The Granitoid Concrete Pavement of Calumet, Michigan - Over One Hundred Years of Service

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ABSTRACT
In 1906, the village of Red Jacket, Michigan (present day village of Calumet) constructed over 1½ miles of street with granitoid concrete blocked pavement, some of which is still exposed at the surface and in service today. Historical records about the construction and the results of a laboratory analysis of a core from the pavement are presented. The durability of this concrete is remarkable since it was constructed without air entrainment in a severe freeze-thaw climate. The granitoid pavement of Calumet has long outlived the major paving material competitor of its day: creosoted wood block pavement.
INTRODUCTION
At the dawn of the 20th century the village of Red Jacket was thriving economically due to the booming copper mining industry. With the Industrial Revolution underway, the demand for copper was high. In 1906, the Calumet and Hecla Mining Company, a large local mining company, made a profit of nine million dollars (1). That same year, a major public works project was undertaken to pave most of downtown Red Jacket. Both creosoted wood block pavement and granitoid concrete blocked pavement were used for the project. Presently, only a small portion of the original pavement is still in service and exposed at the surface: the granitoid pavement in the vicinity of the intersection of Portland and 7th Streets. Figure 1 shows a photograph taken in 1956 of a sign erected on the southwest corner of Portland and 7th Streets to celebrate 50 years of service of Michigan’s oldest concrete pavement (2). This followed an earlier dispute within the state over the rightful designation of the state’s oldest concrete pavement (3,4,5,6). The next year in 1957, a carefully-worded historic marker was erected in Detroit to recognize the “World’s First Mile of Concrete Highway” a stretch of pavement constructed in 1909 on Woodward Avenue between Six and Seven Mile Roads, pavement that was replaced in 1922 when the street was widened (7,8). To this day, ambiguity remains in the State Historic Preservation Office’s description of the Red Jacket pavement, which is listed on the State Register of Historic Sites, but is described simply as “among the oldest extant concrete pavement in Michigan” (9). In 2006, the Village Council of Calumet granted permission to retrieve a core from Portland Street to commemorate 100 years of service. This paper presents findings from the analysis of the core, and findings from a review of historical documents related to the construction.

HISTORY

Bidding

On January 26th, 1906, the Village Council of Red Jacket advertised for bids for the paving of streets, the construction of concrete walks and combined curb and gutters to commence during the summer of 1906. On February 15th the council held a special session to consider the submitted bids for street improvement (10,11). Several paving materials were available to choose from, and the selection of the correct material was important to the Village Council members who took junketing trips to see examples of the various paving materials. Exactly which materials would be chosen by the village leaders was a source of much public interest, as the local newspaper, the Copper Country Evening News (CCEN) reported that “nothing but paving talk can be heard” (10). Materials available at the time included: brick, macadam, creosoted wood block, and concrete, (referred to as granitoid at the time). The fact that the public took interest in what material the streets were to be paved with was best demonstrated when a group of prominent businessmen petitioned the city that brick not be used to pave 6th Street (10,11,12).

FIGURE 2: USGS aerial photography from 1998 with overlays to show extent of the 1906 street improvement project, (left) and white arrows to show present day extent of exposed granitoid pavement (right).

In considering the merits of the potential materials, none received more press than granitoid. Granitoid was favored by the Village Council from the very beginning due to its low cost and durability (13,14). In addition to being well received by the Village Council, it was suspected that the more conservative businessmen would also like it because it had been shown to be a very durable material given that sections laid in Chicago eight years prior were still in good shape (13).

On February 27th, contracts were awarded to two companies to pave the majority of the town (15,16). These two companies were the R. S. Blome Company from Chicago and J. J. Byers, from Houghton. Blome was awarded the contract for paving most of the city with granitoid, while the remaining work was awarded to Byers who agreed to use creosoted wood block. The contracts were signed on March 1st (17,18) and surety bonds approved.
for the contractors on April 3rd (19). $125,000 worth of street paving and improvement bonds were approved for sale by the village of Red Jacket on April 9th (20). Figure 2 consists of an aerial photograph of downtown Red Jacket with overlays to show which streets were scheduled to be paved, along with which materials the streets were ultimately paved with.

