Road to the Future

Introduction

Man's travel began millennia ago with the first step of the first man in his desire to satisfy a basic need for food shelter, clothing or social interaction. From the fist step there evolved a system of transportation that still satisfies these basic needs. In order to understand our present need for transportation and predict the future needs it is informative to take a trip into the past to explore old transportation systems and how they have evolved in the past 6000 yrs. Of particular interests is how engineering and road building technology has developed and changed.

The record for many of these developments is sketchy and in many cases requires extrapolation from observations of travelers that have recorded their experiences and are included them in the written record. The intention is to approach the subject in a chronological manner discussing each period to the extent possible from available records Some of the periods discussed are sparse in information related to the technology of roads and as a consequence will suffer in the length of the discussion. In all cases the intention is to give some feel for the engineering that was involved and the changes that have occurred. Obviously the modern era has much greater resources in terms of reference and documentation and these areas of transportation will not be extensively treated.. Land transportation and highways are the particular areas of interest. The many photos that are incorporated with the discussion help to illustrate the particular road being discussed. Citations in the various sections will allow the interested reader to pursue the subject in greater detail.

With this short introduction let us begin our journey of a thousand miles.

Early Roads

The first roads were paths made by animals and later adapted by humans. The earliest records of such paths have been found around some springs near Jericho and date from about 6000 BC. These early paths usually were close to water and or provided a secure environment for the animals that used them. As the need for greater speed of travel developed the trails moved out of the water logged stream beds and up the valleys to drier ridges. This type of path was common for early man and many examples can be found both in Europe and in North American. There was probably no technology involved in developing these paths with the exception that someone had to make a decisions related to where the path should go (normally the path of least resistance associated with a tendency of directionality associate with going from point a to point b).

The first indications of constructed roads date from about 4000 BC and consist of stone-paved streets at Ur in modern-day Iraq (26) Any one that has been in this part of the world realizes that the terrain allows a good deal of meandering for the roadways and tracing the ancients routes is difficult at best. A typical route with caravan travel is shown below

Figure 1 Caravan travel on desert route

The roadways in some cases were 200 to 400 feet wide and compacted 20 to 24 inches deep ( ). They were made by early people who herded their livestock to fields for pasture and between towns as part of the emerging economic system. Continual traffic by people, animals and vehicles hardened the surface and caused the roadway to sink into the landscape. Some of these routes can still be seen from satellite (22). The figure below show many roads radiating from Tell Brak an ancient site in present day Syria.

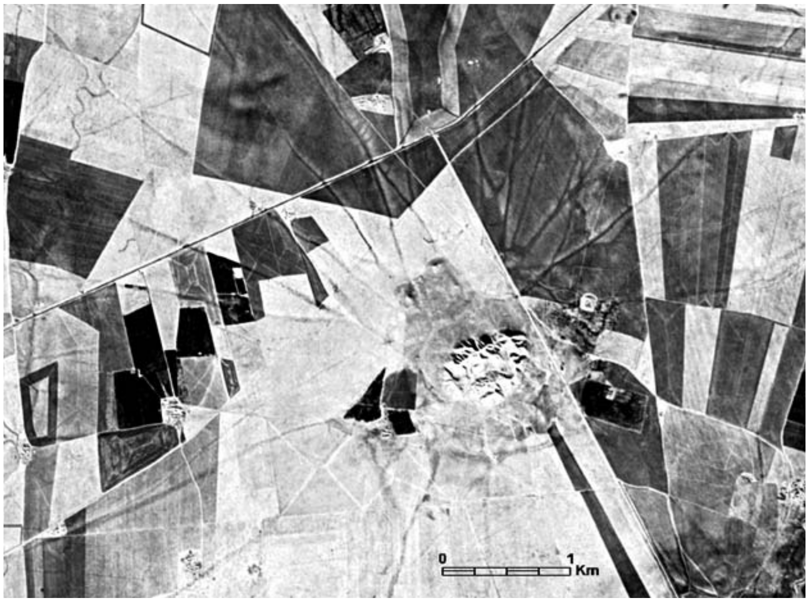

Figure 2 Satellite view of ancient roads

Egyptian roads

Egypt was not a great road building society. Its primary mode of transportation was by boat. However there are references to the use of chariots with the requirement that they must have had roads at some level of design.

Figure 3 Egyptian chariot

Many of the roads were a result of canal digging: the embankment of excavated earth serving as road even in times of inundation. They were paved only when there were special circumstances (religious ceremonial routes) which happened only rarely (5]. Thanks to the scarcity of rain even ordinary roads were passable all year long.

