LDS Temple Window Study

The Church of Jesus Christ of Latter-day Saints

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Executive Summary

The purpose of this report is to verify whether or not the current code requirements for window systems are being used in engineering practice for temple design and construction, and to recommend improvements where there are any discrepancies. This report will help answer the following questions:

1. Who is responsible for the engineering design of the attachment of the window system to the structure? Is it the structural engineer of record, the architect, the window manufacturer, or the window installer?
2. How are window systems (including stained glass windows) designed to withstand out-of-plane loads? This includes the panes of glass and the window frames.
3. Are building in-plane deformations considered when designing window systems according to ASCE 7-10?

The information of the report came from many different sources including written code, manufactures, practicing engineers, and glass contractors. In the appendix an annotated bibliography of the sources has been included for reference.

Abstract

Non-structural systems are often overlooked in engineering design, and do not meet the standards of LDS Temple design. This has been seen in various ways by previous studies done on temples. As determined by this temple study, window systems also fall in this category. In some situations windows fail to meet code requirements or to even be engineered. Though this is not always the case, specifications for the design and engineering of windows for temples will help ensure design quality. It is recommended that all windows, curtain walls, and storefronts be designed in accordance with ASCE 7-10 Section 13.5.9. Stained glass windows should be structurally designed according to chapter 5 of the SGAA Reference and Technical Manual. Connections of windows to the structure must be designed and specified by a professional engineer. In the end it would be wise for the structural engineer of record to check the shop drawings of window systems to ensure that proper techniques were used in design and that these recommendations were followed.

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Introduction

The Church of Jesus Christ of Latter-day Saints is continually announcing the construction of new temples all around the world. Currently there are 144 temples in operation, 14 more under construction, and 15 more announced. These structures are sacred edifices to the members of The Church of Jesus Christ of Latter-day Saints where sacred ceremonies connect families forever and explain God's plan for His children.

Recently, there have been various issues with temple window systems. In some cases these issues have caused significant weathering damage to the temple interiors as well as damage to stained glass windows. These issues raise a concern for the quality of these systems. In the past, non-structural systems have been overlooked in their engineered design. For these reasons the Church would like to investigate the structural aspect of window installation.

Research has been conducted in order to answer the question of how windows are engineered. This report looks specifically at the design of window systems for out-of-plane loads, in-plane deformation caused by building movement, as well as attachment methods.

The first section of the report will discuss the various parties involved in the design of window systems, how they interact, and what they are accountable for. The next sections will cover connection of the window system to the structure, stained glass windows, out-of-plane loads, and in-plane deformations respectively.

Window System Design

There are many different types of window glazing systems. Curtain walls are systems with horizontal and vertical mullions with glass infill. They are supported at each level and the engineering requirements are more stringent than other systems. Storefronts are single story systems that include a perimeter and intermediate framing. These systems are anchored at the tops and bottoms of the mullions. Windows include factory assembled glazing units with a perimeter frame. They are anchored around their perimeter. Each window system has its advantages, and all these types can be used in temple design.

The design of window systems passes through many companies before it ever becomes built. This explanation will cover the general path of design until the window system gets installed. The description will also follow an actual project that is in the process of being built. This building is the Ara building B, and the owner is a development firm called Freeport West. From talking to other contractors, and engineers this description matches the general flow of information and responsibility.

The owner of property where the Ara building was to be built hired Hilton Williams Architects for the design. The architecture firm drew up the first set of plans for the building including the window systems. Once the building was designed, the contract was sent out for general contractors to bid on. The contractor that won the bid was then responsible for the rest of the building process. In the case of the Ara building, Big-D construction was hired as the general contractor. Due to the size and intricacies of the project Big-D sub-contracted the window design to B&D glass. At this point B&D glass was responsible for producing the shop drawings for windows of the building. B&D Glass then contracted the engineering firm Anchor Engineering to check and approve the proposed design. Once the engineers approved the shop drawings, the involved parties also had to approve any changes. In the case of the Ara building, the shop drawings have been approved by the engineer and Big-D construction and need to be approved by the Architects. Pending approval, the shop drawings will then be sent to the manufacturer to fabricate the parts of the window system. The window system will then ready to be installed by the contractor.

