Faithful Preservation – Another 100 Years

Old Faithful Inn Renovation – Yellowstone National Park

By Thomas Beaudette, P.E. and Janna Moser, P.E.

At eight years and counting, the National Park Service (NPS) is renovating the Old Faithful Inn in Yellowstone National Park. The Inn is reportedly the largest wood A-frame structure in the world and is a historic treasure. Having spent $30 Million to date, the goal is to equip the structure to last another 100 years and beyond.

Early History

In the winter of 1902-1903, 29 year old Robert Reamer owned a moderately successful architectural firm in San Diego. Through a mutual friend, he was introduced to Harry Childs, president of the Yellowstone Park Transportation Company. Childs happened to be visiting Southern California with his family.

For the sum of $3,000 per year, Reamer walked away from his established architectural firm and traveled back to Montana with Childs and his family. On the train trip, Reamer sketched his "yet to be approved" schematic designs of a rustic style lodging structure at the Upper Geyser Basin in Yellowstone National Park. As of that trip in early February 1903, the mandate to build the hotel building was compelling but firm plans had not been established.

In March, Childs traveled to Washington DC to garner approval for Reamer's schematic plans from the Department of the Interior (DOI). While the DOI ultimately approved the plans in May, President Theodore Roosevelt personally consulted with Reamer in April during a working vacation to the Park. So, for an initial loan commitment of $100,000 from the Northern Pacific Railroad, Childs and the Yellowstone Park Transportation Company began construction of the hotel at the Upper Geyser Basin. This hotel was later to be known as the Old Faithful Inn and ultimately a national historic landmark.

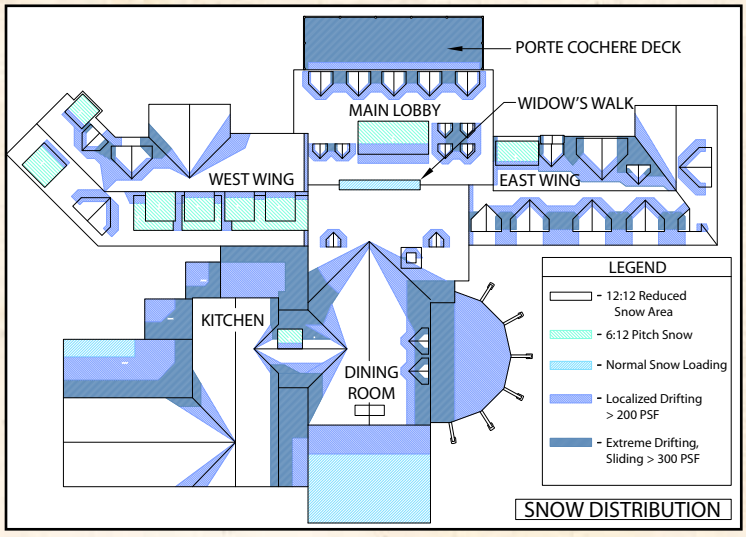
More out of necessity than any other factors, the Inn was "green" well before its time. Hundreds of tons of native rhyolite stone were quarried for the foundations and fireplaces. Thousands of local trees were harvested from designated areas within four miles from the construction site. The trees provided logs for the lowest floor level and were also milled for the upper floors, roof structure, and door/window trim.

The distinctive, gnarled log knee braces were handpicked from the Yellowstone Lake area. Forty laborers worked through the summer of 1903 and into the following winter towards a grand opening goal of June 1904, an impressive one year construction period. Robert Reamer remained hands-on and active throughout the construction process. He balanced his time with a significant renovation and expansion of the Lake Hotel structure, some 50 arduous miles away. The Inn was completed within the one year time frame at a final cost of $140,000.

View from the northwest – undated, circa 1904. Courtesy of NPS Archives and A&E Architects.

As Reamer sketched through his designs on his train ride, he had a basic knowledge of the heavy snow loads and extreme environment of Yellowstone Park. At the same time, he could not have fully appreciated the demanding design constraints required for his hotel structure. Yellowstone National Park ranks as one of the most stringent snow and seismic design regions in the United States. Ground snow in the area is an impressive 140 psf. The Park contains one of the world's largest calderas creating approximately 2,000 earthquakes per year, making it one of the most seismically active areas in the United States.

Combine the high snow loads, seismic activity with the immediate geothermal area, and the fact that the Inn is totally closed and winterized every season, it is easy to conclude that the survival of the 100 year old Inn is a marvel. In addition, the Inn has been threatened by fires on many occasions. The closest call was the 1989 wildfires that completely surrounded the Inn. It survived the intense blaze thanks to a full deluge system that had been installed on its roof only one year prior.



Roof snow load contours used for structural analysis.

Structural System

The main "Old House" 1904 building can be broken into four areas; main lobby, wings, dining room, and kitchen. The main lobby consists of "bark-on" stacked interior log columns, tie beams and knee braces, in conjunction with stacked main level perimeter log walls and rough framed upper floor walls and balcony floors.

The main lobby extends 75 feet to the ridge, using log column segments no greater than 12 feet in length. Log trusses and purlins form the steep 12:12 pitched roof over the lobby. A maze of log stairs and walkways extend from the third floor level to a "Crow's Nest" platform at the peak of the lobby and the "Widow's Walk" that sits atop the roof.

Three story wings on each side of the lobby accommodate 140 hotel rooms. A fourth attic story in the west wing houses employees. The east and west wings were similarly constructed of stacked logs at the main level, with rough framed milled material for the upper level walls, floors, and roof. The dining room has two log scissor trusses which span an impressive 56 feet across the large open eating area. The two story kitchen with warehouse basement understandably has more practical framing using milled lumber throughout.