Egyptian construction

Egypt is rich in limestone and it was used extensively in constructing their buildings and roads Basalt was also used in paving roads and laying lower courses of buildings. In the Fayum an Old Kingdom road paved with flagstones facilitated the transportation of stone from the basalt quarries at Gebel Qatrani to Lake Moeris, where it was loaded onto ships. This perfectly straight road was 11.5 kilometres long and had a width of more than 2 metres. At Buhen in Lower Nubia some roads were paved with burnt-clay tiles (17)

One interesting point related to road utilization obtained from figures at grave sites is the use of a liquid (maybe milk with high butter fat, probably water) poured beneath sleds used to haul heavy loads to decreases the friction. (Ref)

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Figure 4 Egyptian mode of transport

An interesting sidebar related to roads in early Egypt is given by Parry (23) in relation to the construction of the pyramids. It is generally believed that the stone blocks that were used in constructing the pyramids were dragged up earthen ramps to the location of their final placement. This process was aided by using wood rollers or some kind of lubricant such as wet clay of water soaked earth. Parry contends that using that technique it would be impossible to construct the pyramid in the known time. He proposed that a series of sector shapes cradles were placed around the stones to encase them in a roller shaped device that could be moved up the ramp with substantially less labor and time compared with the usually method. In any case this points out the difficulty of determining what actually occurred in the distant past.

In terms of major routes the King's Highway is mentioned frequently in discussions of ancient transportation. The King referred to is the king of Egypt and the highway is the route used to spread the influence of the pharaoh to areas under dominance of the Pharaoh. It is a multi-path route spreading through out the Middle East from Heliopolis (Cario) to Resafa (an ancient road on the way to Baghdad). ( )

Figure 5 Route of the Kings Highway

There are many references to roads and highways in the bible. But the references are usually not engineering orientated and require some interpretation. For example the quote (Luke 3:5)

EVERY RAVINE WILL BE FILLED,
AND EVERY MOUNTAIN AND HILL WILL BE BROUGHT LOW;
THE CROOKED WILL BECOME STRAIGHT,
AND THE ROUGH ROADS SMOOTH;

is a mini road design manual. It tells the prospective engineer that road profile should not follow the terrain and may requires embankments and excavation to make a good road. In addition the suggestion that the road should be made straight suggest the choice for alignment and the command to make the roads smooth suggest an improved wearing course. All of these topics are discussed in modern highway design manual is great detail. (this is Roman road building at its best and bit of knowledge by Luke could be the bases for this verse). Another related passage is (Jeremiah 31:21) [21]

"Set up road signs;
put up guideposts.
Take note of the highway,
the road that you take.
Return, O Virgin Israel,
return to your towns.

This quote is a clear instruction to provide road markings and signs A common practices even at this early date. Shown below are Roman mile markers found in the desert along the ***Via Trajan (Ref).***

Figure 6 Roman mile posts

Chinese Roads

Great civilizations such as the Chinese must have developed many road building techniques that would be of historical interest. However much of this information is lost in the haze of the past. There are some routes that are justifiably famous including the Silk Road and the Ancient Chinese Tea Horse Road   The great wall of china could also be considered a road as it had a military purpose and troops used it to move from point to point along its breadth.

From the little evidence known, Chinese engineers laid out their roads as straight as possible and frequently were 50 to 60 feet wide (enough space for five chariots to pass). They did not use surface stone and thus there are few remaining samples of their road building efforts. (2) In the pictures below it can be seen that the terrain is difficult and road building took a high level of skill.

  

Figure 7 Difficult terrain along Ancient Tea Horse Road

Silk Road

Marco Polo made this route famous and it is a good example of a name that suggests a definite route when it actually had a good number of branches and alternatives. Even the route is hard to define as it wanders around as it proceeds from the Middle East through Afghanistan and the Himalayan plateau into western china.

The Silk Road was a route that was famous for trade and cultural exchange but has little technical information related to construction or planning. It is redundant to say that this route was primarily developed to increase trade between the east and west, but it was also used for military purposes. The great Genghis Klan's army use this route to control their adjacent territories. Note the alignment and the mode of transport in the picture below. For a detailed description of the route geography see the web site http://www.ess.uci.edu/~oliver/silk.html#1

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Figure 8 Easy terrains along Silk Route

Greek

Greece is a country that does not lend itself to development of major road networks because of geography and political reasons. The country is mountainous and roads are likely to be expensive to build and hard to maintain. In addition the city states politics did not provided the basis to develop a country wide roads system. Most roads were single tracks following stream beds or the path of least resistance. Typically the roads would be muddy, narrow tracks with a few exceptions paved with slabs of fieldstone. (4)

One innovation traced to Greek technology is the use of carved ruts in the road path. In order to make roads as safe as possible the Greeks cut grooves (3 to 6 inches deep) in the road. Evidence points to the fact that much of Greece was covered with these roads. One can only imagine the disputes that would erupt as opposing traffic met and tried to pass each other. (12)

Figure 9 Greek road with wheel ruts

The reason for using this type of road is usually given to be a way to reduce the effort to make a serviceable road. The groves were true and level but the remaining part of the traveled way was rough and unleveled. (2). It might also be possible that in critical situations a lubricant could be poured in the grove to lower friction at the interface. It is also conceivable that on steep grades it would be easier to place rocks or other wedges behind wheel to prevent the wagon from going backward. On the other hand concentrating the wheel loads at a particular point on the travel way would lead to premature failure because of the stress concentrations.. Typical dimensions for the ruts were 4 in deep and 9 in wide with a space between of approximately 4 to 5 ft.