The chain of design may be more complicated in the case of temple design. Multiple glass contractors can be used for the temples due to the stained glass windows and other systems involved. Nonetheless this description shows the different parties involved and displays where in the process the engineering gets done. The next two sections will focus on the engineering of the window systems.

Connections

The connection of the window frame to the structure is normally shown in the shop drawings and is checked by a professional engineer contracted by the window glazier. This anchoring system is checked for breakout shear strength, pry out strength, and steel anchor strength. This information was provided by B&D Glass and checked on the shop drawings approved by Anchor Engineering, but it is unclear if the structural engineer of record checks the anchoring system. A second source to the engineering of window connections was Art Harms P.E., an engine from Dynamic Industrial Technologies. Through an interview, it was conveyed that he designs and specifies the connections of window frames to the structure for the projects he works on. These anchoring systems are specific to the material that they are connecting to, otherwise it would be impossible to design for a breakout or pry out strength. The quantity and type of screws, bolts or anchors are provided as well. Also as a professional engineer Mr. Harms has reviewed the window system designs of many other firms and has never seen a situation where the connection of the window frame to the structure was not specified.

Contrary to the confident testimony of Mr. Harms, Jeff Pulver, a specialist at Bountiful Glass, stated that the connections of windows frames to the building structure are not always engineered. He explained that for big office buildings, the connections are certainly designed, but on smaller scale projects like some temples, it is not always the case.

Out-of-Plane Loads

Mullions are the main structural elements that resist out-of-plane loads in window systems. We have verified that professional engineers design the mullions in these window systems. This information was found through the same engineering contacts above and many confirmations from manufacturers. Initially architects size the mullions by referring to drawings and charts from a specific window manufacturer. Down the line engineers run the calculations of the specified mullions checking for moments and deflection. Usually deflection governs for larger window systems. If the mullions are not strong enough, heavier mullions can be used or steel reinforcing can be added inside the mullions for support. There is no reason to believe this part of the window system is not properly designed.

Stained Glass Windows

Another concern is with the ability of stained glass window systems to handle loads. One problem that has arisen in temples is the settlement of the glass pieces in stained glass windows. This forms gaps between the glass and the cames (steel supports that encase the glass pieces). Holdman Studios is a stained glass manufacturer in Lehi that has worked on many temple projects for the LDS Church. Currently they are working on stained glass windows for the LDS Rome temple. Aaron Yorgason is the liaison for all large scale projects that Holdman studios works on, and provided valuable information as to the reasons for this failure.

When hearing about the problem with stained glass windows, he was confident that the manufactures had not met the guidelines designated in the SGAA Reference and Technical Manual for such stained glass systems. Holdman Studios has been involved in the repair of many temple stained glass systems. According to Mr. Yorgason there are specific guidelines for stained glass windows provided by the Stained Glass Association of America (SGAA). The glass in the window has to be designed to support its own weight. This sometimes requires steel reinforcing bars to be attached to the back of the stained glass. This practice is part of the design in Holdman Studios, but is sometimes neglected by other providers. The root of the problem is the ability of the stained glass window to hold its own weight. Adherence to guidelines set by the SGAA would solve the issues of the failing stained glass systems.

In-plane deformation

Of the many glaziers, contractors, and engineers contacted for this report, not one considered in-plane deformation from seismic loads in design. We were simply told that the frame manufacturer made sure the frames were designed with the necessary gap. This might be alarming at first, but the code in ASCE 7-10 and the current practices in window manufacturing reveals that the design of window systems is conservative in this area. This section will look at the code governing in-plane deformations due to seismic loads in order to understand why engineers might not consider them.

