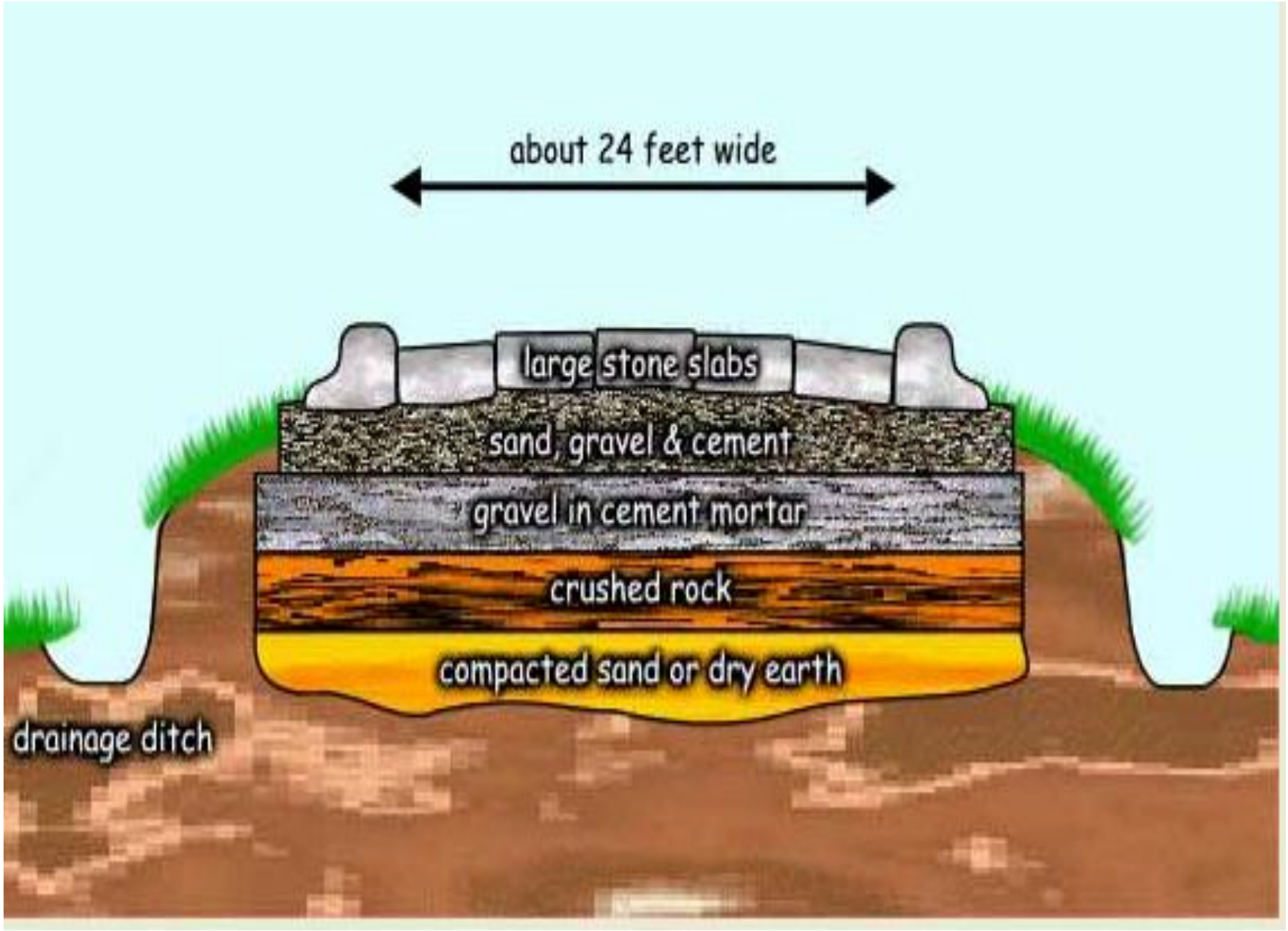
- It is suggested that the Romans took up the practice of a military road system from the Carthaginians. It is estimated that the Romans built about 87,000 km of roads within their empire (about equal to the length of the U.S. Interstate system).
  - Since the primary purpose of these roads was for foot soldiers, the roads were straight, but virtually without regard to grade. They generated high noise levels, were rough and labor intensive (slave and "statue" labor often used).