Roman Roads

Ah! Romans- the great builders of ancient time. Their road building provides many examples both from their literature and on the ground such as the well know Appian Way. If ever advanced civilizations are associated with transportation infra structured Rome is a prime example. Roman roads were an expression of roman might and the ability of man to overcome nature. As such they had much to say about roman cultures as well as there construction abilities.

. At its peak the Roman Empire covered most of the Mediterranean and included large portions of present Europe as well as the Middle East. The map shows the extent of the roman road system at its largest with approximately 50000 miles of routes which compares with the 45000 miles of Interstate routes in the United States

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Figure 10 Extent of Roman road system

The road building techniques used by the Romans is a good model for present techniques. The basic idea is to provide a structure that has successively stronger layers as we proceed from the sub grade to the surface. The major difference is in materials that were used. Present day surface materials like asphalt and concrete are superior in ease of construction compared to the rock slabs used by the Romans. In fact the major difference between then and now is in the amount of human labor where slave labor is used instead of Caterpillar excavators. The typical Roman road was a layered system as shown below and is described by (1,2)

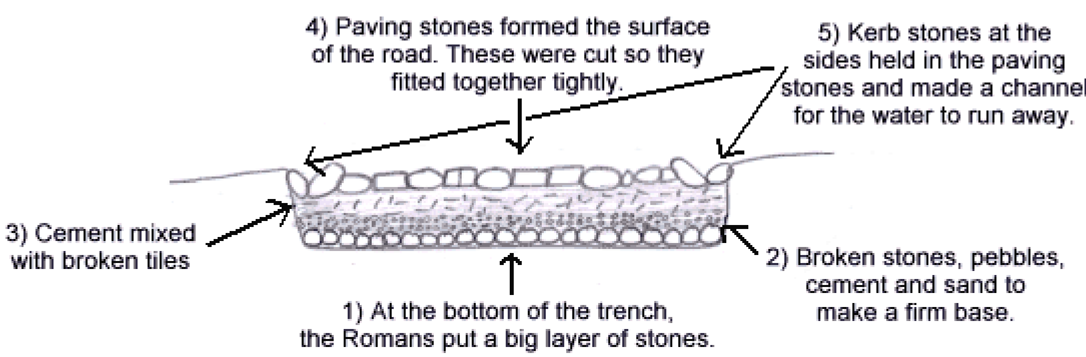


Figure 11 Typical section of Roman Road

The builder would first clear and grub the area as is typical in the modern construction sequence. The Romans then cut a trench and that was filled with large stones. This composed the *statum* or basement layer. Next, was a layer of cemented pebbles and finer stones composing the *rudus*. The third layer of fine cemented sand called the *nucules* was followed by the top course of paving stones called the *pavimentum*. Curb/Kerb stones were put at the sides of the road to hold in the paving stones and to make a channel for the water to run away.

The reference to cement above might lead the modern reader to think of modern Portland cement used in concrete roads. In fact it was not too different. Adam (1) stated that the concrete was a mixture of lime, pozzalan and water. The ancients hand mixed their components (wet lime and volcanic ash) in a mortar box with very little water to give a nearly dry composition; carried it to the job site in baskets placing it over a previously prepared layer of rock pieces; and then proceeded to pound the mortar into the rock layer. The close packing by tamping reduced the need of excess water for workability purposes, which in turn reduced the water/cement ratios a source of voids and weakness. Again, we have a similarity in the ancient material versus modern roller compacted concrete practices, which is that of tightly compacting (with modern compactors) the materials placed at low water/cement ratio..

Thickness design was done based on the experience of the engineer/builder. As in present construction, there is great variation in the thickness of the layers. There are sections of Roman roads where the surface layer is only two to three inches thick, while some are one to two feet in the center and thin to a few inches at the sides (9). The total depth of a road, from surface to the bottom of the base, could reach 1 to 1.5 meters. Also, the road surface is sloped to each side from the center, in some places dropping as much as a foot on a road 15 feet wide (7%)--a considerable amount compared to the present value of about 0.3 of a ft for the 15 ft road width (2%). (9).

Intentional ruts are an interesting feature of some ancient Roman roads as they are for early Greek roads. While there are some ruts that developed from general use, there are others that are purposeful, between 6 and 30 centimeters deep, with sharp edges shaped by a pick or a point and hammer. Also it was noted that there are places where grooves are marked in the road to prevent horses from slipping (3). The same type of road groves were also noted in the Greek roads constructed prior to the major road building efforts of the Romans and is an example of early technology transfer..