According to ASCE 7-10 Section 13.5.9.1 a window system must meet relative displacement requirements. In this same section there are exceptions to this requirement. Please refer to Exception 1.

EXCEPTIONS:

1. Glass with sufficient clearances from its frame such that physical contact between the glass and frame will not occur at the design drift, as demonstrated by Eq. 13.5-2, need not comply with this requirement:

$$D_{clear} \geq 1.25 D_p \qquad (13.5\text{-}2)$$

where

D_{clear} = relative horizontal (drift) displacement, measured over the height of the glass panel under consideration, which causes initial glass-to-frame contact. For rectangular glass panels within a rectangular wall frame

$$D_{clear} = 2c_1\left(1 + \frac{h_p c_2}{b_p c_1}\right)$$

where

h_p = the height of the rectangular glass panel
b_p = the width of the rectangular glass panel
c_1 = the average of the clearances (gaps) on both sides between the vertical glass edges and the frame
c_2 = the average of the clearances (gaps) top and bottom between the horizontal glass edges and the frame

Figure 1: ASCE 7-10 Section 13.5.9.1 Exception #1

If there are gaps between the pane of glass and the frame that prevent contact during the design drift, then the exception has been meet. An equation for D_{clear} is shown in the code that calculates the movement a frame can undergo until contacting the glass. The equation uses as inputs: average gaps on the sides, average gaps on the top and bottom, and the height and width of a glass pane. The theory behind the equation assumes that the frame will deform into a parallelogram allowing the glass to readjust and rotate until contacting the frame. D_{clear} is explained in more depth in the commentary of ASCE 7 under Section C13.5.9.1.

Table 1 below was created to demonstrate the effectiveness of allowing glass to rotate in the frame. In the table it is assumed that the allowable story drift (D_p) is 0.01*hxx (according to Special Projects Department Temple Structural Guidelines), and that the average gaps between the glass and the frame are ¼ inch. The required displacement is 1.25*D_p. Each value in the table is the amount of accommodated displacement available given the height and width of a glass pane and given a ¼" gap at the sides, top, and bottom. If the accommodated displacement (per D_{clear} equation) exceeds the required displacement, then the ¼" gap is adequate. These values are shaded in the light blue. If the accommodated displacement is less than the required displacement, then the ¼" gap is not adequate. These values are shaded in dark blue. After talking to frame manufactures, a range of 1/4-3/4 inches was given as a normal gap size. The table uses a combinations of glass heights and widths and shows which combinations will work for a combination of widths and heights.

Table 1: Accommodated displacement (inches) given ¼" clearance at sides, top, and bottom and required displacement given an allowable story drift of 0.01*hxx

D_p (in)	Height (ft)	Width (ft)									
		1	2	3	4	5	6	7	8	9	10
0.15	1	1.00	0.75	0.67	0.63	0.60	0.58	0.57	0.56	0.56	0.55
0.30	2	1.50	1.00	0.83	0.75	0.70	0.67	0.64	0.63	0.61	0.60
0.45	3	2.00	1.25	1.00	0.88	0.80	0.75	0.71	0.69	0.67	0.65
0.60	4	2.50	1.50	1.17	1.00	0.90	0.83	0.79	0.75	0.72	0.70
0.75	5	3.00	1.75	1.33	1.13	1.00	0.92	0.86	0.81	0.78	0.75
0.90	6	3.50	2.00	1.50	1.25	1.10	1.00	0.93	0.88	0.83	0.80
1.05	7	4.00	2.25	1.67	1.38	1.20	1.08	1.00	0.94	0.89	0.85
1.20	8	4.50	2.50	1.83	1.50	1.30	1.17	1.07	1.00	0.94	0.90
1.35	9	5.00	2.75	2.00	1.63	1.40	1.25	1.14	1.06	1.00	0.95
1.50	10	5.50	3.00	2.17	1.75	1.50	1.33	1.21	1.13	1.06	1.00
1.65	11	6.00	3.25	2.33	1.88	1.60	1.42	1.29	1.19	1.11	1.05
1.80	12	6.50	3.50	2.50	2.00	1.70	1.50	1.36	1.25	1.17	1.10
1.95	13	7.00	3.75	2.67	2.13	1.80	1.58	1.43	1.31	1.22	1.15
2.10	14	7.50	4.00	2.83	2.25	1.90	1.67	1.50	1.38	1.28	1.20
2.25	15	8.00	4.25	3.00	2.38	2.00	1.75	1.57	1.44	1.33	1.25
2.40	16	8.50	4.50	3.17	2.50	2.10	1.83	1.64	1.50	1.39	1.30
2.55	17	9.00	4.75	3.33	2.63	2.20	1.92	1.71	1.56	1.44	1.35
2.70	18	9.50	5.00	3.50	2.75	2.30	2.00	1.79	1.63	1.50	1.40
2.85	19	10.00	5.25	3.67	2.88	2.40	2.08	1.86	1.69	1.56	1.45
3.00	20	10.50	5.50	3.83	3.00	2.50	2.17	1.93	1.75	1.61	1.50

