CLAYBANK BRICK PLANT – A FUNCTIONAL AND BUILDING ENVELOPE/ WATER DIVERSION RECOMMENDATION FOR A HISTORIC BUILDING

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ABSTRACT

The Claybank Brick Plant became a National Historic Site in 1997. It is composed of a series of both wood frame and masonry structures that functioned to produce brick, using on-site clay to produce both face and refractory brick. Built between 1912 and 1930 and closed in 1989, the plant was composed of a brick factory, ten round downdraft kilns, power plant, stock shed and housing. The products were used in significant local government and institutional structures as well as sold for military use. The plant survived economic fluctuations and demolition. The surviving kilns provide examples of simple, elegant structures tolerating progressive states of deterioration.

However, there are inherent complications as a result of site conditions related to both site geology and topography, both of which have affected the landscape in and around the plant. Situated between a moraine and an alluvial fan, the plant has been subjected to a significant amount of water infiltration over time. In addition, the subgrade deposits from the last glaciation are composed of layers of sand and clay till which attract and retain the surface run-off.

The paper will present a brief history of the Claybank kilns, an overview of the design and function of the structures, site conditions, and will discuss observations and factors contributing to the deterioration of the structures and recommended remedial work. Concluding remarks will address the remedial work that will be conducted in early 2013, which will be included in the final presentation.

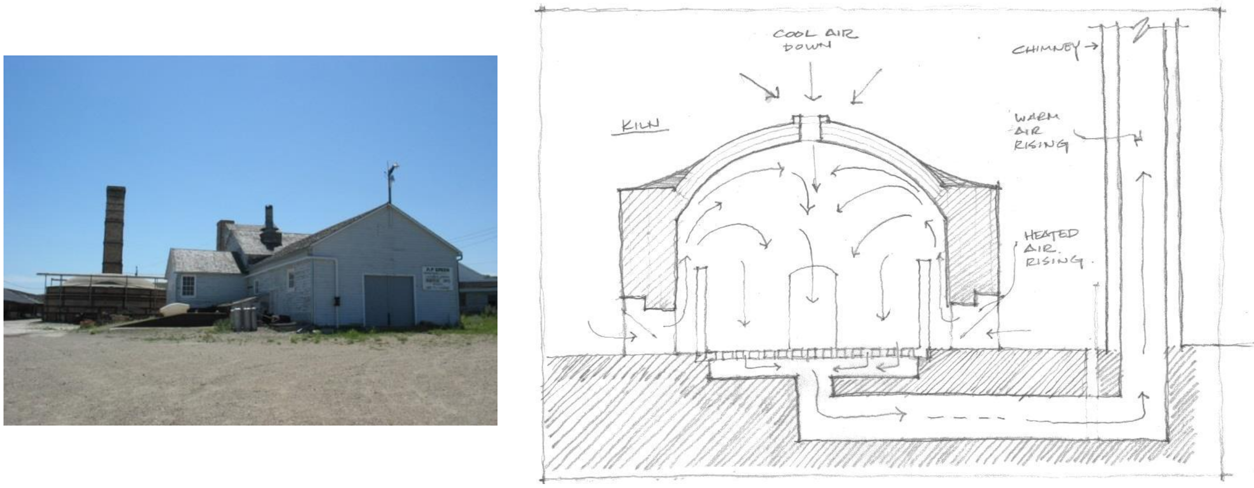
KEYWORDS: masonry conservation, kilns, domes, geology, topography.

INTRODUCTION

The paper will present a brief history of the Claybank kilns, an overview of the design and function of the structures, site conditions, and will discuss observations and factors contributing to the deterioration of the structures and recommended remedial work. Concluding remarks will address the remedial work that will be conducted in early 2013, which will be included in the final presentation.

HISTORICAL OVERVIEW

The Clay Bank Brick Plant is a Provincial Heritage Property with National Historic Designation and is owned by the Saskatchewan Heritage Foundation. The plant is located on 132 Hectares of land, 1.6 km SE of the Village of Clay Bank, Saskatchewan, approximately 100 km south east of Regina. It is comprised of a series of both wood frame and masonry structures that functioned to produce masonry products, using on-site clay to produce both face and refractory brick. Built between 1912 and 1930s and closed in 1989, the plant was composed of a brick factory, ten round downdraft kilns, power plant, stock shed and employees' housing [1].



a) b)

Figure 1: a) Clay Bank Brick Plant site office, kiln and smoke stack, b) Section of down draft kiln. Note that the cool air forces the warm air down through to the kiln floor and releases the air through the connected smoke stack.