Roman Road

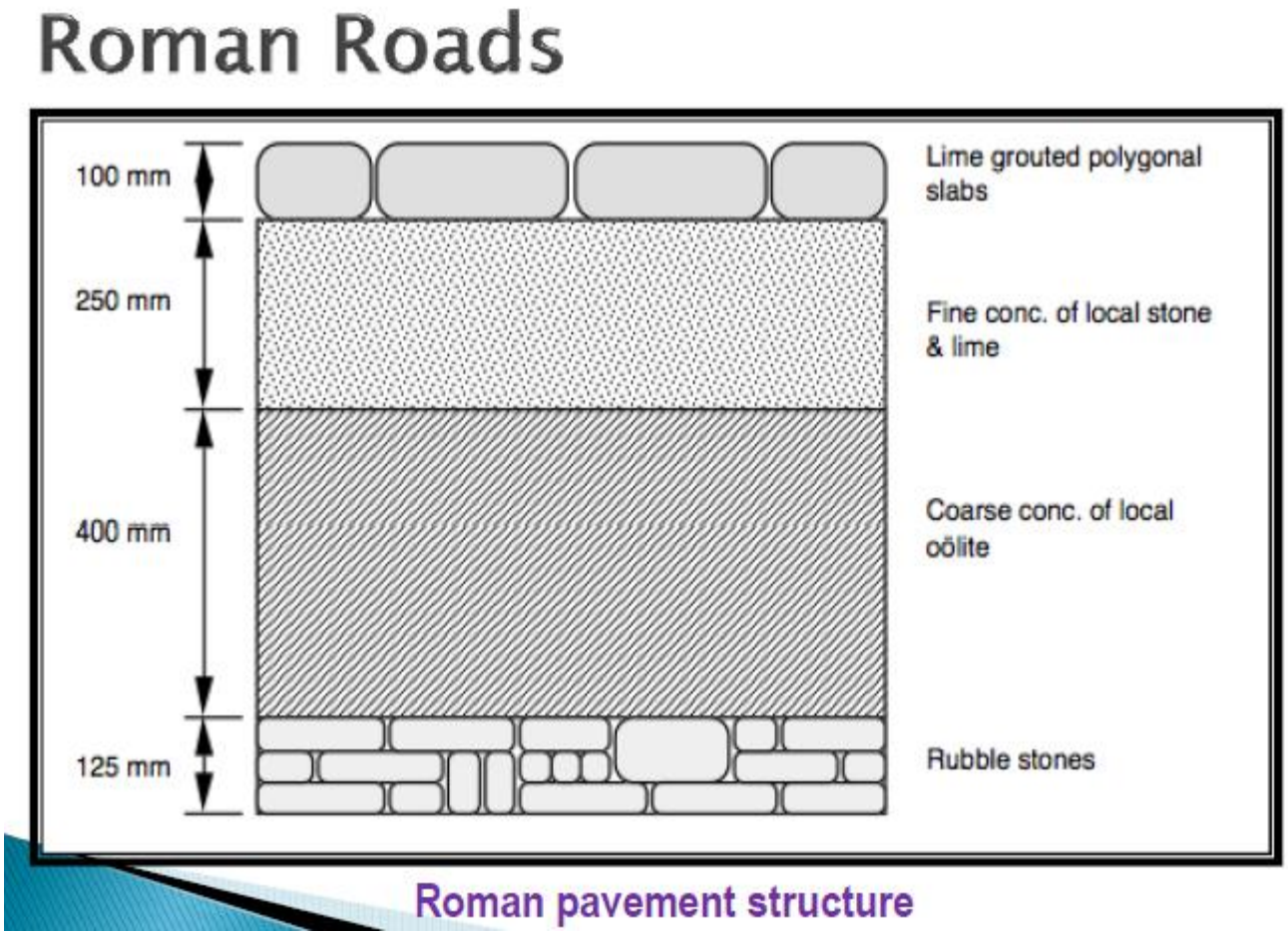
The Roman design for their primary U.K. roads generally consisted of four layers (top to bottom) as follows:

- Summa Crusta (surfacing): Smooth, polygonal blocks bedded in underlying layer.
- Nucleus: A kind of base layer composed of gravel and sand with lime cement.
- Rudus: The third layer was composed of rubble masonry and smaller stones also set in lime mortar.
- Statumen: Two or three courses of flat stones set in lime mortar.