Over the years, many modifications and additions have been made to the original Old House constructed in 1904. Log walls in the main lobby were removed in 1927 to expand and allow for a more open gathering space. An extensive porte-cochere addition created a drive-under entry and an upper level geyser viewing area. The dining

Before and after photo of north side steel framing ultimately covered with logwork. Courtesy of JK Lawerence Photography and A&E Architects.

room was extended to the south and east in the 1920s. In 1936, an addition between the kitchen and west wing was designed by the original designer Robert Reamer, housing the Bear Pit Cocktail Lounge and celebrating the repeal of prohibition and the Park's decision to allow sale of alcoholic beverages.

During the park closure during WWII, log struts and braces were added to the lobby trusses to supplement deficient roof sections. The lobby logs were also peeled of bark during this time. Reamer designed the large east and west housing wings (1913 and 1937) in a utilitarian fashion so as not to distract from the original Old House.

THE RENOVATION DESIGN PROCESS

The "Old House" renovation design process began in 2001, with the goal of the project to bring the Inn into code compliance while respecting the historic fabric of a national landmark. Several original architectural elements which had been removed through the years were to be brought back, per original photos and drawings. Log walls removed early on have been re-established and used for lateral shear transfer. The in-filled area around the main lobby fireplace was re-framed to reestablish the original recessed gathering area. Truss connections on the lobby log trusses have been re-designed to allow for the removal of struts installed in the 1940s.

The extreme nature of the setting for the Inn has shown its effects on the structure. In 1959, the Inn was within 45 miles from the epicenter of a major 7.5 magnitude (Richter scale) earthquake which collapsed the side of an entire mountain, creating Quake Lake and causing several fatalities. The earthquake brought down the Old Faithful dining room fireplace and collapsed the brick flues of the lobby fireplace, but otherwise did minimal damage to the Inn. Even so, large snow accumulations caused severe damage to north side dormers of

the main Lobby and both Wings. Isolated areas of the north roof framing were separating from general fatigue.

The NPS-adopted design code for this project is the *2001 International Building Code* (IBC). The basic design snow load (p_f) for the roof is reduced for the 12:12 pitch, however, intersecting roofs of the wings, dining room, main dining room, and kitchen create many valleys and drifting areas. Further accentuating snow accumulation is Reamer's original design concept of clustering small gable and shed dormers on the north side of the main lobby roof and east and west wings. The immediately adjacent dormers funnel snow to concentrate, back-up, and exert very large forces on the dormer roofs. The east wing dormers have been ripped from the main roof several times over the Inn's history.

In-Plane log wall shear test at Montana State University.

Sliding snow from the steep pitched roofs causes serious snow accumulation on adjacent flat roof additions in the employee dining area, the Bear Pit Lounge, and the entry porte-cochere. These areas are designated for design snow loads in excess of 300 psf. All roofs have supplemental sheathing applied, and dormers were reattached throughout. The lobby and dining room roofs have new steel beams installed within existing structure depth, providing challenging constraints and unique details along with interesting working conditions at 12:12 pitches and extreme weather situations.

The lobby truss connection upgrade was a challenging process, not only from a design standpoint but to construct as well. New steel pipe/plate bearing connections were installed in place, several stories above the main level. The dining room truss connection upgrade utilizes a new high-strength cable in lieu of the original rod.

Renovated lobby and recessed gathering area- 2008. Courtesy of JK Lawerence Photography and A&E Architects.

Seismic retrofit of the Inn was obviously a huge challenge. The historically sensitive nature of the project is not conducive to the addition of major lateral force resisting elements. Although the existing structure has survived a major seismic event, the large open main lobby had minimal lateral force resisting elements at the main level, especially considering the log walls removed early in its history.

Reports from the 1959 earthquake revealed that the flexible nature of the lobby core tolerated the movement as it swayed, without failing. The non-ductile main fireplace withstood the lateral forces, however the internal flues were not so fortunate.

The lobby area was initially designed to distribute lateral forces down through the "log frames", column tie logs and knee braces. A 3D finite element model utilized a time-history seismic analysis to determine the building response. This model showed excessive member/frame deflections and high knee brace forces within the original construction.

The existing gnarled knee braces are woefully inadequate to resist the high seismic loads. A combination of methods was implemented to solve this inadequacy. First, the roof and floor diaphragms were upgraded with additional structural sheathing. Second, the log walls were replaced in areas previously noted, and all walls were reinforced with structural pinning. Next, wood sheathed shear walls were added in strategic locations. Finally, in certain areas, structural steel moment frames were installed and buried in log beams and columns to withstand the more extreme lateral loads.

Load testing was done at Montana State University to analyze the lateral capabilities of existing and upgraded log wall interfaces. Supplemental pinning was strategically installed to hide their presence by placements out of typical viewing lines, as well as artistic disguise to make the pins appear to be knots. At upper levels, existing interior framed walls designated as shear walls were retrofitted with light gage steel braces. The reason for this retrofit is to preserve certain architectural details like jamb thicknesses. The tall end walls of the lobby were significantly stiffened with a combination of Laminated Veneer Lumber (LVL) studs, steel T-beams, and structural plywood for both in-plane and out-of-plane lateral forces.

The renovation of the "Old House" is divided into four main phases and several off-shoot projects. While Reamer completed the original construction project in one year, the final "kitchen" phase is on-going, putting the project at eight years and counting. The original builders did not have to worry about tourists wandering through the job site and having to work around a partially occupied building.

There is one thing that hasn't changed however; winter construction in the Park. A note was found inside one of the original copper balls of the flagpoles atop the Widow's Walk. It said, "Feb. 1904 – Cold as hell, don't want to be here anymore." As this heavy renovation work is done during the closed winter season, builders today surely have had similar thoughts.▪

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For the project team, see the online version of this article. Visit **www.STRUCTUREmag.org**.