Cross section of the roads varied considerably depending on their function, importance, and the nature of the terrain, The widest roads, called *decumanus maximus*, were 40 feet, while byroads were 8 feet wide (3). In general, we may assume, the wider the road, the greater its importance. The general width of countryside roads was 20 feet to allow vehicles to pass, but all roads narrowed over difficult terrain (3). Such roads are sometimes wider than the width of two carts (one in each direction) because they were widely used.. However, some mountain roads are too narrow (less than 3 meters) and too steep (over 15% grade) for carts and could only be used by beasts of burden (1).

In towns the road widths were also varied, though width is standard when the town planning conformed to a certain layout. “At Pompeii the main roads have an approximately uniform carriageway width (4 meters) and distance from wall to wall (8 meters)” (1). Secondary roads and alleys within the city are as narrow as 2 meters. The width of the street also varied depending on the surrounding buildings and whether there was a portico on the pavement (1).

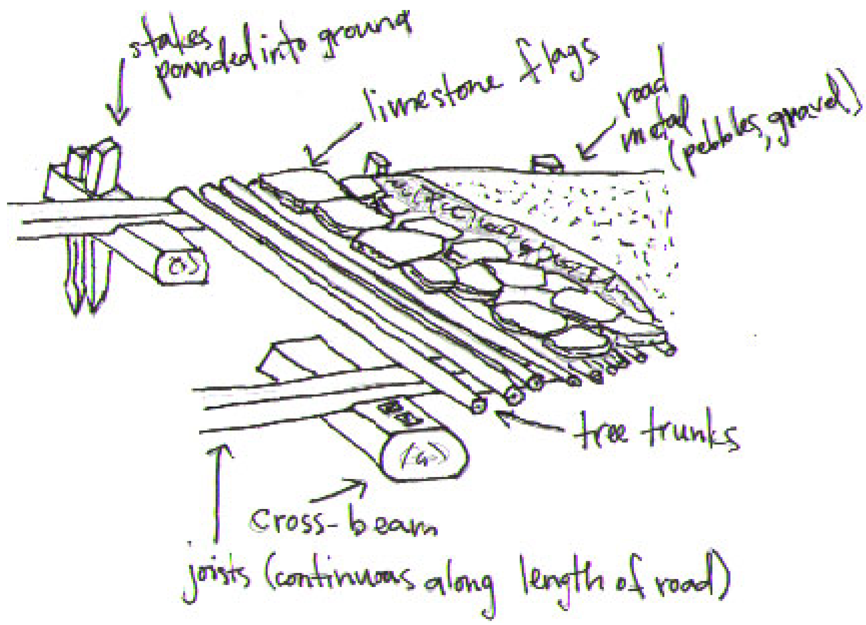
Figure: 12 A Roman street in Pompii with wheel ruts

Drainage

Adequate drainage is the key to a long lasting road and Romans were very conscience of this fact and included side drainage ditches in their typical cross sections. Part of the ditch included a strip of land on which cultivation and building were forbidden. This strip may have been for grazing. In modern terms this would be the back slope of the roadway

The way in which the Romans dealt with the problem of unstable or marshy ground in constructing roads is particularly interesting. Especially on marshy land, roads were given “a proper causeway, and not just an earthen ridge” (3). Such roads are based on a wooden framework,

Two rows of unconnected cross-beams were placed on the marshy soil for the whole length of the road. Each beam was 2 meters from the next one and there was a gap between the rows. Each beam came out 40 cm from the road and this projection had slots to pound stakes through the beam and into the ground. These beams supported two continuous rows of joists on top of which were laid a solid series of tree trunks. On top of the tree trunks were large, flat limestone flags, covered by road metal of gravel and pebbles (9).



A representation of the diagram in J. Mertens' book.

Figure 13 Roman road in difficult terrain

Difficult terrain

Steep ground required a different solution. When following a preferred straight path, it is inevitable that some local obstacles such as steep-sided valleys will be encountered.” To cross these, the Roman road is turned along the side of the valley and continues in a zigzag pattern up the steep slope, sometimes using grades in excess of 15%.

An ancient Roman road cut into the Italian mountainside.

Figure 14 Roman road with side hill cut

The most basic way of overcoming hilly obstacle, though not always the easiest, is to cut a passage through the rock for the route. Such roads are sometimes found in mountainous regions and along steep coasts. In these situations, the Romans tried as often as possible to cut into only one side of the rock (1).

A tunnel is the ultimate solution whenever cutting a path or going over or around the obstacle. The tunnel of Furbo on the via Flaminia which “begins by cutting into the rock face and then penetrates the rock for a length of 38 meters” (1).

The Romans also build some roads in the desert. These roads have left little physical evidence, because their courses were mostly undefined except when crossing stony country (91). However, some “gently curving ridges” have survived, the remainders of small rocks and sharp objects pushed aside in order to protect the feet of the animals. The remains of wells and watchtowers are also found along dry desert routes (3).

Measurement and alignment

Roman measures were of course different then the present English system of measurements the following table is provided to allow conversions the reader to convert from Roman distance to modern distance.

