PIXAR ANIMATION STUDIOS: FABRICATION AND ERECTION CHALLENGES

Ron Long and Dan McGill & Jawed Umerani, S.E.

Ron Long is with SME Steel (formerly with AFCO Steel).

Dan McGill is with M&M Bros., Inc.

Jawed Umerani, S.E., is with Umerani Associates and OneBuild (formerly with Rutherford & Chekene).

Project Description

The new headquarters for Pixar Animation Studios, located in Emeryville, California, is a two-story 220,000 square foot exposed steel frame structure with masonry brick veneer facade. It is a state-of-the-art seismic base isolated building, designed for the seismic performance goal to remain operational after the Maximum Considered Earthquake (MCE).

Architecture and Engineering
The Vision

The Owner and the Architect envisioned a building which would emulate the circa 1920 construction with state-of-the-art technologies. The building would invoke images of exposed steel riveted construction through highly-developed details and finishes. From the onset, the guiding principles were:

- To deploy classical framing configurations
- To evolve the design, such that building components could be pre-fabricated in the shop as much as possible and bolted together in the field, thereby minimizing the field welding
- To assimilate the building with the City of Emeryville's loft and warehouse context

Pixar produces animated feature films, which often must be delivered in time for the holiday seasons. The down time due to a seismic event was not acceptable. The project site is about 5 kilometers from the Hayward Fault, in a high seismic activity region. In order to meet the Seismic Performance Goal to remain operational after the Maximum Considered Earthquakes (MCE), seismic isolation systems were proposed. High Damping Rubber Isolators, Lead Core Rubber Isolators and Friction Pendulum Isolators were considered. After meticulous studies, High Damping Rubber Isolator System, manufactured by Bridgestone, was selected.

Structural System

Due to differential settlement nature of bay mud fill at the site, deep foundation system, which relied upon frictional resistance of piles, was recommended by the geotechnical engineer. Pile lengths vary from 30 to 70 feet, depending

Interior entrance lobby.

Pixar Animation Studios.

on loading and soil conditions. The foundation system consists of groups of 14-inch square precast prestressed concrete friction piles, topped by pile caps. Pile caps, designed to receive and support the isolators, are interconnected with concrete grade beam system to resist flexural loading imposed by the structure, when it is displaced during a seismic event.

Over the building footprint of 240 ft. x 480 ft., there are 120 High Damping Rubber Isolators and 92 PTFE/Stainless Steel Sliders supported over Pile Caps. The first floor steel framed platform is supported over the isolation system.

First floor framed platform supported over base isolator.

Site specific dynamic analysis was performed by utilizing seven time histories. These time histories are recorded ground motions of actual seismic events. The average displacement at the Design Basis Earthquake (DBE) is 17 inches and at the Maximum Considered Earthquake (MCE) is 23 inches. The clear distance between first floor steel and the perimeter moat wall is 30 inches, which is controlled by the stability of the isolator.

The two-story exposed steel framed structure is supported over the first floor platform. W10 beams at the second floor and W8 beams at the roof are spaced at 6'- 0" o.c. These beams are continuous over girders for multiple bays and the flanges are bolted together. Double channels are utilized at columns and connected to flanges. Wide flange girders bear on articulated WT built-up seats bolted to W10 column flange. Girder web connection to column is via double angle bolted connection. Braces are back-to-back MC10 channels stitched together with bolts. Brace connections to columns, beams and girders, are exposed to view and are articulated field bolted assemblies. Finished wood decking was integrated with floor and roof systems for appearance.

Central atrium features saw-tooth roof and skylight, supported over triangular trusses. Two pedestrian bridges, cable suspended from the roof trusses, connect second floor of the east and west wings of the building. The bridge features include built-up & bolted girders, wood decking and rod bracing below the deck.