Many of the combinations shown above meet the required displacement assuming a ¼ inch gap. Panes of glass larger than 4x20ft or 5x10ft would require a larger gap between the glass and frame. Even though glass of this size is not typically used in window systems, there are specialty firms that manufacture glass panes up to 10x20ft.

In rare cases the gap may be smaller than ¼ inch due to various constraints. Holdman Studios manufactured stained glass windows for the LDS temple in Rome. The dimensions of the stained glass panels were approximately 2 ft. wide by 8 ft. tall. Aaron Yorgason, the liaison for Holman Studios, mentioned that the gap between the stained glass panels and their frames would only be about 1/8 inch. Because of this situation Table 2 was created to demonstrate which window dimensions would work with a 1/8-inch gap on each side.

Table 2: D_{clear} given values of c_1 & c_2 as 0.125 inches and an allowable story drift of 0.01*hxx

$1.25*D_p$ (in)	Height (ft)	Width (ft)									
		1	2	3	4	5	6	7	8	9	10
0.15	1	0.50	0.38	0.33	0.31	0.30	0.29	0.29	0.28	0.28	0.28
0.30	2	0.75	0.50	0.42	0.38	0.35	0.33	0.32	0.31	0.31	0.30
0.45	3	1.00	0.63	0.50	0.44	0.40	0.38	0.36	0.34	0.33	0.33
0.60	4	1.25	0.75	0.58	0.50	0.45	0.42	0.39	0.38	0.36	0.35
0.75	5	1.50	0.88	0.67	0.56	0.50	0.46	0.43	0.41	0.39	0.38
0.90	6	1.75	1.00	0.75	0.63	0.55	0.50	0.46	0.44	0.42	0.40
1.05	7	2.00	1.13	0.83	0.69	0.60	0.54	0.50	0.47	0.44	0.43
1.20	8	2.25	1.25	0.92	0.75	0.65	0.58	0.54	0.50	0.47	0.45
1.35	9	2.50	1.38	1.00	0.81	0.70	0.63	0.57	0.53	0.50	0.48
1.50	10	2.75	1.50	1.08	0.88	0.75	0.67	0.61	0.56	0.53	0.50
1.65	11	3.00	1.63	1.17	0.94	0.80	0.71	0.64	0.59	0.56	0.53
1.80	12	3.25	1.75	1.25	1.00	0.85	0.75	0.68	0.63	0.58	0.55
1.95	13	3.50	1.88	1.33	1.06	0.90	0.79	0.71	0.66	0.61	0.58
2.10	14	3.75	2.00	1.42	1.13	0.95	0.83	0.75	0.69	0.64	0.60
2.25	15	4.00	2.13	1.50	1.19	1.00	0.88	0.79	0.72	0.67	0.63
2.40	16	4.25	2.25	1.58	1.25	1.05	0.92	0.82	0.75	0.69	0.65
2.55	17	4.50	2.38	1.67	1.31	1.10	0.96	0.86	0.78	0.72	0.68
2.70	18	4.75	2.50	1.75	1.38	1.15	1.00	0.89	0.81	0.75	0.70
2.85	19	5.00	2.63	1.83	1.44	1.20	1.04	0.93	0.84	0.78	0.73
3.00	20	5.25	2.75	1.92	1.50	1.25	1.08	0.96	0.88	0.81	0.75