Roman Mile = 1000 passus =1618 yds or 1480 m = 4854 ft

Passus ("pace"; pl. passus) = Closest Roman approximation to our yard or meter measurement = 5 pedes = 4' 10.25" or apx 1.48 m

Roman Foot= 12 unciae =apx 11.5" or 29.4 cm

Uncia (pl. unciae) = Roman Inch

It is known that Romans constructed many facilities that required a knowledge of angles and distances however, ancient literature is virtually silent on the subject of road surveying although there are reliefs on a grave markers that depict a Roman engineers with a gromas. (24).: The groma which is shown below. The groma is used to establish a straight line forward by sighting along a line established by the opposing vertical strings and a forward marker. At is also possible to establish a right angle to the forward line of sight and use offsets to carry the line around sight obstacles

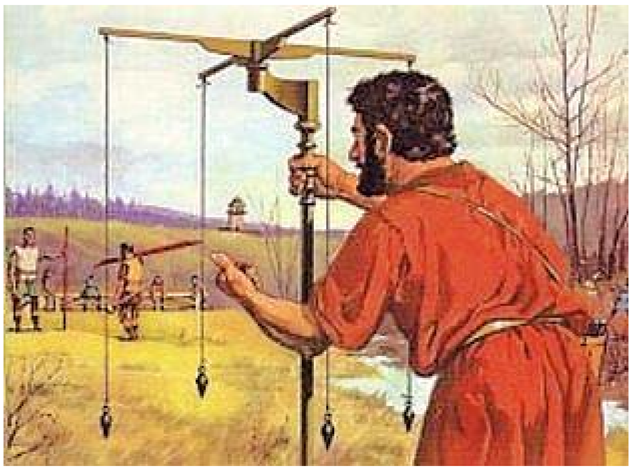


Figure 15 a gorma being use to project a line forward

European Period

After the fall of the Roman empire, Roman roads fell into disuse and wheeled vehicles more or less disappeared throughout Europe until they began to make a slow comeback nearly a thousand years later during the middle Ages. During this time period movement of goods and people were largely on foot or by pack animal and earthen tracks were sufficient. Bridges, usually the responsibility of the religious orders, were the main priority as water crossings were often hazardous. Tolls and public contributions were sometimes used to affect repairs.. By the thirteenth century with consolidation of national states the crown took over road responsibilities. The medieval states built roads much like the Romans with blocks cemented with mortar on sand foundations. There were also roads of gravel or broken stone on a sand base. (6)

The spread of private toll roads in the England and the construction of the state-managed network in France, together with an expanding postal service went hand-in-hand with a rapid growth in road transport during the eighteenth century.

Early in the nineteenth century, the technologies of the light high pressure steam engines stimulated the introduction of motorized road vehicles (see the figure below). Some were operating reliable scheduled services carrying up to eighteen passengers at average speeds of 25km per hour. As the service of these vehicles became more common the need for improved roads became apparent.

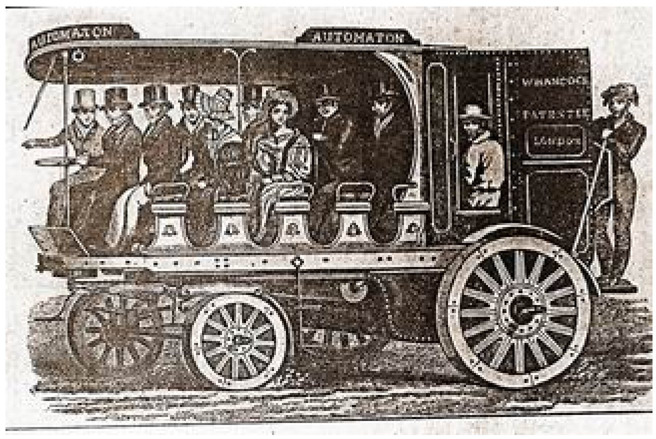


Figure 16 Steam powered vehicle of the mid 19 th century

During this period, people disagreed about how roads should be constructed and continued to use the Roman model. However, certain basic principles began to be enunciated. Around the middle of the 18 th century, Tressaguet in France and Metcalfe in England proposed a method of construction relying on a firm well-drained foundation of fitted large rocks topped by layers of progressively smaller ones, forming a convex surface allowing surface drainage making it more impervious to water.

Macadam at the beginning of the 19th century proposed a far more economical road section by getting rid of the large stones altogether and replacing them with much smaller sized stone. He still required good subsoil drainage followed by layers of relatively fine stones to keep the roadbed firm. This resulted in a road much thinner and cheaper to build. In fact he insisted that thickness should be dictated only by the need to protect the roadbed and keep it dry rather then to provide the high load bearing capacity. Macadam discovered that the best stone or gravel for road surfacing had to be broken or crushed, and then graded to a constant size of chippings.

American Period

Native American Trails

In the early days the Native North Americans did not have pack animals and walked from place to place. They did hunt so many of their walking paths were the same as the paths made by the animals that they hunted. Locations of Indian trails are hard to verify because the native tribes left no written records of their travels.