According to the historical records the total plant operation was built spanning 1912 to the early 1930s and is the most intact 20th Century brick plant in Canada, having provided 70 years of brick production. Four types of brick were produced, most commonly T-P Moka, Ruff-Tex and fire brick. The products were used in significant local government and institutional buildings, notable buildings across Canada including the Bessborough Hotel in Saskatoon and the Chateau Frontenac in Quebec City [1], as well as sold domestically and internationally for military use. The plant survived many economic fluctuations, and the threat of demolition [1]. The surviving kilns provide examples of simple, elegant structures tolerating progressive states of deterioration.

PHYSICAL DESCRIPTION

The design and function of the kilns:

The original owner Tom McWilliams, commissioned the engineering firm Richardson-Lovejoy of Columbus, Ohio to design a state-of-the-art brick plant. The design accommodated a highly efficient down draft system, utilizing a heat recovery process to dry the masonry units. The kilns were fire with coal that was shovelled through coal boxes in the wall distributed around each kiln. Natural gas was introduced in the 1960's [1]. The kilns are composed of masonry walls and dome, with an oculus at the center providing ventilation and natural light. The walls and domed roof structures were constructed with brick. Loads from the dome are supported by the exterior loadbearing brick walls. The walls are approximately 43 courses high and the diameter of the plan is 9.75m. Steel bands were used to resist the lateral thrust from the dome structure. Turnbuckles were used to keep the bands tight during the firing process [2]. The dome is approximately 4.25m from the floor to the top of the ceiling of the domes. The masonry structures and brick floors are supported on footings below grade [3], from 0.4m to .9m deep.

Each of the kilns were re-built at least once, some as late as the 1950s, ‘60s and 70’s, and having survived in better condition to this day [4]. Kiln 4, for which remedial work will be conducted commencing in 2013, was built in 1914, converted to gas power in 1960 and closed c1980 [4].

SITE INFLUENCES

TOPOGRAPHY

The plant is located within the Dirt Hills, an arcuate moraine formed by thrusting ice during the last glaciation which caused compressive flow in the underlying glacial drift and bedrock deposits. This compression flow below grade caused bedrock and drift thrust slabs to stack and form the Dirt Hills Structure and end moraine, in 3 distinct slabs and shear zones. Over time, the clay and glacial clay till, with occasional sand layers, was formed [3]. The Dirt Hills landscape covers an area of approximately 7.5km wide, 120m high and 40km long [3].

At the Clay Bank Plant site, the surface elevations range from 660.0m at the north end to 662.5m at the south end. Run-off from a hill approximately 6m in height at the south end of the site causes a point of concentrated ground moisture, running towards the kilns. The most southerly kilns are affected more by this flow.

The Dirt Hills to the south are about 100m higher than the Clay Bank location. Land to the north is poorly drained because of the relative flatness of the land. Ditches have been built to act as drainage relief features, specifically from the north to south along the west side and into storage ponds [3].