With a 1/8" gap, significantly fewer glass dimensions meet the required displacement, but the Rome stained glass windows still have sufficient gaps to prevent contact at design seismic drift.

The following table has been created to aid the design of gaps in window systems. Each section gives the minimum combination of gap sizes required for the window dimensions. This assumes that the gap is the same on the for c_1 and c_2.

Table 3: Minimum required average gaps (c_1, c_2) for various window dimensions

	Width (ft)									
Height (ft)	1	2	3	4	5	6	7	8	9	10
1	1/8 in	1/8 in	1/8 in	1/8 in	1/8 in	1/8 in	1/8 in	1/8 in	1/8 in	1/8 in
2	1/8 in	1/8 in	1/8 in	1/8 in	1/8 in	1/8 in	1/8 in	1/8 in	1/8 in	1/8 in
3	1/8 in	1/8 in	1/8 in	1/4 in	1/4 in	1/4 in	1/4 in	1/4 in	1/4 in	1/4 in
4	1/8 in	1/8 in	1/4 in	1/4 in	1/4 in	1/4 in	1/4 in	1/4 in	1/4 in	1/4 in
5	1/8 in	1/8 in	1/4 in	1/4 in	1/4 in	1/4 in	1/4 in	1/4 in	1/4 in	1/4 in
6	1/8 in	1/8 in	1/4 in	1/4 in	1/4 in	1/4 in	1/4 in	3/8 in	3/8 in	3/8 in
7	1/8 in	1/8 in	1/4 in	1/4 in	1/4 in	1/4 in	3/8 in	3/8 in	3/8 in	3/8 in
8	1/8 in	1/8 in	1/4 in	1/4 in	1/4 in	3/8 in	3/8 in	3/8 in	3/8 in	3/8 in
9	1/8 in	1/8 in	1/4 in	1/4 in	1/4 in	3/8 in	3/8 in	3/8 in	3/8 in	3/8 in
10	1/8 in	1/8 in	1/4 in	1/4 in	1/4 in	3/8 in	3/8 in	3/8 in	3/8 in	3/8 in
11	1/8 in	1/4 in	1/4 in	1/4 in	3/8 in	3/8 in	3/8 in	3/8 in	3/8 in	1/2 in
12	1/8 in	1/4 in	1/4 in	1/4 in	3/8 in	3/8 in	3/8 in	3/8 in	1/2 in	1/2 in
13	1/8 in	1/4 in	1/4 in	1/4 in	3/8 in	3/8 in	3/8 in	3/8 in	1/2 in	1/2 in
14	1/8 in	1/4 in	1/4 in	1/4 in	3/8 in	3/8 in	3/8 in	1/2 in	1/2 in	1/2 in
15	1/8 in	1/4 in	1/4 in	1/4 in	3/8 in	3/8 in	3/8 in	1/2 in	1/2 in	1/2 in
16	1/8 in	1/4 in	1/4 in	1/4 in	3/8 in	3/8 in	3/8 in	1/2 in	1/2 in	1/2 in
17	1/8 in	1/4 in	1/4 in	1/4 in	3/8 in	3/8 in	3/8 in	1/2 in	1/2 in	1/2 in
18	1/8 in	1/4 in	1/4 in	1/4 in	3/8 in	3/8 in	1/2 in	1/2 in	1/2 in	1/2 in
19	1/8 in	1/4 in	1/4 in	1/4 in	3/8 in	3/8 in	1/2 in	1/2 in	1/2 in	1/2 in
20	1/8 in	1/4 in	1/4 in	1/4 in	3/8 in	3/8 in	1/2 in	1/2 in	1/2 in	1/2 in

Even though in-plane loads are not generally considered during the design of windows, the required gaps explained above are smaller than the typical gaps seen in manufactured window systems. For the design of unique systems with large panes of glass, it is important to have the required gap size shown in Table 3.