Sitting and Marking

Native Americans tended to avoid difficult terrain and as a result Indian trails generally followed ridges and drainage divides to minimize stream crossings and swampy bottomlands. When large creeks and rivers couldn't be avoided, the Indian trails often led to rocky shoals or shallows that could be easily crossed or safely forded.

As the trails became worn from human use, they were marked by Indians for future travelers. A broken twig served as a pointing finger; a stroke of the axe or blaze on a tree served as a signal to turn in that direction; a sapling bent across the trail was a warning signal; a stick in the mud meant that there was no bottom; and a feather on a bush or located along the side of the trail meant that there were friends ahead or nearby (13).

Records of trips by the settlers reveal that much of their travel followed established Indian trails. As such, the trails, together with the region's waterways, served as the earliest corridors of travel, communication, trade, and warfare.

Although the locations of many of the old trails are unknown, remnants of a few trails are known. The illustration below shows some known trails in the state of Michigan.

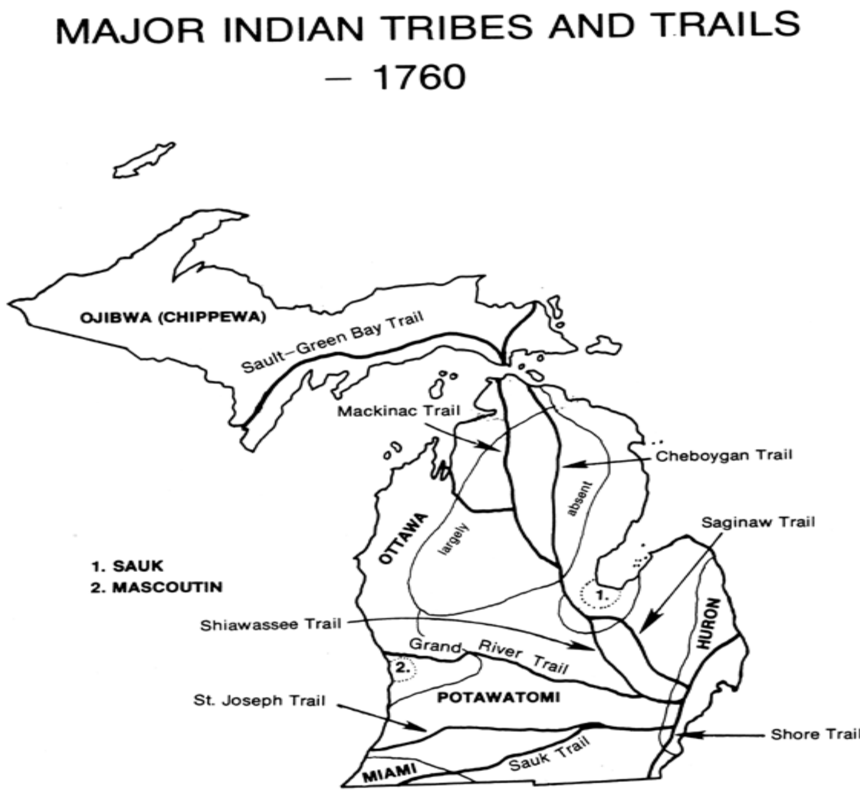


Figure 17 Indian trails in Michigan

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Early American road construction

Alexis de Tocqueville is best known for *Democracy in America*, which he wrote after spending 10 months of 1831 and 1832 in the United States In America, Tocqueville found that travel, particularly by road, was far more primitive than in Europe. For example, of a stage journey in New York, Tocqueville noted:
Trail infernal, carriage without springs . . .

Improvement to American roads came slowly and involved several unique practices and modes.

Plank Roads

Since mud or snow often slowed passage on even the best early roads, plank roads came into vogue for a very brief period.   Successful reports of plank road use in European countries created the opinion that they would be an improvement over the crude military and state road conditions. Plank roads were seen as a practical means for agricultural products to reach markets, since farmers could use their own vehicles and such roads were cheaper to construct than railroads.

Plank roads were typically constructed of wood planks two inches thick and eight feet long, which were nailed to four-inch-square stringers at a 90-degree angle. Tolls were charged for traveling on the roads, usually one-cent per mile for single animal vehicles and an additional half-cent per animal hauling a vehicle. A typical drive from Milwaukee to Green Bay with a team would cost $3.78. (18)

To help finance road construction, private turnpike and plank road companies were chartered and organized. The earliest plank road to be chartered and surfaced in Wisconsin was built between Lisbon and Milwaukee in 1846. Between 1852 and 1871, there was a gradual decrease in charters granted, and plank roads eventually fell out of favor, in part, because they did not prove to be as profitable as had been expected. Stock company dividends were small and irregular, and actual operations of the plank roads revealed that the surface decayed badly in five or six years, making it hazardous for travelers and costly to repair. Rather than make necessary costly repairs, many owners abandoned the roads. .

