The History of the US Interstate Highway System 1960-1990

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The development of the US Interstate Highway System was the largest civil engineering project in the world with a final cost of $110 Billion; its development was driven by political and economic factors, within American society, and also at the international level in the context of the Cold War between the US and the Soviet Union. The Interstate System had a major social, economic and cultural impact on American society.

Limited Access Roads in the 1920s/1930s

A number of limited access dual carriageway roads were built in the US during the 1930s and 1940s. The Pennsylvania turn-pike was the first high speed highway in the US, which would eventually become Interstate 70. In New York City, the Holland tunnel (1928) was built in as the world's longest ventilated tunnel, while the Queens to mid- town Manhattan tunnel (1940) was constructed based on the latest innovations in tunnel construction. These were the early experimental tunnel projects to connect Manhattan to the outer boroughs of New York which would form the basis for further tunnel development during the interstate programme from the 1950s onwards.

As early as the 1920s, the Michigan State Highway commission utilised T Beams for the construction of highway bridges on an experimental basis which would be further developed within the interstate programme in the 1950s. It is interesting to note that the use of shallow truss decks and riveted plate girders for bridge construction during the pre-war era would be superseded in the post war era by newer construction methods to facilitate greater span construction for highway bridges and greater structural integrity. The Tacoma Bridge collapse in 1941 was an influential event in transitioning from the discredited shallow decks to deeper stiffened decks.

The genesis for the creation of the Interstates was the end of the Second World War, when the Supreme Commander of the Allied Forces, Dwight D Eisenhower saw the German Autobahn system in 1945 which influenced his thoughts towards the creation of a similar controlled access, dual carriageway highway system in the US.

When Eisenhower became President in the 1950s, he facilitated the introduction of the 1956 Federal Highway Act which was the legislative framework behind the creation of the Interstates. The economic benefit associated with the creation of the Interstates was not the only motive behind their creation. In the context of the Cold War, the Interstates were viewed as advantageous in defence terms for rapid deployment of military forces to either the Pacific or Atlantic coasts and for possible evacuation of cities in the event of a war with the Soviet Union.

The key themes across all the Interstate projects are construction risk, engineering innovation and knowledge sharing and the relationship between highway engineering and society.

The construction risks associated with the Interstate projects reflected the challenging geography of the US in terms of building the Interstates through: the Rocky Mountains, the Colorado Plateau and the Sierra Nevada Mountains in the West; the soft delta areas of the Mississippi River in the South and the large urban areas on the East and West coasts.

The construction risks were addressed through engineering innovation in the areas of tunnelling, bridges, elevated viaducts and piling. The highway in society theme linked to the economic development which the interstates facilitated but also those political, economic and environmental factors which influenced the design and construction of the Interstates in particular ways to protect existing community area and environmental features from adverse impacts.

Interstate 95- The key Transport corridor for the East Coast

The original cities of the US on the East coast created the demand for an efficient transport link on the Atlantic coast given the more widespread use of cars and heavy vehicles in the post war boom period in the 1960s. The East coast corridor contained 70 million persons in the cities from Boston to Washington DC to Miami and accounted for one third of all economic activity in the US economy.

Between New York and Washington DC there were a number of key interstate projects which contributed towards the development of Interstate 95 linking from Maine down to Florida along the Atlantic Coast. The Baltimore to Philadelphia section of Interstate 95 reflected the post war thinking in the geometric design of roads in North America and Western Europe in terms of: broad horizontal curves with minimum radii of 700 metres; maximum vertical gradients of 4% that would be more acceptable to road users; and a wide median within the interstate cross sections for safety purposes and future upgrade needs. Interstate 95 was opened on 14 November 1963 by President John F. Kennedy which reflected the important political and economic factors influencing the development of the Interstate in the 1960s.

Further north, Interstate 95 was routed east of Philadelphia in the dock area of the city known as Penn's Landing, the original landing area for European immigrants during the 17th century. The original proposal by the Pennsylvania Highway Commission was for an elevated section of roadway at Penn's landing however a coalition of planners and architects objected to the proposal based on the detrimental visual impact of such a proposal. The engineers subsequently revised Interstate 95 to an at grade vertical alignment which addressed the concerns but which nevertheless had a dramatic impact on the residential and community buildings in this section of the city, effectively bisecting the residential areas at the harbour.

At the technical level, the development of Interstate 95 on the soft coastal ground at Penn's landing required piling however the close proximity of the city water supply to the city sewer outfall pipe, which had contaminated much of the ground in the area, required an innovative solution to prevent ground disruption which might contaminate the city water supply pipe. The engineering solution was the installation of cylindrical metal tubes into the contaminated ground which were then cleaned out through the removal of all ground material. The piles were then driven into the empty cylindrical tubes. The solution insured that vertical stresses were avoided during the pile installation phase which might have otherwise caused disturbance of the underground services.