Construction

Excavation, Subgrade, Curb and Gutter

With the contracts awarded and the choice of materials made, all the people of Red Jacket could do was wait until the weather improved to allow paving to begin. They would not have to wait long however, as construction was started by Byers on April 23rd, and by Blome on May 1st (21,22).

The citizens of Red Jacket reacted positively to the street improvement project. The local news reported favorably about the large number of summer jobs that would be created by the roadwork. On April 23rd, when reporting that contractor Byers had begun work, the CCEN stated that “It is likely the improvements will take up most of the summer and that a large number of men will be employed. The employment of many men will be welcomed in Calumet where so many at present are out of work” (21). Similarly, prior to commencement of work by Blome the CCEN reported that the work “will require many laborers,” and that “a force of laborers will be wanted” (23).

Construction began with the lowering of existing water and sewer mains to ensure that no damage would be done to the pipes during construction (21,24). Once the mains were lowered, trench excavation for conduits commenced, as the Village Council had passed a resolution that “all overhead wires in the village be placed underground this summer” (25). Aesthetics were very important to citizens of Red Jacket; when rumors spread that trees along 8th Street would be cut down to make way for construction, citizens “interceded with village authorities and engineer, and obtained a promise that the trees should remain” (26). According to the village specifications, all excavation was to be done by hand, except when rock was encountered (27). At least one instance of blasting was reported when a tree root was blown through a window (28). For conduit, 3” diameter paper pipes were used and concrete poured around the pipes. Approximately 45 manholes were placed along the conduit lines. The depth of the manholes varied from 6 to 10 feet. They were 4 feet in diameter, and built with two rings of brick to yield 8” thick walls. The tops tapered down to 2 feet in diameter, and had covers weighing at least 350 pounds (27). After the conduits and manholes were placed, the trenches were backfilled and graded. In sections requiring fill either sand, gravel, or stone were used, and compacted in 6” lifts. For cut sections, the only requirement was that organic matter be removed and that the subgrade be compacted. Concrete curb and gutter was placed on 6” of clean gravel or cinders. Six inch thick concrete foundations were installed for streets with railways (27).

Paving

Paving with granitoid began with the placement of a 5” layer of damp sand, gravel, or crushed stone atop the subgrade. After compaction, a 5¼” layer of concrete was placed. The village specifications describe the mix as containing 1 part portland cement, 3 parts sand, and four parts crushed stone (27). The specifications further state that mixing was to be performed, (by hand) on a mixing board. Sand and cement were mixed dry, and water added sufficient to make a stiff mortar, after which the crushed stone was added. Mixing continued, with the occasional addition of water, until all the stone was coated with mortar, after which the concrete was transferred by shovel and rammed into place. Before setting, the concrete was coated with a 1¼” thick mortar consisting of 1 part portland cement, and 1½ parts of granite screenings or sharp clean sand “thoroughly mixed and wetted to the proper consistency and carefully worked to surface brick shapes” (27). The timing of the placement of the mortar over the concrete as described in the specifications contrasts with a newspaper statement that “concrete is allowed at least two days to set before the granitoid is placed on it” (29). However, there may have been some confusion, as the same article describes a situation where the granitoid workers, (the workers placing the final mortar layer) “suspended operations for a few hours in order to allow the concrete men to catch up and keep the required distance” (29). Figure 3 shows drawings from a Blome 1910 patent of a pavement blocking device that traversed on rails and stamped the brick pattern into the mortar (30). Although no mention was made of mixing machinery in the specifications, the use of mixing machinery was mentioned in several newspaper accounts (31,32,33,34,35).
Paving with creosoted wood block began with a concrete foundation made in a manner similar to the concrete base of granitoid pavement, but with 7 parts crushed stone instead of 4. After moist curing for a minimum of 7 days, a 1” layer of sand was placed over the concrete, followed by the wood blocks, and leveled with a 5 ton roller. After leveling, expansion joints along each side of the street were filled with bituminous cement or pitch. Sand was then swept onto the surface of the blocks to a thickness of ¼” (27). Figure 4 shows a photograph of a wood block left over from the project. As the wood block paving operation was beginning in Red Jacket, problems were reported with a wood block paving project completed the previous summer on College Avenue in the nearby town of Houghton (36,37,38). The secretary of the Kettle River Quarries Company, (KRQC) manufacturer of the wood blocks, suggested that “the sand was swept off too soon, and in consequence the blocks were not given substantial time to settle” (37). Wood block pavements were understood to require adequate time for the sand “to work in between the blocks” as the “creosote which oozes out of the blocks in warm weather mixes with the sand and forms cement which welds the blocks firmly together” (38). Problems with wood block paving did not stop at College Avenue; the appearance of streets that had already been paved with wood block in Red Jacket was also causing alarm (39). The CCEN reported that a KRQC engineer responded to an urgent call from the Village Council and arrived on July 19th (40). In addition to the company engineer and the village engineer, a civil engineer from Minneapolis was called to investigate (40). Rumors were circulating that Byers might sub-let its contract for 6th St. to Blome (41). The three engineers met to discuss the problem and to decide whether 6th Street would be paved with wood block or not (42). On July 12th the Village Council voted unanimously to release Byers from its contract to pave 6th St. and give that work to Blome so that the important street would be paved in the more reliable granitoid (42,43).