Certain practices in window system design may cause limitations on the method explained above. Commonly rubber shims are placed on the bottom of the pane of glass to transfer the weight to the frame without direct contact. These shims can reduce the effectiveness of the bottom gap if placed incorrectly. Two window contractors verified that shims are to be placed at quarter points along the bottom of the frame. This still allows flexibility in the case of seismic drift. If the shims were to be placed at the corners, there effectively would be no gap. This would reduce the flexibility of the window frame. Jeff Pulver, a specialist at Bountiful Glass, also stated that the top and bottom gaps are typically larger than the side gaps. This would help reduce the effect of the shims that take up part of the gap.

Late in our research that we received information from Arcadia, Inc, a frame manufactured used by Mollerup Glass, that lateral drift is in fact accounted for on a project by project basis based on the code from ASCE 7-10 13.5.9. We corresponded via email with Henry Nguyen and Greg Millward, both from Arcadia. They confirmed that, "Glazing system selection and performance, including structural and seismic design should be based on specific project requirements. Accommodating seismic drift can be one of the more complicated issues in glazing system and overall building design." When asked how they calculate the minimum gap needed in a window frame they responded that, "The amount of internal clearance (glass to frame) varies with different glazing systems. The ability of a specific glazing system to accommodate in plane lateral displacement by deformation, or racking, is determined according to ASCE 7, 13.5.9."

It was relieving to finally confirm what glaziers had been telling us along the way and hear from a window frame manufacturer that lateral drift and minimum glass clearance inside the frame were indeed being design for using the appropriate code. We hoped to hear from other frame manufacturers. Unfortunately EFCO, US Aluminum, and others never responded to our requests and emails.

Recommendations

In-plane loads

- All windows, curtain walls, and store front systems must be designed in accordance with ASCE 7-10 Section 13.5.9
- Architects or engineers may refer to the provided chart to ensure that the specified gaps between the frame and glass are sufficient given the glass dimensions.
- Require the placement of the shims at quarter points along the bottom. (Meaning not at the corners)

Connections

- Require all window connections to be engineered and specify the attachment method of the window system to the structure. (no matter the scale of the window)
- Require the structural engineer of record to review the window attachment shop drawings and calculations.

Stained glass windows

- Require stained glass window contractors to comply with the SGAA Reference and Technical Manual, and specifically comply with chapter 5, Structure and Reinforcement.

Appendix

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Annotated Bibliography

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- The company has a general rule of thumb that governs window system connections to the building
- For a big office building window system connections will be specified
- Caulk joint between window system and structure is 0.25”
- Typical thickness of window shims used is 0.5”-0.75”
- Tempered glass is used when required by building code or if the window is under 7 ft. tall for the LDS church
- Gap provided between the glass and the window frame (including rubber setting blocks) is 0.5-0.75”
- Setting blocks are placed at quarter points (1/4 the way in from the sides of the window), only two setting blocks are used
- A professional engineer will typically specify window system connections on a big office building, but has never seen it for a structure like a temple

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- Window system connection guidelines are specified by the manufacturer and checked by an engineer for connecting to the structure
- Rubber setting block thickness: 0.5-0.75”
- Window manufacturer will design the system to allow 3/8-1/2” shim space on the top and sides to allow for seismic movement
- Two setting blocks are placed at quarter points