The complex Federal –State relationship delayed completion of Interstate 95 at Philadelphia as the Pennsylvania State legislature had refused to pass federal emission limits legislation which led to a withdrawal funding for Interstate 95 which only resumed once the Pennsylvania State legislature has passed the federal legislation.

A section of Interstate 95 north of Philadelphia was never completed due to the objections of the politically powerful community of Princeton which illustrated the influence of political lobbying on the routing of the Interstate system. The completion of this missing link of Interstate 95 will be finally completed as part of the current interstate upgrade programme.

A good example of innovation on Interstate 95 was the Fort Mc Henry Tunnel at Baltimore Harbour which was completed in 1985. In order to relieve the existing tunnel which had to accommodate 120,000 vehicles per day, the second tunnel was proposed. The engineering technology for the tunnel was immersed tunnel segments which were given added complexity given that the geometric alignment of the Fort Mc Henry Tunnel, which changed not only in the vertical alignment but also in the horizontal alignment too. A key innovation in the tunnel was the use of white paint on the surface of the pavement and high powered lighting to avoid the ‘dark tunnel effect’ at the entrances of the tunnel which would otherwise have created sudden braking movement by road users.

Other interesting features on Interstate 95 include: the Robert Prowse memorial Bridge which incorporates continuous steel beams to replace the pre-war use of riveted plate girders; and the reduction of the dual carriageway to a single carriageway cross section on Interstate 95 in Franconia Notch Park (New Hampshire) in order to preserve the national park features.

The late Irish engineer Dick Burke worked on the design of Interstate 95 with US Consultants in New York during the early 1960s and he subsequently used this experience to lead the design team on the M7 Naas Bypass, Ireland’s first motorway, in the 1970s.This illustrates the international knowledge sharing in relation to geometric design in terms of the influence of the Interstates on the Western European motorway network and vice versa.

Interstate 75- Michigan to Florida

In parallel with Interstate 95, Interstate 75 was another key north south route on the other side of the Appalachian Mountains from Michigan south to Florida. I75 served the seasonal tourist traffic to Florida. The planning for I75 in Florida was influenced by the community objections in Miami against the proposed route terminal point near the city. The peninsula geography of Florida limited alternative route options for I75. The alternative route for I75 was eventually located further north of the original route which addressed community concerns regarding the proximity of I75 to Miami however the new route had to cross a wetland national park called Alligator Alley. The design of the road features included large culverts and animal underpasses to maintain adequate water flows and access for wildlife in the national park.

Further north on I75, the twin peninsula geography of Michigan near the Great Lakes required the design and construction of the longest suspension bridge in the US to link the peninsulas. The Mackinac Bridge was designed to account for low temperatures and high speed winds in the area; the bridge was designed to sway 8 metres in high wind conditions. The foundation for the Mackinac Bridge was constructed to penetrate 210 feet into the bedrock under the lakebed.

Other interesting features on interstate 75 in the State of Michigan include: the Dunbar Bridge constructed from T Beams in 1955 which reflected the more widespread use of T Beams within the Interstate programme in this period; and the construction of the Rouge River Bridge (1967) and Zilwaukee bridge (1988) which had high clearances over the water surface (35-40 metres) to enable marine shipping passage.

Interstate 10 on the Gulf Coast

The central region of the US commonly referred to as the Mid-west was served by key east –west interstate routes such as Interstate 10 along the Gulf coast in the south and Interstates 70, 80 and 90 further north.

Interstate 10 linked the southern states of Florida, Mississippi, Alabama, Louisiana onto the Midwest states of Texas and New Mexico. The design of I10 in the soft ground conditions of the Mississippi River delta required innovative engineering solutions. The I10 was located on an elevated viaduct carried on piles driven into the Atchafalaya Swamp, near the Mississippi River delta. The Atchafalaya Bridge was 26km in length. The contractor responsible for the construction of the Atchafalaya Bridge was Boh Brothers, a contractor with extensive experience in piling. The precast segments were sailed into place via the network of canals within the Atchafalaya Swamp and lifted by crane into place on top of the piled columns. The Atchafalaya Bridge was completed in 1973.

Further west along the I10, there were opportunities for the engineers to reduce the costs of the Interstate 10 project. The very low traffic volumes on I10 in west Texas, in an area mainly used for cattle ranching, meant that the junctions could be designed as at- grade junction given the very low likelihood of accidents. In terms of pavement type, I10, like most Interstate, was a concrete pavement type based on slip form concrete construction. This pavement construction method was also used by Belgian engineers in the construction of the auto routes in Belgium which illustrated the theme of knowledge sharing in road design and construction between the USA and Europe.