Construction with wood block on 8th and Oak Streets was completed on August 9th, after some experimentation on the affected areas with the addition of different sands and creosoted oil, although problems continued to persist (31,32,44). Construction with granitoid was completed on September 29th (45). The CCEN had only good things to say about the R. S. Blome company, writing that the company “has done remarkably well,” and that “nothing but favorable comment is being heard on the way the R. S. Blome company has carried out its contract” (45,46) There was even talk of a public vote of thanks towards the Village Council for its handling of the project (47). During the time that Blome was hard at work paving sections of downtown Red Jacket, they received additional contracts from around the country. On August 8th, the CCEN reported that Blome had been awarded a contract for $200,000 to pave the town of Gary Indiana with granitoid (48). Likewise, over the next two months, Blome won additional contracts from the United States Government to pave parts of Washington, D. C. for $100,000, and several more to pave streets in Michigan City, Indiana and Chicago (49,50). The CCEN reported that “granitoid as a paving material is rapidly coming to the front in the country,” and that “Red Jacket is to be congratulated for securing it for some of its streets” (49). Many of these projects were advertised in a brochure published by the R. S. Blome Co. circa 1910, including images from the 1906 paving project, as shown in Figure 5 (51).
FIGURE 4: Creosoted wood paving block from 1906, from personal collection of J. M. Johnson, past coordinator of the Village of Calumet Historic District Commission, approximately 7” x 3” x 4” in dimension.

FIGURE 5: Southerly view of intersection of 6th and Elm Streets reproduced from circa 1910 advertisement brochure (51).
CORE EXAMINATION

A core was retrieved from the granitoid pavement of Portland Street in March of 2006. The core was photographed and cut into slabs. Figure 6 shows photographs of the core, and Figure 7 shows scanned images of a polished slab, both before and after treatment to enhance the appearance of voids and cracks. The two layers, mortar and concrete, can be seen in Figures 6 and 7. The stone and sand in both the mortar and concrete were from local trap rock mine tailings. The tailings originated from Late Precambrian Keeweenawan basalts, although the basalts likely came from the Calumet and Hecla Lode, a sedimentary conglomerate rock composed of eroded basalt fragments, and rich in native copper (52). The hardened cement paste of the mortar was very dense, and without any sign of air entrainment. The hardened cement paste of the concrete was less dense, with abundant entrapped air. The appearance of the concrete reflects the construction practice of ramming, a method commonly employed at the time (53). The following sequence, reproduced from a construction handbook published in 1908, describes seven basic steps for producing concrete (53):

1. Loading barrows to transport the cement, sand and stone to the mixing board.
2. Transporting and dumping the material.
3. Mixing the material by turning with shovels and hoes.
4. Loading the concrete by shovels into barrows.
5. Transporting the concrete to place.
6. Dumping and spreading.
7. Ramming.