- Curtain Walls are used if the window is greater than 11’ to accommodate for water
- Storefronts are used for anything storefront
- Local building code governs the engineering requirements
- ASCE – 7 is used in the engineering process
- The glass subcontractor has the responsibility to make sure the plans are correct and up to code

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- The term window is typically used as an umbrella term for all fenestration
- Fenestration is typically classified in 4 categories
    - Window
    - Window Wall
    - Curtain Wall
    - Storefront
- Curtain Walls are typically used on larger window openings

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- Holdman Studios has worked on 43 different temples.
- They specialize in art glass and their windows are three-pane glass.
- Holdman uses EFCO frames. EFCO is a manufacturer of architectural aluminum window, curtain wall, storefront and entrance systems for commercial and architectural applications based out of Monett, MO. We attempted getting information from EFCO but they did not reply to any of our requests.

- Holdman Studio specifies to EFCO the out of plane loads that the window needs to withstand and EFCO provides the appropriate window frame.
- The manufacture's engineer designs the frame and the plans are sent back to Holdman.
- Based on our conversation with Aaron Yorgason it seems like out-of-plane loads are definitely something that is accounted for when manufacturing a window.
- We also inquired about how they account for lateral displacement and whether they are leaving a big enough gap on the sides for the windowpane to move in case the structure is deflected. They said that they just leave that to the manufacturer of the window frame and that most time they end up with a gap of about 1/8" to ¼". They prefer at least ¼" as this gives them more room to work with.
- They also recommended using tempered glass if there is a fear that deflections will be so great that the glass will fail. They use tempered glass in all of their windows. It is only slightly more expensive and much safer.
- When it comes to installation Aaron informed us that the general contractor and the architect give them the information that they need, from screw size to caulk type and size. This information is given to them in the specifications.
- That information is then used to educate the installation crew to insure proper connection to the structure.
- Holman adheres to several codes such as ASCE, CRF, AAMA, WDMA, SCA, and SGAA (specific for art glass) in order to insure safety and to make sure that specifications for wind loads, hurricane resistance, etc. are met.

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801-397-1177
Contacted via telephone on April 9, 2015

- 3/8" for store fronts and ½" for curtain walls. Temples usually fall under the second category.
- They use frames made by US Aluminum and Arcadia. Those frames are engineered for seismic and window loads, thermal and moisture protection.
- They normally use the window frame manufactures specifications when it comes to installation.
- When anything out of the ordinary is needed they work closely with the architect to insure they get all the specifications.

Henry Nguyen and Greg Millward
Arcadia, Inc
1850 E Maule Ave, Las Vegas, NV 89119
hnguyen@arcadiainc.com

gmillward@arcadiainc.com
702-944-4680 ext. 4694 (Henry)
323-908-5420 (Greg)

- How do design for lateral drift under seismic loads?
  Seismic design is tailored to the specific project requirements. Two main considerations are the amount of inter-story drift to be accommodated, and the interaction of the curtain wall/window system with adjacent structures and building cladding or finishes.
- Do you specify a minimum gap that must be available for the glass pane to rotate inside the window frame?
  The amount of internal clearance (glass to frame) varies with different glazing systems. The ability of a specific glazing system to accommodate in plane lateral displacement by deformation, or racking, is determined according to ASCE 7, 13.5.9 (attached).
- How are frames designed so that they transfer loads from the window to the structure?
  Anchorage varies depending on the type of glazing system and is designed to meet the wind, seismic, and live load requirements, and the structural conditions (support provided) for the specific project.
- Do you provide specifications for installation to people who buy your frames?
  Project specific engineering and shop drawing services are available.

Contacts who didn't respond:

EFCO frames (works with Holdman Studio)

Re-View Historic Windows and Doors out of Kansas City (worked in Provo City Temple)

Ed Hymas with Bennett's Contract Glazing

Ira Fields with Steel Encounters

US Aluminum (frame manufacturer for Mollerup)