The total thickness was as much as 0.9 m and road widths of 4.3 m or less.


about 24 feet wide
large stone slabs
sand, gravel & cement
gravel in cement mortar
crushed rock
compacted sand or dry earth
drainage ditch

Roman Road


Roman Roads
100 mm
250 mm
400 mm
125 mm
Lime grouted polygonal slabs
Fine conc. of local stone & lime
Coarse conc. of local oölite
Rubble stones
Roman pavement structure

Roman Road



Roman Roads

- Roman road construction was not inexpensive.

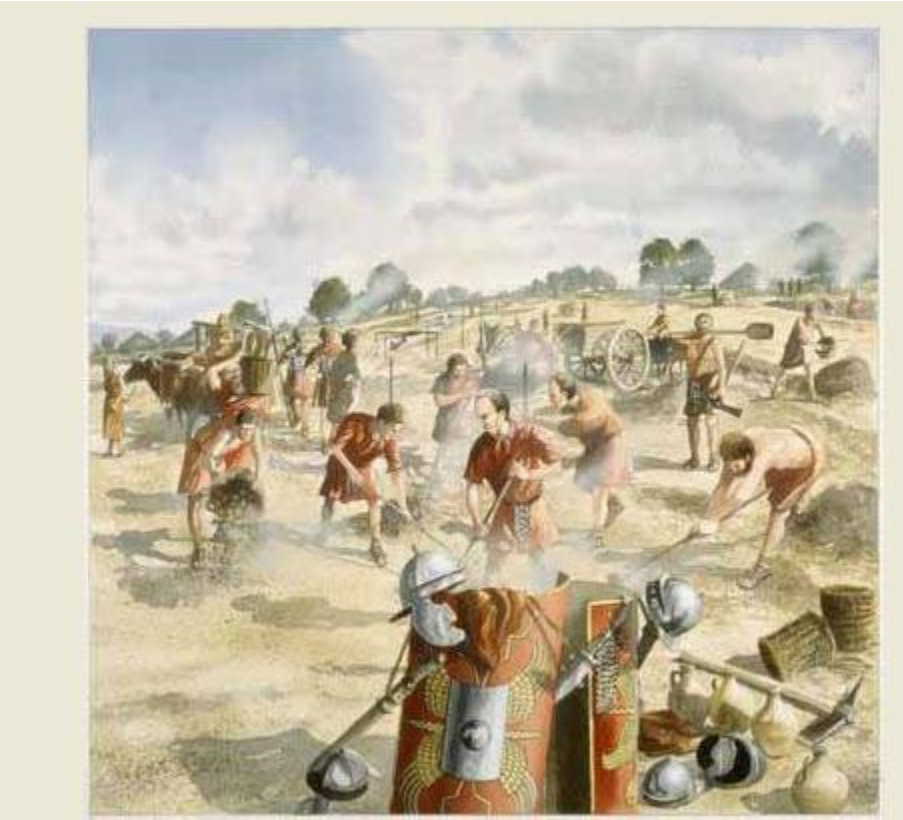
- Updated construction estimates of the Appian Way in Italy are about $2,000,000 per km



