# Analysis 2

*Pre-fabricated Metal Stud Crete® Panels-Structural Breadth*

## Background

The current façade design calls for stick built 3-5/8" masonry on a 7-5/8" metal stud back-up with exterior sheathing board, 1" cavity board insulation and sheet membrane air barrier. Masonry is attached to the structure using 6"x6" continuous clip angles welded to pour stops which are attached to spandrel beams. 4"-9" Architectural Pre-Cast Concrete spandrels are featured at each floor level and rest on the 6"x 6" angles as well. Due to owner delays, completion of the façade has dictated the start of interior partitions due to dry-in issues.

## Methods

- Perform Quantity Take-Off of Existing Façade
- Complete Cost & Schedule Comparison of Two Systems
- Analyze Attachment Detail
- Perform Structural Analysis of Spandrel Beams to Determine If Downsizing Is Feasible

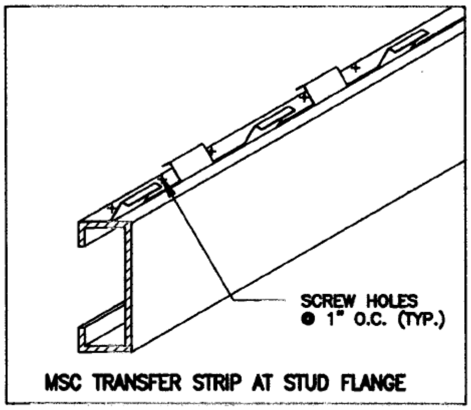
## Resources

- Holder Construction Company
- Metal Stud Crete® Panel Company
- Architectural Engineering Faculty
- Endicott Clay Products Company
- AISC Steel Design Guide 22
    - Façade Attachments to Steel-Framed Buildings

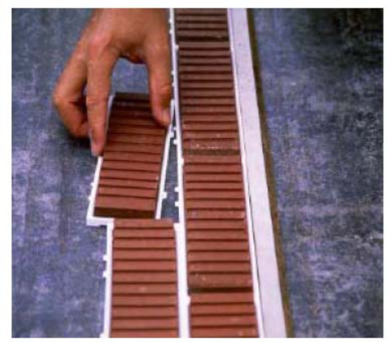
## Proposed System

The proposed façade system is a pre-fabricated panel system called the Metal Stud Crete® system. The Metal Stud Crete® system consists of light-gauge metal framing, shear-transfer strips, 2.5" of reinforced pre-cast concrete, and a thin-brick facing. The shear-transfer strips create a composite system between the concrete and metal studs. Various manufacturers of thin brick can be used such as the Endicott or Scott Systems. Panels can also be sandblasted for a limestone like finish.

To fabricate the Metal Stud Crete® lanels large fiberglass casting tables with rollers are used. Cold formed metal framing is fabricated into the correct panel sizes then the "Y" shaped shear strips are screwed to the front of the panels. Thin brick, any necessary molds, and reinforcing are placed in the bottom on the casting forms. The panels are then placed in the casting forms and secured for the proper concrete thickness. Concrete is then poured into the forms, cured, and forms are striped. The panels can be fabricated up to 16' tall and 40' wide. Typical panels for the TETC project will be approximately 15'x15'.




Scott Systems & Endicott Brick both fabricate thin brick for casting into pre-cast concrete panels. The use of thin brick on the Metal Stud Crete® system requires more labor because each brick has to be hand laid into the forms and snapped together using the thin brick gaskets provided. After casting these gaskets must be removed by hand.



For the TETC project, Panels spanning one floor vertically and 15' in width will be used. The panels will be approximately 9" thick consisting of 5-5/8" of stud back up with 2.5" of concrete with a 0.5" brick facing. The Architectural Pre-Cast spandrels will be incorporated into the top of these panels.

Panels will be attached to the existing steel spandrel beams using angle clips running continuously at 4' O.C spacing. After erection, all panel joints and perimeters must be caulked for moisture control. The use of this system allows for grade beam shelves to be eliminated for masonry bearing at the ground floor. This makes formwork unnecessary and allows an accelerated grade beam placement method that is analyzed in the following analysis

## Schedule Comparison

The Metal Stud Crete® system provides very significant schedule savings in erection time. The panelized system reduces schedule time by 51% from 91 to 45 day durations. The

schedule acceleration allows interior finishes to begin nearly 8 weeks early. A production rate of 12 panels per day was used to calculate the schedule.

Both the panelized and stick built systems construct one elevation of the building at a time, following the structural steel sequence. One negative impact of the panelized system is increase durations for caulking panels. The 15’ x 15’ panels increase the number of construction/control joints by a factor of 3. However, quick erection of panels allows a caulking crew to closely following the completed panel erection. The use of these panels also eliminates the need for hoisting of Architectural Pre-Cast Spandrels. Summary schedules of the existing façade system and the proposed system can be found on the following 2 pages for comparison.