Team Development Bidding and Management

A project of this nature with the evolving design only 70% complete and the given schedule, the contractor chose a team concept approach to select a fabricator erector. Cost, although a factor, was not the governing issue in selecting the team. All members of the team had to demonstrate their commitment a project of this magnitude.

Team Approach/Select Committed Players

Early on in the project it was determined that the fabricator, detailer, erector, engineer, architect and contractor would commit key personnel to attend weekly design/construction meetings to discuss RFIs, Value Engineering ideas, and upcoming design modifications that would save time and money. This collaborative process and the proactive approach to seek input and feedback from the entire design and construction team proved to be great of value to the finished product and the final cost.

Any new designs issued were priced within 5 days. These changes could then be discussed at weekly meetings and decisions could be made as to what actions were to take place.

Uniqueness of the Project

The Pixar project is unique for its seamless integration of architecture, structure and building systems. The vision had been to build a circa 1920 building with the state-of-the-art technologies (exposed steel frame structure with articulated braced frame system, all bolted together and erected over a base isolated steel framed platform). The entire structural system and all connections had to pass the rigor of architectural concerns of aesthetics.

The Owner being in the business of developing the finest animation, believed in perfection. Such an extraordinary expectation could only be met by creating extensive mock-ups of rolled and built-up members, and their connections. These mock-ups served several critical purposes:

- Helped end users physically observe and provide feedback on the structure and its connections
- Became basis for the design and the aesthetics
- Source of refinements in design of architectural aspects
- Provided the opportunity to address the constructability issues in the areas of limited access
- Helped determine that the paint had to be field applied

The design modifications and refinements had to be managed early on, because of their repetition and interdependency in design and fabrication through the project, as well as the impact on the schedule. Since the detailer was engaged early, while the design was still evolving, issues related to shop and field processes and capabilities that uniquely helped the project were identified and incorporated. This early involvement also helped prioritize the detailing process and releasing the design to minimize re-detailing.

DETAILING

Understanding the Design

With first glance of the PIXAR Animation Studios' Design Drawings, it was immediately and abundantly evident that this project was "unique" in its entirety. There appeared to be "nothing conventional" about it. This project was going to require an extraordinary effort by the detailer to understand the "out-of-the-box" thought process of the architect and the structural engineer in developing such a "non-standard and unconventional" system of framing and connection configurations.

Detailing production was underway simultaneously with the evolving nature of the framing and connection design. It was necessary, for the entire duration of the project to maintain direct communication with the structural engineer to understand the direction of the evolving design and with the fabricator for the special requirements needed in shop fabrication.

Effective Communication

This project required "team meetings" which were set-up and attended with a positive and productive atmosphere. All participants were collaborating with the unified goal to deliver what any owner would want…VALUE! "Team Meetings" enabled detailer, fabricator, and erector to:

- Identify the alternatives to achieve the same design objectives
- Propose modifications or variations of design to achieve uniformity across the project and in due process, speed-up the detailing and the shop productions
- Communicate the foreseeable shop and field challenges of detailing, fabrication and erection
- Proactively, seek guidance and resolve issues

Base Isolation

High Damping Rubber Isolators have circular steel flange at top and bottom. Both flanges have a circular pattern of twelve 1-1/2" diameter A449 anchor bolts. The anchoring of isolators presented interesting setting and placement considerations and issues. Tolerances for the placement of individual anchor bolt as well as the circular anchor bolt pattern, as a whole, were very tight.

The base plates of the Stainless Steel Sliders are 6'-6" square, with headed studs shop welded to the underside in a grid pattern. The welded studs align with oversize circular pockets created in the extended pile caps. When installed, the studs are embedded in the pockets and when the plate is plumb and in its final position, the grout is flooded to fill the pockets and the underside of the base plate.

Templates and Setting Plans

Templates were provided to assure bolt pattern fit-up with isolators. The diameter of the bolt hole and the circular bolt pattern required exact match to isolator pattern. Bottom of isolator elevations were critical, as well as rotation of patterns. Anchor bolts with couplers at the top were embedded in extended pile caps receiving isolators. Once the isolator was in place and bolt holes aligned with embedded couplers, it was secured with headed bolts engaging the couplers. Vertical and horizontal plains of these embedded items required special attention in field placement as well as continuous inspections.