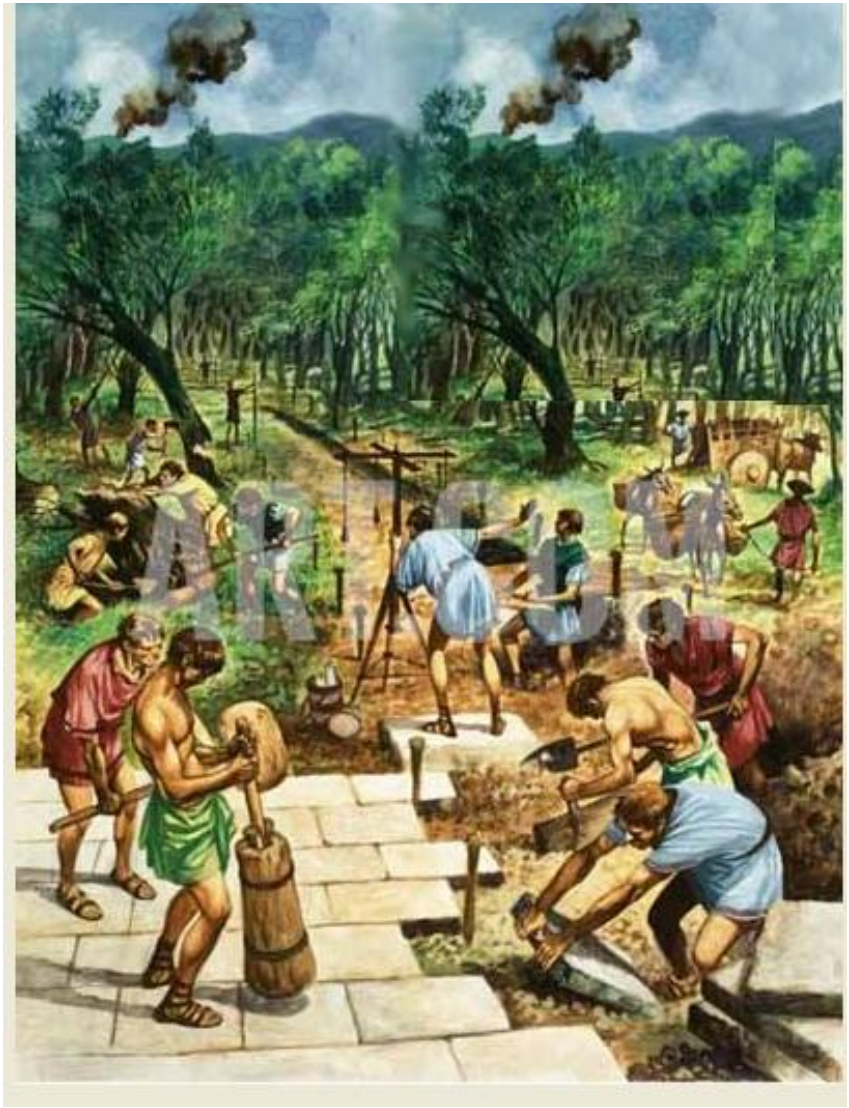
Roman Road



Roman Road



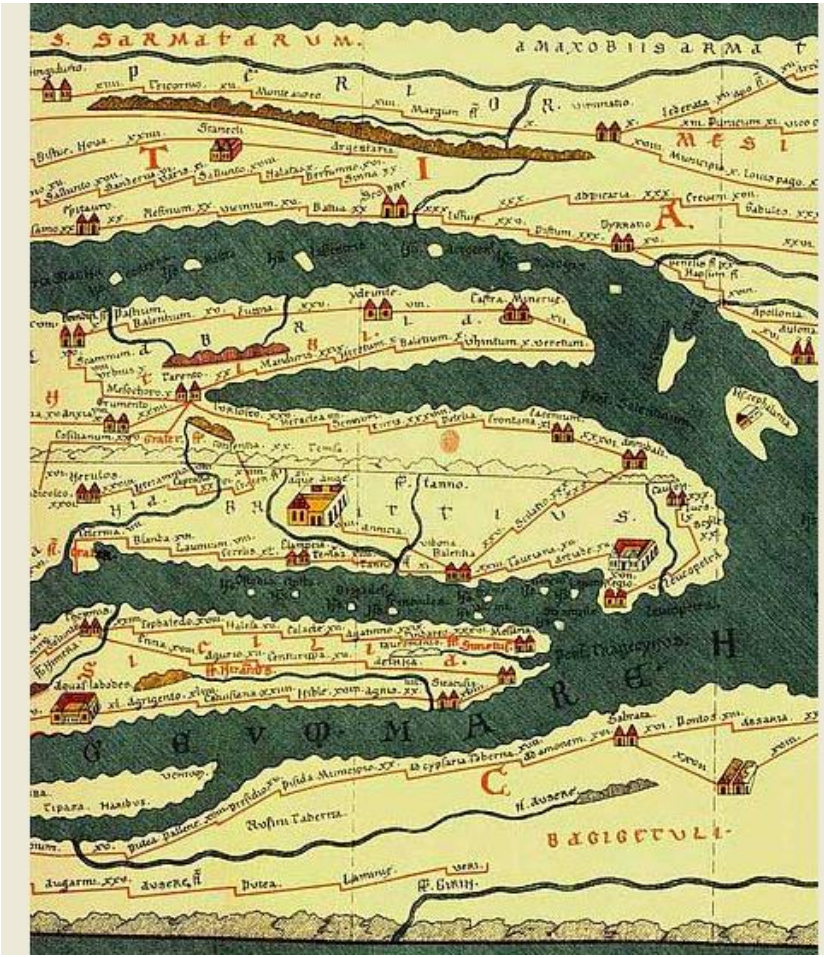
Roman Road



Roman Road



Roman Road

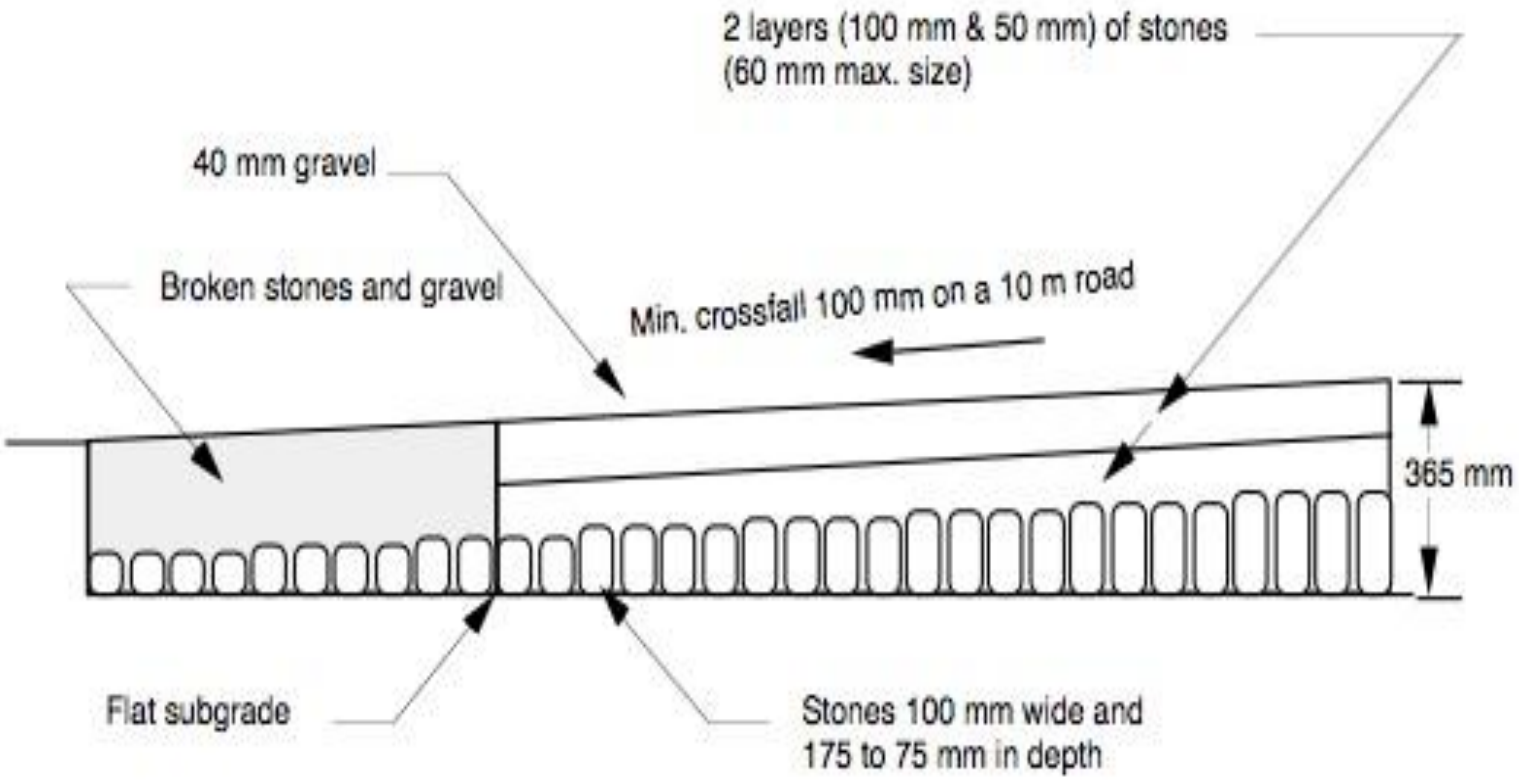

S. SARMATARVM.
a MAXOBIIS ARMA
Ravenna
Rimini
Pesaro
Fano
Sinigaglia
Ancona
Loreto
Recanati
Fermo
Ascoli
Adriatic Sea
Tyrrhenian Sea
Rome
Tiber
Naples
Capua
Benevento
Salerno
Amalfi
Sorrento
Gaeta
Terracina
Velletri
Tivoli
Subiaco
Aquino
Arpino
Sora
Isernia
Venafro
Teano
Sessa
Nola
Avellino
Melfi
Venosa
Matera
Gravina
Bari
Barletta
Trani
Manfredonia
Foggia
Lucera
Troia
Ariano
Benevento
Capua
Aversa
Pozzuoli
Cumae
Misenum
Baiae
Puteoli
Neapolis