## Cost Comparison

The only negative impact of the pre-fabricated Metal Stud Crete® panels is an increase in cost. The Metal Stud Crete® panels result in a 29% increase of approximately $820,000 in the façade system cost. These costs are likely a result of the fabrication and shipping process. Typical panels would be used throughout the building, but many panels will be unique to coordinate with the architecture of the façade. The 15' x 15' panels also have to be transported to site via truck. A cost comparison of the two systems can be seen below in Table 1-Façade Cost Summary Comparison.

| Metal Stud Crete ® Panels | | |
|---|---|---|
| **Pre-Cast Panels with Stud Back-up** | | |
| Façade Area (SF) | Unit Price ($/SF) | Total Cost ($) |
| 107,137 | $28.00 | $2,999,836.00 |
| **Endicott® Thin Brick** | | |
| 107,137 | $6.00 | $642,822.00 |
| | **Total Cost** | **$3,642,658.00** |
| **Conventional 4" Hand-Layed Brick** | | |
| Façade Area (SF) | Unit Price ($/SF) | Total Cost ($) |
| 107,137 | $26.32 | $2,819,845.84 |
| | **Total Cost** | **$2,819,845.84** |
| | **Difference** | **$822,812.16** |

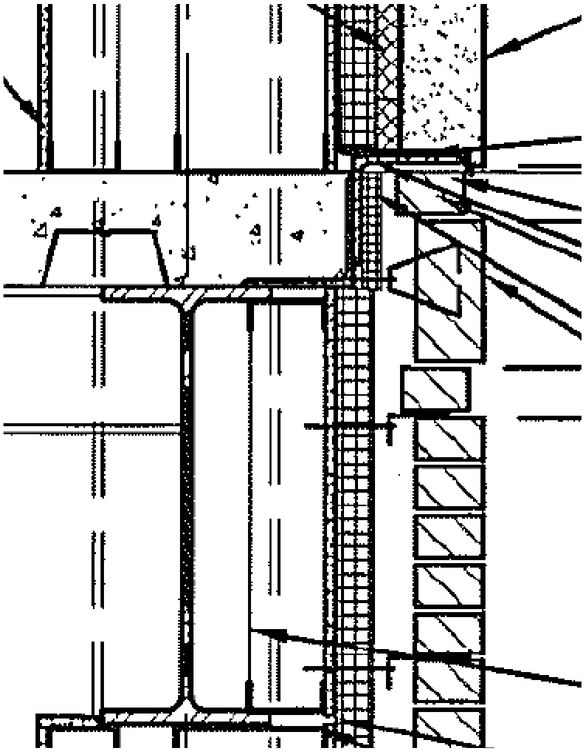
Table 1- Facade Cost Summary Comparison

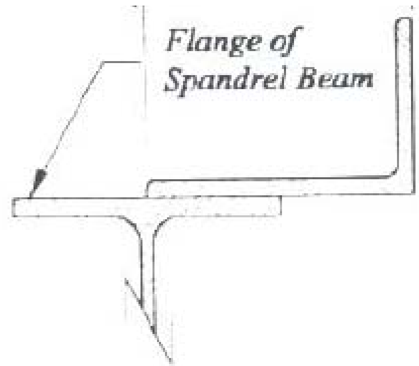
* Unit Prices obtained from Holder Construction Companpy & The Metal Stud Crete® Companyy

## Connection Details

Small modifications to the masonry connection details must be made in order to utilize the Metal Stud Crete® panels. Currently, the masonry assembly rests on 6"x 6x 1/2" continuous angles welded to the pour stops. The proposed connection detail uses 6"x 6x 1/2" continuous angles attached to the concrete pour stops and a bolt connection to the metal framing of the panel.

At the base of the panels connection is made from the bottom track metal framing to the grade beam/ SOG concrete using ½" wedge anchors. Vertical panel-to-panel connections are made using self taping screws between metal framing. Theses joints are then caulked after completed erection. These connection details can be seen below in Figures 2-5.