One of the most interesting sections of the Interstate system was Interstate 70 in Colorado and its connection to Interstate 15 in Utah. Three of the top five engineering innovations of the entire Interstate system are located along this section of highway reflecting the challenge of building Interstate 70 through the Rocky Mountains and the Colorado Plateau.

Interstate 70- Engineering Highlight of the Interstate System

The Eisenhower Tunnel on I70 is one of the engineering innovation highlights on the Interstate system. The tunnel was designed to traverse through the Rocky Mountains which effectively divided Colorado during the wintertime. The twin bore tunnel was constructed at 11,000 feet above sea level. The eastbound bore was initially developed as a smaller pilot bore to obtain geological data for construction of the westbound bore. The geological data indicated that the rock at the tunnel was extremely hard. The harsh working conditions, at 11,000ft, required shift working by a large work team to excavate the 500,000 cubic metres of rock to construct the tunnel. The technical problems associated with collapsing of the rock face in the tunnel required 190,000 cubic metres of concrete facing to hold the tunnel rock face in place.

The water inflow from the rock face of the tunnel required a drainage system to accommodate 300 gallons per minute and the engineers designed a drainage system to accommodate 500 gallons per minute. The ventilation requirements for the tunnel was based on empirical data from emission testing of vehicles within the tunnel , which stipulated the provision of 1.6 cubic feet of air per minute to address the higher emission levels of vehicles at the higher elevation of the Eisenhower Tunnel. The westbound tunnel was opened in 1973 and the eastbound one was finally opened in 1979 at a total cost of 490 million.

The Colorado State Engineer in charge of construction of the Eisenhower tunnel was Charles Schumate. Interestingly Schumate had no engineering qualification having worked his way from chainman up to the position of state engineer. The Colorado State legislative actually had to change the law regarding the education requirements for the position of state engineer to facilitate Schumate's appointment.

Another engineer, Janet Bonnema, was refused permission to work within the tunnel on gender grounds and subsequently took a legal action against the Colorado Highway Commission to enable her to work within the tunnel. Schumate , the Colorado State Engineer, eventually granted permission for Bonnema to work within the Eisenhower Tunnel which led to a strike by the male workforce however most returned to the tunnel works to work alongside Bonnema.

These events reflected broader societal changes taking place in the US during the 1960's which would change and influence perceptions of highway engineering as a 'male-only' working environment towards a more diverse profession.

Interstate 70 - Glenwood Canyon section

Further west along I70 was the Glenwood Canyon section, where the route had to be accommodated within the vertical faced canyon of the Colorado River which narrowed to 150m at certain points. The Sierra Club and Colorado Open Spaces environmental groups brought a legal challenge to stop construction of I70, although the court did not stop construction of the route it did place restrictions on the construction methods within the canyon. The river had to be diverted twelve times to incorporate the I70 interstate cross section into the canyon particularly to preserve trees cutting for the roadworks. The construction works were completed by a consortium led by Kiewit construction, a contractor with expertise in canal and dam construction. At particularly constrained locations within the canyon, the opposite carriageways had to be located vertical relative to each other through the use of elevated viaducts based on slip form cantilever construction where the viaduct section is constructed from the top of the support column in a segmented manner. The cantilever construction method avoided impacts on the canyon floor and river. The Interstate engineers were briefed on this construction method, a first of its kind in the US, by French engineers which illustrated the highway knowledge sharing relationship within the North Atlantic region at the time.

Interstate 70 - Green River Valley section

Further east the I70 traversed Green River Valley in the State of Utah. This section was an interesting example of how geology influenced the road cross section. Such was the scale of the earthworks required to traverse the valley, it was decided to adopt a single carriageway road cross section to reduce rock excavations to 3.5million cubic metres. In 1990, the I70 cross section at Green River Valley was upgraded to a dual carriageway section to meet traffic demand.

Interstate 15- Virgin River Valley

At the western terminal point of I70, it connects to a key north- south interstate-Interstate 15 which has a key role in linking the Midwest interstates, I70, I80 and I90 to the western coast of the US. Interstate 15 was the route of the old Spanish trail through the Virgin River Valley. Like the Glenwood Canyon section, the dual carriageway road section was constructed in a manner to meet environmental protection requirements. The solution was to avoid visually inappropriate embankments or cuttings and opt instead for elevated viaducts for fill sections and retaining walls for cutting sections. Rock cuttings were engineered to incorporate a natural visual appearance. Kiewit Construction was also involved at the Virgin River Valley section of I15 and used their expertise to divert the Virgin River many times to facilitate construction. The innovative design and construction of I70 and I15 reflect the difficult topography and geology of the Rocky Mountains and Colorado Plateau. The routes were completed by the mid 1970's. The demand for these routes was driven by the new industries of the Sun Belt states (California, Arizona, New Mexico and Nevada) during the 60's/70's which included the aerospace, electronics and defence sectors. The new industries required year round access from east to west for commercial reasons and this illustrated the economic and social factors which influenced on the development of the interstate system.