Newspaper accounts indicated that a mixing machine was used instead of the hand-mixing described in the third step, but the subsequent steps outline a likely sequence for the placement of the concrete base. The following excerpts from the same handbook provide further insight into the ramming process, “Concrete that is mixed with very little water requires long and hard ramming to flush the water to the surface… Tests show that dry mixtures when carefully deposited and well tamped produce the strongest concrete… Concrete made ‘sloppy’ requires no ramming at all, and very little spading” (53). A modern interpretation of the concrete base might be that the concrete was poorly consolidated, but the appearance seems consistent with pavement construction practice of the day. The entrapped air voids did not appear to significantly affect the strength of the concrete, as compressive strengths of 5,480 psi were reported in laboratory tests performed by the Portland Cement Association during an investigation of the pavement in 1956 (2).

Thin sections were prepared from one of the slabs. Petrographic microscope images comparing the concrete and mortar portions are shown in Figure 8. The contrast in density between the cement paste of the mortar and the cement paste of the concrete is best observed in the epifluorescent images at the bottom of Figure 8. The abundant entrapped air and relatively porous cement paste of the concrete base has led to extensive carbonation. Carbonation is best observed in the crossed-polars image, which shows bright highly birefringent patches of calcium carbonate in the cement paste. The cement used contained abundant coarse cement grains on the order of a tenth of a millimeter in cross-section, some of which are indicated with white arrows in the plane polarized light images at the top of Figure 8. The center portions of these large grains were often unhydrated, and contained pristine cement phases such as tabular alite crystals, \([3\text{CaO}(\text{SiO}_2)]\) (typically abundant in modern portland cement) rounded belite crystals, \([2\text{CaO}(\text{SiO}_2)]\) and periclase crystals, \([\text{MgO}]\) as shown in the back-scattered electron (BSE) and characteristic elemental x-ray maps of Figure 9. A newspaper account suggested that Alpha brand portland cement may have been used (22). At the time, Alpha cement was produced at two locations near the town of Alpha, New Jersey, and one location near Martins Creek, Pennsylvania (54).
FIGURE 6: Photographs of core as retrieved from Portland Street, tic marks along left side approximately every cm, along right side every inch.
FIGURE 7: Scanned image of slab cut from core as polished (left) and after treatment to enhance visibility of air voids and cracks (right). Bright stickers observed around perimeter of slab were placed to assist with image alignment. Tic marks along left side every cm, along right side every inch.
FIGURE 8: Petrographic microscope images from mortar (left hand side) and concrete (right hand side). From top to bottom: plane polarized light, crossed polars, and epifluorescent mode (darker regions indicate increased porosity in these inverted epifluorescent mode images). White arrows indicate large cement grains.
FIGURE 9: BSE images and corresponding characteristic elemental x-ray maps from unhydrated interior portions of three different large cement grains.

DISCUSSION AND CONCLUSIONS

Downtown Red Jacket was paved during the summer of 1906 for $125,000. Two companies were awarded contracts to do the work. The first company was J. J. Byers, a local company who paved using creosoted wood blocks. The second company was the Chicago based R. S. Blome Company who paved using granitoid concrete blocked pavement. Both companies began their work in April and ended their work in September. Several newspaper articles made clear the novelty of paving roads with concrete, (13,14,16,18,22,23) however none stands out more clearly than a September article in the CCEN entitled “Rain Affects It” (34). This article was written after a section of
granitoid laid on 6th Street needed to be redone due to rainfall, which may have affected its strength after setting. While the need to relay a significant portion of road due to bad weather might make the news today, it is very unlikely that the article would be given the title “Rain Affects It” given today’s familiarity with the material. The durability of the granitoid pavement is somewhat surprising given the absence of entrained air. The high density of the cement paste in the upper mortar layer as observed in thin section suggests reduced capillary porosity as compared to the cement paste of typical modern concretes; a fact that likely played a role in the durability of the pavement. The limited traffic in the small town of Calumet has also undoubtedly contributed to the long life of this pavement.

If creosoted wood block pavement is the distant cousin of modern asphalt concrete, then certainly modern portland cement concrete is the great-grandchild of granitoid pavement. Much as creosoted wood has fallen into disuse, there may come a time in the not-too-distant future where old asphalt roads are fed straight into a cement kiln, turned into portland cement, and used to construct new durable portland cement concrete pavements.

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