Issues of the N-S Braced Frames and Connections

Steel framing clearances were to be maintained throughout the braced frame detailing. Bolting patterns were determined by girder size depth connections. Work point set-up of each brace was determined by bolt alignment and clearance conditions. Each connection "evolved and developed" the connection criteria. T.O.S. elevations were critical. Contrary to a "standard set-up" of work points creating connection locations, an actual "evolution of connection" created the work point locations.

Issues of the E-W Braced Frames and Connections

Connections of brace to column and to girder, exposed to view, required built up gusset & stiffener assemblies to accommodate the effect of "horizontal embedded plate" into floor slab.

Interior framing and walkway bridge.

Built-up Braces and Bolting of Multiple Items

Multiple "pieces" and excessive connection material thickness created bolt alignment and fit-up concerns. Considering bolt pattern alignment, hole pattern layout "creation" and minimal to no hole oversizing allowances, detail location and shop fabrication drilling locations were critical.

Girder to Column Seated and Double Angle Connections

To accommodate the rolling tolerances of the wide flange steel girders, affecting the actual depth of the member, it was decided to maintain the top of steel elevation of the seat at column at constant elevation. This elevation was established for the maximum variation in depth, which made the punching of holes on columns uniform, all across the building. Shim plates were required for full bearing of girders on the seats.

Bolt Head Orientation for Uniformity and Visual Impact

Direction of bolt incursion was required for visual effect throughout all braces. Bolting required symmetry overall throughout building. "Stitch bolting" was to be located throughout vertical bracing system to maintain consistent "elevation" of bolting patterns.

Uniform Projection Bolt Thread per Connection

"Stick thru" of all bolts was to be maintained. Each connection within itself however required an "exact/matching" stick thru condition. Shop bolted conditions (back to back vertical braces)and field connections had to be matched by erector.

INTERIOR FRAMING AND WOOD DECKING Tolerances

All tolerances were to be held to absolute minimums. Due to multitude of connected pieces of rolled material items, "draws" were not realistic. Compacted or "tight" fitting connections were to be absolutely maintained. Numerous layers of material were aligned and sharing common patterns and bolts.

Clarity of Shop Drawings and Shop Notes

Conveying "unusual" information to shop fabricator was a constant concern and a necessity to insure owner's satisfaction. (Steel fabricator to be commended for control and management of drawings throughout production and fabrication on this job.)

Clarity of Field Erection Drawings and Field Notes

Notifying field erector of numerous "field fit sequencing" conditions allowed erector to be aware of creating inaccessible bolting conditions prior to "flying steel". Clearly communicating bolt head orientations, and identifying specific "untightened" bolts on shop assembled items.

Triangular Trusses and Interior Walkway Bridges

Located in the center of the PIXAR Animation Studio is a 60'-0" wide, open, entrance lobby. Fifteen custom designed triangular trusses (with camber), along with saw-tooth skylight framing and two interior walkway bridges span this impressive lobby. Numerous architectural features were incorporated into these items for visual effects.

FABRICATION

Production shop vs. Artist studio

Due to budget and schedule impacts, fabrication of this project had to be based on production, while being sensitive to the architectural requirements. This meant fabricating an architectural exposed project without utilizing the architectural exposed specification. The shop superintendent approached this project based on a pride in the finished product while maintaining the production schedule.