Stage Roads

Stagecoach service began as road networks were extended from town to town across the states and were available during the early colonial periods. In the book, **John Adams** ( ) it is noted that Abiligail Adams made the trip from Quincy MA to Philadelphia (340 mi) in a two week period.

The stagecoach reached its height of popularity during the period of private turnpikes and plank roads. Numerous stage companies obtained franchises and provided regular service throughout the States.

The majority of stage companies had obtained contracts from the federal government for transporting the US mail in addition to passengers and freight.

As the stagecoach system gained popularity, it expanded into all areas of the state. Stagecoach service remained an important secondary link to more remote areas of the state until the late 19th century, when the expanding railroads offered faster and more comfortable travel to extended areas of the state.

The stage route shown below might be considered typical. Note the gravel surface, curves and the “road side barriers”.

Figure 18 Western stage road

Modern Highways

Around the beginning of the 20 th century the design of roads began to be put on a more engineered basis. Particularly with the advent of the Bureau of Public roads (1919) and the advent of the American Association of State Highway Officials (1914) standards of practice began to be published and engineering concepts were incorporated into the road building process. Alignment, cross section and traffic control all be came subjects of interest to the highway engineer. This evolution has continued to the present time and present day road design is becoming more of a science and less of an art as time passes aon. The figures below show the progress of American roads from the early 20 th century to the present. Discussion of the design principals of modern roads is a far reaching subject and is the subject of many publications and text,

Figure 19 Dirt, and muddy, roads were still common in the 1930s.

It can be seen that the highway above is not exactly modern in the 21 century sense. It doses show straight but rolling alignment and very little consideration for drainage of the cross section. From this beginning modern highways advanced to include more extensive design consideration as shown in the freeway section below. However this section has many shortcomings when compared with present design in particular related to the cross section and the lack of shoulders and guard rails.

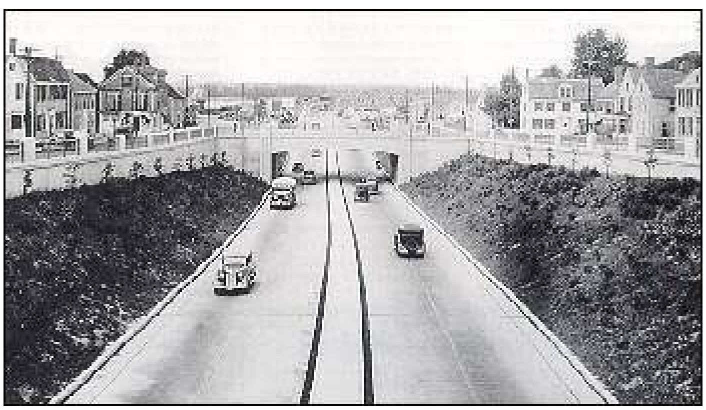


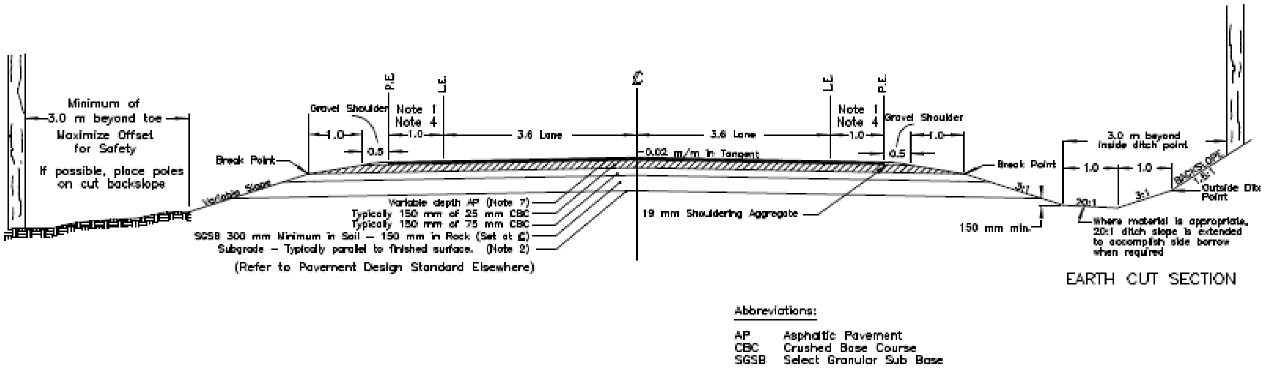
Figure 20 Early freeway in Mass., circa 1935, showing access control.

The existence of 21 century roads illustrates the departure of the road from alignment and cross section design to the emphsis on road side elements, ascetics and safety considerations as illustrated in the section of Wisconsin route 23 shown belown.