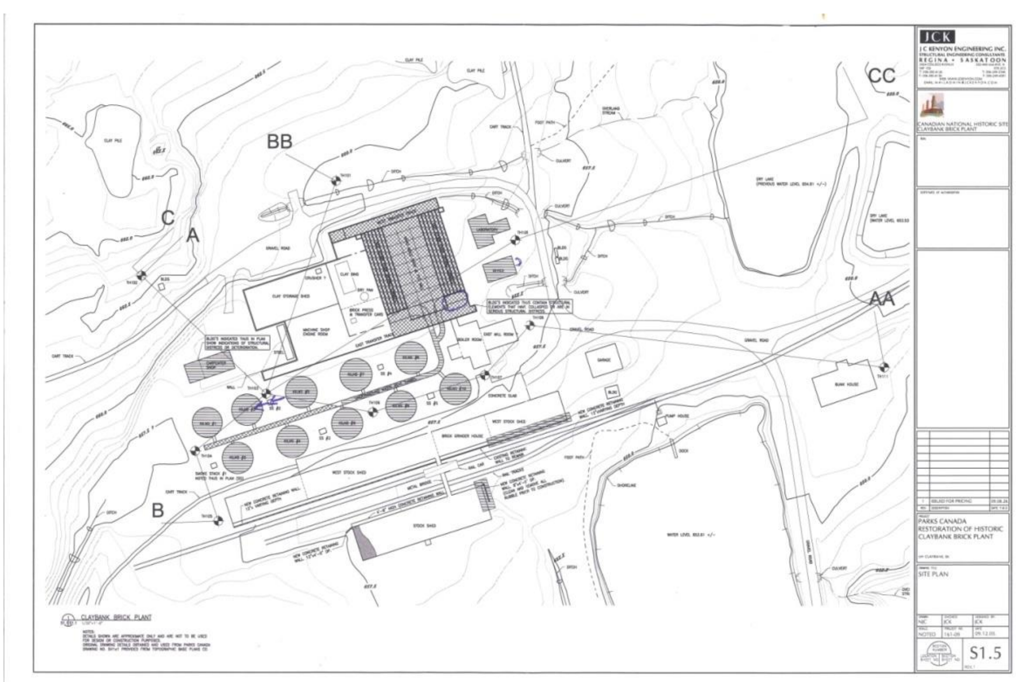


Figure 3: Clay Bank Brick Plant site plan including site grading pattern.

HYDROLOGY

Nine standpipe piezometers were installed in 2000 to monitor groundwater fluctuation. Water levels ranged from 1m-6m below the existing ground surface. Due to groundwater influx the sand and clay are very moist. The sand does not constitute an aquifer, rather contains perched water. Because of the dampness of the site, the perched groundwater elevations vary between the wetter months between May and September and the drier months between December and March, in accordance with seasonal variations [3].

In addition, nitrate and sulphate content was tested in both the soil and water on site and it was concluded there were significant concentrations of both elements. Two brick samples from the base of kiln 6 were tested and it was determined the average sulphate content was 1.5% (based on dry brick sample weights), which would help confirm the chemical effects on the masonry [3].

OBSERVATIONS AND ANALYSIS

From a site visit conducted in the summer of 2012, it was observed that a number of kilns have suffered significant deterioration due to water damage particularly those abandoned at the south end of the site. The kilns appear to have received damage from the ground up due to wicking of ground and subsurface moisture, and from the top down, from inadequate diversion of water from the domed surface to the exterior kiln walls, and from the dome surface itself.

There is a significant problem with collection of surface run-off, proximity to a groundwater recharge area and storage ponds. As a result, the moisture content on average exceeds the plastic limit for the soil which contributes to the soils tendency to expand when frozen. When the water table is 2-3m from the ground surface it is drawn to the surface through capillary action. With the freezing of the ground, suction increases the availability of water to form ice lenses closer to the water table. The grade-supported structure rises in the winter and moves down in the spring, increasing movement within the structure and results are seen as the effects accumulate over the decades [3].

The soil, which would have been dried out and desiccated during the productive years of the plant, has, since the kilns' shutdown, had increases in moisture content. The ground would have undergone yet another form of swelling at different rates depending on surface drainage, exposure to sunshine or shade, or vegetative growth. These differential movements would likely cause distress and shear cracking in the kiln walls [3].

In addition, the groundwater and soil contain high concentrations of sulphate salts. Masonry in direct contact with the ground would have absorbed sulphates through porosity and dissolved due to moisture wicked through evaporation of the surfaces. As concentrations increase, osmotic attraction pressures develop due to the chemical differences between the high concentration area near the brick face and the low concentration area of the groundwater, further increasing the rate of water movement to the evaporation front resulting in evidence of sulphate residue and chemical effects on the exterior kiln walls. This would also have occurred within the kilns where heat concentration would have increased rates of evaporation [3].

Figure 4: Example of abandoned kiln as example of advanced deterioration showing foundation settlement, mortar and masonry deterioration and biological growth.

The bowler hat shape of the dome has created a concave area on the exterior where efflorescence appears on the interior surface. The exterior shape from the oculus down to the walls has provided a profile that allows water to shed onto the face of the walls. Although there was mortar deterioration on the wall surfaces of these structures as well, those domes that shed water onto the wall surface, but which had a more consistent dome shape, presented less interior surface deflection and efflorescence. Significant biological growth has accumulated on the older kilns, particularly on the north face of the structures where the surfaces are moister and shadier than those exposed to the south.