Herculaneum
Pompeii
Stabiae
Surrentum
Amalphi
Paestum
Velia
Policastro
Sapri
Tegianum
Buxentum
Laus Pompeia
Thurii
Sybaris
Crotona
Locri
Rhegium
Messina
Taormina
Catania
Syracusa
Augusta
Lilybaeum
Panormus
Drepanum
Segesta
Agrigentum
Selinus
Mazara
Trapani
Marsala
Caralis
Sulci
Tharros
Bosa
Olbia
Turris
Alghero
Sassari
Porto Torres
Ajaccio
Bonifacio
Corsica
Sardinia
Sicily
Africa
Mauretania
Numidia
Byzacium
Tripolis
Gaetulia
Hadrumetum
Thysdrus
Thapsus
Leptis Magna
Oea
Sabrata
Tacape
Gabes
Carthago
Utica
Hippo Regius
Bona
Tabraca
Thabraca
Bagiensis
Tipasa
Caesarea
Icosium
Rusazus
Rusucurium
Saldae
Igilgili
Rusicade
Cirta
Sitifis
Auzia
Tubusuctu
Tubusuptus
Rusguniae
Rusubbicari
Rusippisir
Rusazus
Rusucurium
Igilgili
Saldae
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Telford and Macadam

Telford

- Telford was the "**Surveyor of Public Works**" for the county of Salop
- Telford build roads on relatively flat grades (no more than 1 in 30) to reduce the number of horses needed to haul cargo.
- Pavement section was 350 to 450 mm in depth, in 03 layers

Telford


2 layers (100 mm & 50 mm) of stones
(60 mm max. size)
40 mm gravel
Broken stones and gravel
Min. crossfall 100 mm on a 10 m road
365 mm
Flat subgrade
Stones 100 mm wide and
175 to 75 mm in depth