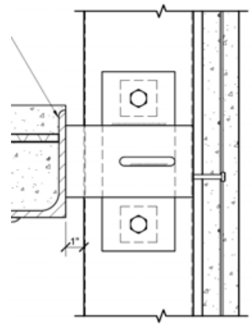



Figure 2- Existing Masonry Connection

Figure 3- Metal Stud Crete Connection to Angle/ Pour Stop

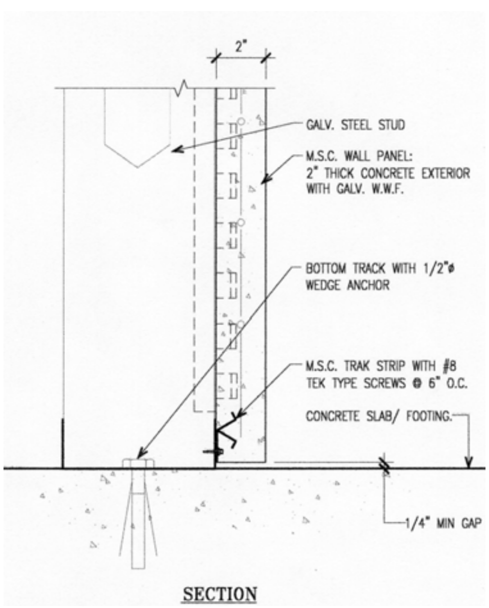



Figure 4-Slab/ Foundation Base Connection

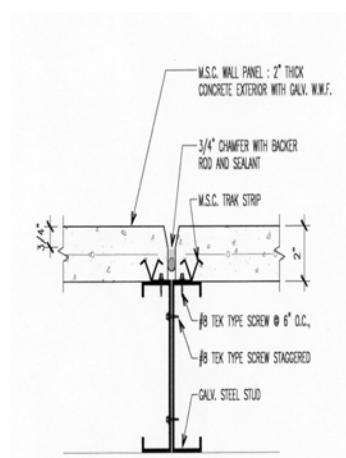



Figure 5- Panel-to Panel Connection

## Structural Impact

The largest benefit of the Metal Stud Crete ® system is the reduction in load from 45 PSF for brick to 36 PSF for the panel system. As can be seen above in the connection details, both systems are supported by angle supports connected to wide flange spandrel beams. The nature of the connection creates an eccentric, torsional load on the spandrel beams. Regardless of the façade system, the torsional load must be accounted for in the beam design. Comparison of loads and member sizes can be seen below in Table 2- Spandrel Beam Analysis.

The AISC Façade Attachments to Steel-Framed Buildings Guide was used to perform a structural analysis of the existing spandrel beams and to determine if downsizing these members was feasible. This guide defines steps to analyze a steel spandrel beam for torsional effects due to a façade attachment. This process checks beams for shear, flexure, deflection and rotation. Deflections and rotations of both the spandrel beam and roll beams framing into the spandrel beam are calculated to determine capacity.

Three typical spandrel beams were checked in this analysis and each beam was evaluated for downsizing the member. A W30 x 90, W27 x 94, and W21 x 44 were checked. All three beams were able to be downsized, but only the larger two members were chosen for downsizing. The W21 x 44 member was not downsized to keep more members typical. Adjacent framing to the W21 x 44 was of the same size. Additionally, downsizing of the W21 x 44 would introduce a more shallow shape than the roll beams framing into the spandrel beam and this would increase the possibility for shear failure in the connection due to coping. The W30 x 90 and W27 x 94 members were both downsized to W24 x 76 to introduce more typical members. Detailed calculations of this process can be found in Appendix A.

| Spandrel Beam Analysis | | |
|---|---|---|
| | **Metal Stud Crete ®** | **Traditional Brick Façade** |
| **Unit Weight (PSF)** | 36 | 45 |
| **Member Size** | W 24 x 76 | W 30 x 90 |
| | W 24 x 76 | W 27 x 94 |
| | W 21 x 44 | W 21 x 44 |

Table 2- Spandrel Beam Analysis

## Cost Impact of Downsizing Beams

The cost savings of downsizing spandrel beams for all the W30 x 90 and W27 x 94 members in the building. Continuing the structural analysis for the remaining spandrel beams would increase the number of beams to be downsized and increase cost savings. The results of the cost impact are seen below in Table 3- Spandrel Beam Steel Savings.

| Spandrel Beam Steel Savings | | | | | | |
|---|---|---|---|---|---|---|
| **Qty.** | **Shape** | **lb/ft** | **Length (LF)** | **Tons** | **Unit Price ($/Ton)** | **Total Cost** |
| 17 | W30 x 90 | 90 | 30 | 23 | $3,000.00 | $68,850.00 |
| 10 | W 27 x 94 | 94 | 30 | 14 | $3,000.00 | $42,300.00 |
| 27 | W 24 x 76 | 76 | 30 | 31 | $3,000.00 | $92,340.00 |
| | | | | | **Cost Savings** | **$18,810.00** |

Table 3- Spandrel Beam Steel Savings

* Unit price obtained from Holder Construction Company. Price accounts for fabrication and installation

## Conclusion

Although the Metal Stud Crete® system introduces a higher first cost, it produces significant schedule acceleration and a positive impact on the foundation system. The 29% increase in cost is offset by cutting schedule time nearly in half, eliminating the need for cold weather protection, and scaffolding. The panelized system also eliminated the need for a grade beam self for masonry bearing and reduced structural framing costs by downsizing members.

Panelized façade systems should be considered more often for the structural impacts as well. To further this investigation, the façade attachment could be analyzed with support conditions at the columns. Due to time, this analysis could not be performed. Spanning the façade panels the width of the column bay would greatly reduce the spandrel beam sizes and eliminate the torsional effect. The columns support the torsional load much better. In this case, the Metal Stud Crete ® panels could span from column to column with a maximum span of 33'.