The development of the Interstates in the Central, Mid-west states of the US included specific measures to protect heritage features. The development of Interstate 80 in Nebraska crossed the 19^{th} century pioneer wagon trails which required additional lands for the road in order to locate the route away from the "overland trail ruts". This heritage preservation initiative within the interstate construction programme indicates how the interstate highway engineers took account of heritage and environmental features when locating the interstate routes.

Another geographic constraint in the Western US was the Sierra Nevada Mountains in California. The east-west I80 crossed the Sierra Nevada at Donner Pass, scene of much tragic loss of life due to harsh weather conditions. The design of Interstate 80 won a 1964 ASCE (American Society of Civil Engineers) award for its innovation in matching geometric design to the mountainous topography of the Sierra Nevada Mountains. The I80 Donner Pass enabled year round access through the mountains. Today a comprehensive winter maintenance regime is required in terms of snow removed and gritting to maintain winter access through the Donner Pass.

Further North, Interstate 90 crossed a similar mountainous terrain through the Cascade Range at Snoqualmie Pass in the State of Washington. Like the Donner Pass, winter maintenance is an important element to maintain access through Snoqualmie Pass in wintertime. The design of the Falcon Falls and other viaducts at Snoqualmie Pass by cantilever construction methods ensured minimal disturbance to the environment landscape of the Cascade Mountains. The viaducts were constructed with hollow box units to enable access to monitor and reset the seismic adjusters within the viaducts which accommodated movements associated with seismic events.

Interstate 5 on the West coast

The Key North South interstate on the west coast is Interstate 5 constructed in the 1950's and 1960's. The development of Interstate 5 in the Sun Belt States reflected the westward movement of the population within the US over the 20^{th} century as developments in ventilation technology made these warmer regions more attractive to live in from a lifestyle perspective.

The development of I5, while welcomed in southern California, home of the new industrial zones associated with the emerging aircraft and electronic engineering sectors; however it was viewed in less beneficial terms in the older northern states like Washington and Oregon. The challenge of building I5 through Seattle centred on the difficulty of building west of Seattle, due to the mountains and coast estuary on the west side of the city, and also to the east, due to mountains and lakes on the east side of the city. The only route option for Interstate 5 was straight through the centre of Seattle which inevitably led to political protests. Interstate 5 was eventually built through the centre of Seattle, which had a dramatic impact in terms of separating residential communities from the business districts. The long term consequences of this project was a series of legal challenges by residents against further interstate developments, some of which were literally stopped during the construction phase. The Interstate 5 case in Seattle illustrated the challenge for the interstate engineers in terms of delivering high quality transport systems with the necessary political support while also minimising environmental damage. The often heard criticism of the Federal interstate programme was that the interstates were located through the poorer and ethnic community areas and not in these areas where the middle classes resided as the earlier case of Interstate 95 at Princeton demonstrated.

Lastly at a cultural level, the interstates were widely utilised by drivers and transportation companies and linked to the American philosophy of westward expansion and opening up new possibilities. However the criticisms of interstates focused on their role in the “Blanding of America”, according to one critic, one now could drive from coast to coast along the interstates without seeing a single thing.

Conclusion

In conclusion the US interstate system was developed as the longest and largest civil engineering project in the world which coincided with the post war role of the US as an emerging global economic superpower. The lessons learned included, the incorporation of environmental protection features by engineers to meet political and environmental demands. These measures included the provision of tunnels and viaducts to negotiate significant topographical features and the routing of interstates to avoid residential areas. In construction technology terms, there was more widespread use of T Beams and continuous steel beams in standard bridges on the interstate system in the post war era with continuous steel beams replacing the riveted plate girders which were used in the pre-war era. For long suspension bridges, there was a shift back to deep stiffened trusses with slender support towers which addressed the oscillation problems associated with shallow decks in the pre-war era.

Public opinion had a strong influence on the development of interstate routes particularly near urban areas or environmental and amenity areas. The interstates developed within a time of rapid growth in the US as it adapted to its new global political and economic responsibilities which drove interstate development at strategic level, however their practical implementation has to address those practical, local concerns that are inevitably always associated with highway development worldwide.