- Welds needed to be aesthetically pleasing while maintaining schedule. It was predetermined that the shop would not meet the architecturally exposed spec so it was up to each individual welder to make each weld as clean and uniform as possible.
- Pieces needed to be shop assembled as much as possible. The assembly in the shop and previous mock-ups showed that approximately 40 % of the tension-controlled bolts had to be manually torqued utilizing a ratchet wrench.
- Handling needed to be in a manner that would not leave gouges scuff marks or any other blemishes.
- Stick thru of the bolts was critical due to the architectural effects and the erection tolerances (too little stick thru and the architect would not accept it and too much stick thru and you could not torque the opposite / opposing bolt)
- Material needed to be inspected for mill marks or other normal damage that occurs prior to fabrication.
- Bolts had to be installed making sure that the details were followed to the letter. Orientation of the bolts was a concern for the architectural appearance.
- Any piece that reached the field and did not meet the architects approval was re-fabricated noting the concerns that the architect had with the original piece.

Shop inspection had to include both structural concerns as well as architectural concerns. Although, AESS requirements were not contractual obligation, the final product proved that an architecturally exposed structured could be built without being tied to an AESS specification (pride and good shop hands proves to be a better ally than the specification)

ERECTION

Mounting/Installation of Isolators

Due to tight tolerances imposed by the Isolators and its anchoring system, surveying and double-checking played a crucial role. Twelve-bolt circular pattern required machined steel templates (holes in isolators were metric) to be utilized for coupler placement. Rotation of isolator needed to match connecting steel above as well as footing closure plates.

Welding of the first floor steel beams to the cover plate at the isolators required that the temperature could not exceed 500 degrees. Welding sequence and monitoring of temperature with temp sticks was part of the field quality assurance.

Full bearing shims were required for tightening cover plates to isolator. This was to make up for any mill tolerances for the steel above.

Sequence of Erection

Unique framing conditions necessitated "breaks" in erection sequencing. These members required bolt up to occur as steel was erected. A complete understanding of these bolting conditions was required. As items were erected, bolt accessibility was lost. Side by side beams attached with horizontally rotated wide flange member and side-by-side column framing conditions created these challenges.

Some connections required bolts going thru 9" of multiple layers of material prior to final plumb up. Due to the rigidity of the braced frames and thickness of the materials barrel and bull pins proved to be of minimal benefit.

Both sides of the building were erected simultaneously. The entrance lobby was erected with trusses thereby connecting the two sides of the building.

Field Adjustment

Due to the inability for alternate connections or field fixes each connection had to fit. A moderate amount of reaming was required but not to the extent that it would diminish the design integrity of that connection. Larger bolts were not allowed due to architectural concerns. When reaming was required, the amount of reaming was noted and forwarded to the engineer for approval. In some cases it was determined that the connection was indeed compromised due to excessive reaming. In these few instances A325 bolts were replaced with A490 in order to increase the capacity of the altered connection.

Combining the rigidity of the structure and the isolator design thermal expansion became a factor but was most evident at braced frame locations. At various times of the day it appeared that it would be impossible to install all the bolts (up to 60 per connection) without major reaming or re-fabrication. Bolts were installed in correlation of the natural movement of the structure during temperature changes.

Field Bolting

Bolts had to be installed so that the bolt stick through matched the existing shop installed bolts. In many instances it was necessary to remove the spline of the T.C. bolts prior to installation.

In the middle of the project it was noticed that Nucor had changed the die casting for the button head of the T.C. bolts. This was noticeable in the flat at the top of the button head. This difference was only noticeable when both types of bolts were in the same connection. This required the coordinating of bolts of the same type in each connection.

It was important that the bolt heads did not get scarred or had any blemishes. Despite the situation, if one bolt was different it had to be replaced or in some cases when an A490 bolt was used then all the remaining bolts needed to be changed to match.

Field Welding

Although field welding was kept to a minimum, field welding was still required. At field welded conditions special care was taken to minimize grinding so that it would not change the look of the steel. Welding needed to be sequenced so that it would not adversely affect the plumb up of the building.

Interior truss and bridge framing.

Photographs and images courtesy of: Karl Backus, AIA; Sharon Risedorph, Photographer; Jawed Umerani, S.E.