Macadam Road

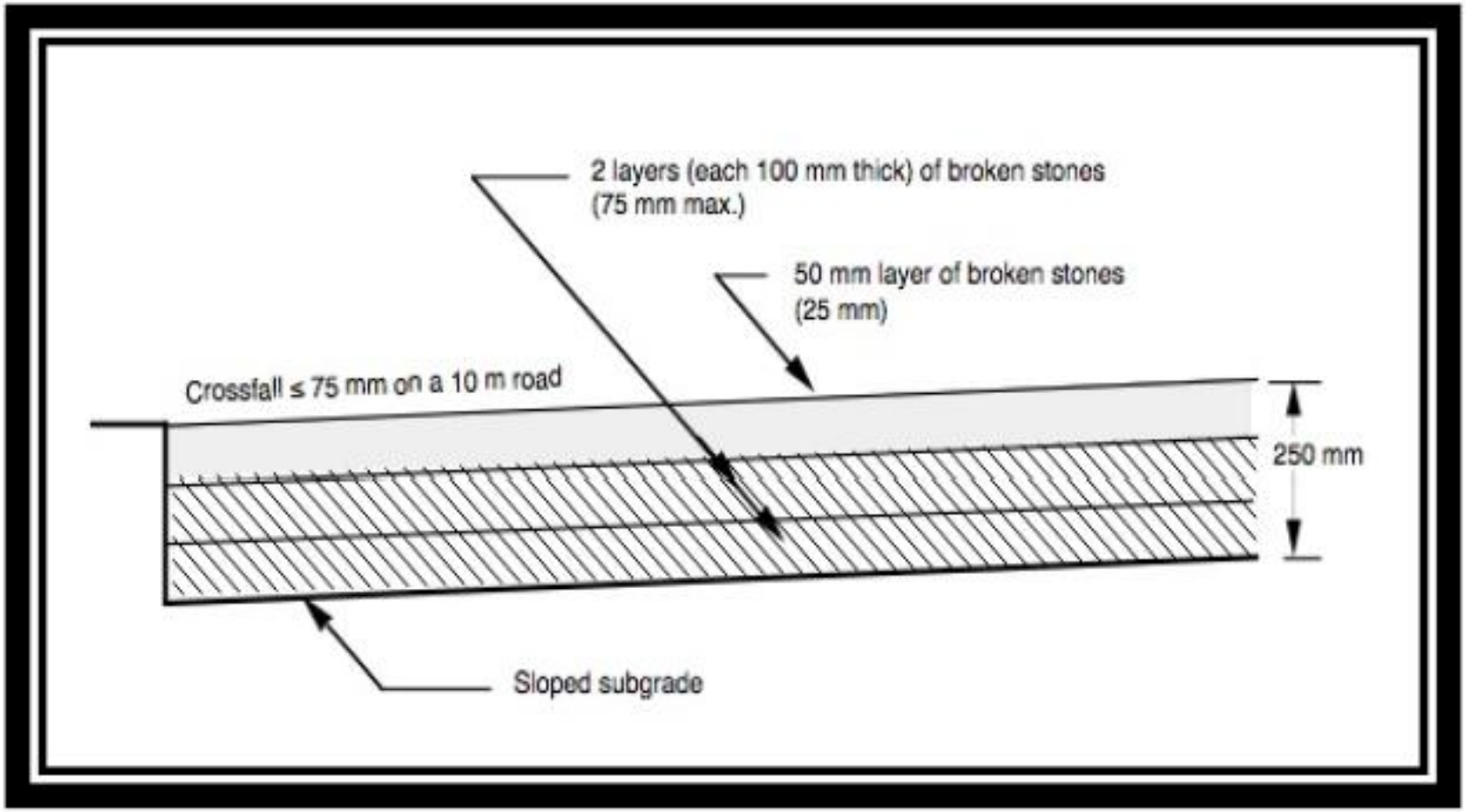
- John Macadam (born 1756) observed that most of the "paved" U.K. roads in early 1800s were composed of rounded gravel .
- He knew that angular aggregate over a well-compacted subgrade would perform substantially better.
- He used a sloped subgrade surface to improve drainage on which he placed angular aggregate (hand-broken, maximum size 75 mm) in two layers for a total depth of about 200 mm .

- On top of this, the wearing course was placed (about 50 mm thick with a maximum aggregate size of 25 mm) .
-
- **Macadam's reason for the 25 mm maximum aggregate size was to provide a "smooth" ride for wagon wheels. Thus, the total depth of a typical Macadam pavement was about 250 mm .**
- An interesting quote attributed to Macadam about allowable maximum aggregate sizes was that "no stone larger than will enter a man's mouth should go into a road" .
- The largest permissible load for this type of design was estimated to be 158 N/mm (900 lb per in. width).

Macadam Roads

- By 1850, about 2,200 km of macadam type pavements were in use in the urban areas of the UK.
- Macadam realized that the layers of broken stone would eventually become "bound" together by fines generated by traffic.
- With the introduction of the rock crusher, large mounds of stone dust and screenings were generated .
- This resulted in use of such fines resulting in the more traditional dense graded base materials which in turn produced pavement thicknesses as thin as 100to150mm.
- The first macadam pavement in the U.S. was constructed in Maryland in 1823.

Macadam Road



Early Bituminous Pavement

Tar Macadam

- In part, due to lack of attention in specifying the tar, most of these streets failed within a few years of construction. This resulted in tar being discredited, thereby boosting the asphalt industry .

- However, some of these tar-bound surface courses in Washington, D.C., survived substantially longer, about 30 years. For these mixes, the tar binder constituted about 6 percent by weight of the total mix (air voids of about 17 percent). Further, the aggregate was crushed with about 20 percent passing the No. 10 sieve. The wearing course was about 50 mm thick.

Any Question

Telford

- The bottom layer was comprised of large stones (100 mm) wide and 75 to 180 mm in depth)
- On top of this were placed two layers of stones of 65 mm maximum size (about 150 to 250 mm total thickness) followed by a wearing course of gravel about 40 mm thick
- It was estimated that this system would support a load corresponding to **88 N/mm** (**500 lb** per in. of width).