

## A Short Historical Review of Concrete Roads and its Challenges in Brazil

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The first paved road recorded in Brazil, Calçada do Lorena (Lorena's Sidewalk), was built about 1792 under the command of engineers from Lisbon Fortification School, following typical ancient Roman practices: carved stones over gravel base (Fig. 1). The function of the road was to ensure accessibility year round in a region with rainfall more than 3,000mm per year. Built under the request of sugar cane producers in São Paulo, this road served as the connection between São Paulo Province and the harbor of Santos.

The first concrete road in Brazil (also the first in South America) was built in 1926 at the same site of Lorena's Sidewalk and was named the "Caminho do Mar" (Sea Way) road. This road passed through the hills of Atlantic rain forest, linking São Paulo city to the shore region of the state (Fig. 2). This 8km long, 2-lane concrete road was paved with concrete mixed in place using rudimentary concrete mixer moving over rails. The steep longitudinal slope of 7% presented some challenges to the paving operation.



**Fig. 1.** View of Lorena's Sidewalk (pictured in April, 2007).



**Fig.2.** View of Sea Way (pictured in April, 2007).

The year of 1928 was another milestone in Brazilian concrete road construction when the hill segment of the roadway linking Rio de Janeiro to the city of Petropolis, also in the Atlantic rain forest, was re-constructed. Originally paved with asphalt, the hill segment, 22km long, 2-lane concrete road with shoulder was completed in 1931. It was considered the best road in Brazil at that time for many years. The construction of these concrete roads was emblematic in a period when most of urban streets and roads were paved using hydraulic macadam with thin asphalt surface layer.

The Sao Paulo Highway Department was created in 1934 with a committee formed at the same time, in charge of design and construction of the first two highway concrete pavements in Brazil. The committee visited Germany and Italy to learn modern European concrete road design and construction techniques. In 1938, the construction of the first highway, "Anchieta Highway", in the country began. The highway was named in a tribute to the Spanish Jesuit priest José de Anchieta, founder of São Paulo Village in 1554. The geometric and pavement designs followed those employed in the "autobahnen" in Germany. Construction was completed and the highway opened to traffic in 1948.

Because of incompatibility between climates in Northern Europe and the Tropical Rain Forest in Brazil, this first concrete highway presented huge maintenance challenges. In Germany, most of the highways were constructed in dry climate areas with less than 1,000mm of annual precipitations. Typical pavement structure consisted of 200mm slabs over sand bases. The technology was adopted in Brazil during the Second World War period and was employed in constructing the Anchieta Highway. At the time, it was very expensive to use dowel bars for joint construction. To minimize potential of joint faulting, the concrete slabs were supported by transversal beams under the joints with compacted sand base between the beams (Fig. 3). With heavy precipitations year round, the sand bases, built in roads on hilly arrears with steep slopes, were soon pumped out under traffic with water flow, leaving slabs supported only by the transversal beams. Transverse cracking occurred soon after construction and the concrete pavements were eventually overlaid with asphalt surface.

A state road located in Pernambuco, northeast of Brazil, linking Recife and Caruaru was constructed in 1938 with some innovative designs. It was the longest concrete road and slabs were built with thickened edges (170 mm thick in the center and 220mm at edges). This concrete road was recently upgraded (2003) with the addition of two traffic lanes and shoulders. The new concrete pavements consisted of 220mm slabs over 100mm RCC base, representing the record of concrete pavement construction in the country.

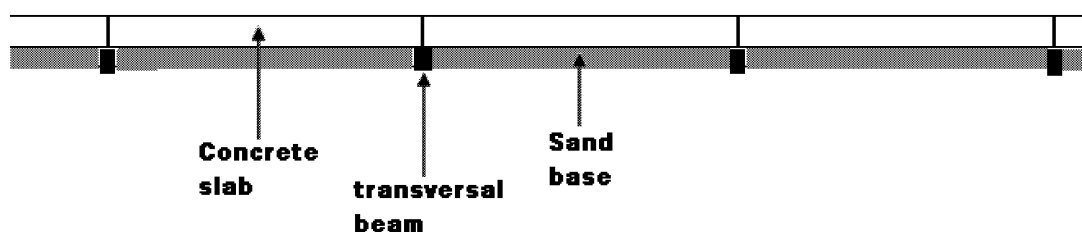


Fig. 3. Typical PCC Section in Anchieta Highway, 1938-1948.

In 1974, the Immigrants Highway was constructed in the same area and parallel to the old Anchieta Highway. The 13-km concrete highway, passing through hilly areas, tunnels and bridges, was considered the most modern highway in the country until recently. During construction, quality control was provided by Switzerland engineer Prof. Willy Wilk. The original pavement design consisted of 220mm concrete slabs over 100mm cement treated crushed stone base and 100mm crushed stone subbase. In 2004, thirty years later, the first extensive rehabilitation works were carried out and only 6% of the original slabs were replaced, representing the most successful concrete pavement construction in Brazilian history. This highway was improved again recently with the addition of three lanes and shoulders. Most of the pavement was in tunneling construction with concrete pavements (240mm PCC over 100 RCC).

Again in the same area and parallel to the old Anchieta Highway, the Immigrants Highway was opened, with 13km crossing the hills in concrete pavements, tunnels and bridges, considered until recently the most modern highway in the country. Control quality expert consulting services was provided by the Switzerland engineer Prof. Willy Wilk expertise during its construction. The original pavement design was 220mm concrete slab over 100mm cement treated crushed stone and 100mm crushed stone base and sub-base, respectively. In 2004, third years later, the first extensive maintenance works were carried out and only 6% of the original slabs were full replaced, making the most successful case in the Brazilian concrete pavement construction. This highway was improved recently with other three lanes and shoulder, most of the new segments in tunneling construction with concrete pavements (240mm PCC over 100 RCC).

When properly designed and constructed, concrete pavements are generally expected to last a long time with minimum maintenance required. However, poor construction or designs would result in early failures. Historical reviews revealed that, in Brazil, deficient operations in concrete curing and joint sawing are the main causes for premature concrete pavement failure. After decades of research and development, design methods based on sophisticated numerical tools and field pavement performance data have been developed filling the gaps of concrete pavement technologies. The new design method for urban highways and buses corridors was issued in 2004 by the Sao Paulo City Public Roads Department. Among other factors, the new design procedure takes into account thermal stresses and concrete fatigue transfer functions developed for Brazilian conditions.

Monitoring field concrete pavement performance and modeling its behaviors with analytical tools have become essential elements in developing ore consistent and reliable design methods as well as for providing appropriate maintenance and rehabilitation strategies. This has been one of current focuses for Brazilian concrete pavement engineers. Another emphasis has been the concrete pavement recycling to promote "Green Concrete Roads" concept. One challenge facing today's concrete pavement community in Brazil is the slownwss in standardization of concrete pavement. Technologies and guidelines of quality controls during construction, such as concrete curing, materials selection, timing of joint sawing, etc., need to be developed for consistent concrete pavement conseruction.