Figure 21 Modern rural highway

Where we are at present in the road design business is available from any state road agency. They have standards and practice for the building of the present system. It is interesting to compare the present with the past practices as described above to see the commonality and difference. Roads are still economic generators d they were in early times. They still provide access to between cities as before and they still provide military purposes as in the days of the Roman empire

The End



Notes:

1. The shoulder may have to be widened for a Shoulder Bikeway
2. -0.03 or -0.04 m/m is used in earth to facilitate drainage, when directed by Geotechnical Branch.
3. For rock ditch details, refer to 440.C
4. For roadside barrier, 1.3 m is required to the barrier face.
5. These are typical gravel depths to be used in the absence of geotechnical investigation.
6. Design Speeds 50 - 80 km/h.
7. Typically Type 'B' or Type 'C' Pavement Design.
8. Fill slopes should be as flat as possible and no steeper than 1.5:1. Desirable is 4:1 or flatter.

Future Roads

What will be the future road and how will it look and where will it be different from the present. It is certain that new materials will be developed , new modes of transport and new construction practices will emerge The answer to some of the this question can be obtained from some insights into future road designs provided by the federal highway administration and its interest in automatic highway systems (AHS). AHS is usually considered in terms of the roadway, vehicle and driver. Each of these components has some areas that are being studied as summarized below

What can AHS offer in the near term?

While fully automated highway systems may be several years or decades away, many applications are already road-ready or near ready. These include:

- **Adaptive Cruise Control** that senses vehicles ahead/behind and alters speed accordingly.
- **Obstacle/Collision Avoidance** that detects obstacles/other vehicles in the road and safely adjusts course.
- **Lane Keeping** with sensors that track markers in/on the highway, ensuring that the lanes are followed precisely.

Demonstration Scenarios

The NAHSC participants are working together to show the world what the future of highway travel might be. These scenarios are not a prototype for a final AHS, but they are a look at the capabilities and potential benefits of AHS to solve mounting traffic problems, such as decreasing safety and rapidly increasing congestion.

Free-Agent, Multiplatform Scenario

Vehicle-based AHS technologies used across different vehicle platforms and to demonstrate the potential of automated vehicles operating in non-automated traffic. Using two buses, one Oldsmobile Silhouette minivan, and one Pontiac Bonneville, the scenario will showcase full automation, obstacle avoidance, and collision warning and will demonstrate an automated lane change and an operator/driver interface.

Platooning Scenario

The cars will travel in a single-file formation guided by magnets embedded in the roadway. As a group, they will accelerate, decelerate, and perform a coordinated stop (to avoid an obstacle). The platoon will split to allow other vehicles to enter and then rejoin as one platoon. Drivers will receive vital information such as vehicle speed, current maneuver, and distance to destination via a head-up display designed by Delco Electronics.

Maintenance Scenario

Using the Infrastructure Diagnostic Vehicle (IDV) and the Debris Removal Vehicle (DRV). IDV, developed by Caltrans, Lockheed Martin, and the University of California at Davis, will be equipped with autonomous lateral control equipment and conventional cruise control for automated driving. IDV will also be equipped with diagnostic equipment to conduct monitoring, physical inspection, and preventative care to preserve the integrity of the AHS infrastructure. These maintenance operations will be performed while traveling under automated control at highway speeds. The DRV, developed by Pick-AII Inc., will demonstrate the automatic removal of debris from the AHS lanes.

Control Transition Scenario

In this scenario, Honda R&D will showcase two approaches to automated highway systems — an infrastructure-supported approach and an independent vehicle approach. Honda's two prototype "AHS Accords" will transition between these two approaches (infrastructure-to-vehicle communications and vehicle-to-vehicle communications) as they demonstrate platooning, automated lane changes, automated start and stop, and obstacle detection and avoidance. The use of multiple sensor systems will demonstrate the concept of back-up technology for better performance and reliability.

Alternative Technology Scenario The Ohio State University will use one manually driven car and two automated cars to show an automated vehicle pass a manually driven car in this scenario, which highlights an additional technology for lateral control. About 6.5 kilometers of the HOV lanes are equipped with radar-reflective tape produced by 3M. This tape (versus the magnets used in other scenarios) and a single camera-based vision system will be used for lateral control. An Eaton Vorad low-powered radar will be used for side vehicle detection and a laser system will be used for longitudinal control.

Evolutionary Scenario
This scenario will showcase the evolution of vehicle automation. Toyota, in conjunction with the Toyota Technical Center, IMRA, and AISIN, will use existing highway infrastructure, two concept automated vehicles — based on the Toyota Avalon — and two non-automated Toyota Camrys to consecutively demonstrate lane-departure warning, obstacle-detection warning, blind spot warning, longitudinal control using Intelligent Cruise Control, automated lateral control using vision system, obstacle avoidance using laser detection, and automated lane-change maneuvers.

http://www.tfhrc.gov/pubrds/july97/demo97.htm

The future is before us and how will we be traveling in that time? I suggest that in the short term highway travel will be pretty much as it is at present. New roads will be limited in development but there will be increase throughput by improvements in traffic control.. Safety will also be a major consideration in the near future and will provide motivation for many spot improvements in the present system. In the long term there may be many discoveries that are not envisioned at this time however some of the items below will certainly become common place as the present increase in on vehicle navigation is showing.