Of the kilns that have suffered less deterioration, it appears that while the masonry walls required repointing, the majority of deflection within the dome has occurred as a result of inadequate diversion of precipitation and consequent moisture infiltration from the exterior dome surface.

ANALYSIS

JC Kenyon Engineering’s first assessment of the exterior wall was conducted in 2005 and determined the deflection was apparent at the base of the exterior walls where there was pressure on the steel bands. In 2011 JC Kenyon Engineering also made additional visual observations related to the deterioration of the kilns due to moisture penetration from the domes [5]. Based on observations during site visits in 2012, a further assessment of the kilns was conducted to determine how the deflection at the base of the domes affected the performance of the structures. The analysis included an examination of the steel bands, the outward deflection at the base of the domes and the effects of the deflection at the base of the domes. Their analysis delved further into the activity of the dome by examining the performance of its lunes and voussoirs and the effects on the exterior wall to determine the total outward thrust on the wall. Further concerns investigated were characteristics of radial cracking in the dome, as well as deflection between the dome base and oculus [6].

a) b)

Figure 5: a) Pattern of efflorescence and ceiling deflection in kiln 4 appears to coincide with the exterior dome configuration. b) Exterior dome configuration at kiln 4. Note the flat surface at the wall to dome connection. Kiln 4 is not as deteriorated as the older kilns as seen in Figure 4.

RECOMMENDED REMEDIAL SOLUTIONS

WATER DIVERSION

In the past water diversion was conducted away from the site using de-watering wells, horizontal sub-drains, and wick drains would create the greatest overall benefits [3], helping the foundations by minimizing saturation of the clay. In this case, it was concluded that, at the very least, water be diverted away from the structure through installation of flashing at the dome surface-wall connection and to divert the water away from the structures a reasonable distance so as not to encourage further deterioration of the joints so they can continue to support the load bearing walls. However, it was financially feasible to address repointing only the top .9m of Kiln 4.

As a result of site conditions and continued deterioration of the structure, the best course of action would be to underpin the foundation, replace damaged brick and repoint with appropriate mortar and improve site drainage. In the event that underpinning is cost-prohibitive, water diversion is recommended for the over-all site [3].

As both the geology and topography of the site, as well as configuration of the domed surface factor into the deterioration of the structures, diversion of water from the structure and site was recommended. This included installation of flashing to dome-to-wall surface connection and positive diversion off of and away from the structures. Reparging the roof surface of the exterior dome surface was also recommended to prevent further infiltration of moisture in from the exterior dome surface.

Due to the variety of factors affecting the condition of the kilns, a mortar mix appropriate for historic preservation was recommended. The age of the structures including the composing masonry, their deteriorated condition, and the concerns about their movement and moisture on site, influenced the choice of mortar. A mortar mix of 1 part NHL to 3 parts sand was recommended by the lime supplier. Repointing to the top .9m of the kiln wall was to be complete by March 31, 2013. It was recommended that heating and hoarding be installed in order maintain a temperature of 15 to 20 degrees C.

RESTORATION WORK 2013

Despite significant problems related to water diversion from both the site and the kiln structures themselves, and overall recommendations from the consultants, the work was limited to repointing the top .9m of the exterior wall of kiln 4. Reparging of the roof was recommended to prevent further moisture infiltration and will be included in the work. A flashing detail was also recommended to divert water away from the wall surface. Due to budgetary constraints, this work was not included in the contract.

Bids for the repointing work were received from contractors in Saskatchewan and Ontario in the fall of 2012. A construction contract was awarded December, 2012 and work was performed during the Winter/Spring 2013. Symptoms of failure of mortar appeared within 2 weeks, showing evidence of cracking and crumbling. Causes of failure are being investigated, and it is likely a combination of factors.

CONCLUSION

By reviewing reports and conducting site visits it is evident that the deteriorated state of the structures cannot be assessed alone, but in combination with a variety of site-related issues.

As a result of the complexities of the natural anomalies of geology and on-site drainage, combined with the recurrent dampness of the site, further deterioration of the kiln structures will continue.

Given the combination of site influences, as well as the condition of the structures, a significant water diversion effort is required. Averting the effects of freeze-thaw heaving below grade, foundation stabilization, as well as protection from and diversion of precipitation off the domes, is required to ensure the longevity of the structures. Minor repairs will provide only temporary remedial solutions and without major remedial efforts both above and below grade, the plant will become a ruin and archaeological site.

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